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Impact of academic development on academic performance

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Abstract

In the CEPS data, mid-term scores in Chinese, mathematics, and English are not based on unified school tests. Therefore, we employ Bayesian BRPN and FBRPN procedures within stratified Cox proportional hazards models, under the generalized concept of relative risk, to identify the most efficient models containing important and meaningful protective or risk factors for student scores in the academic development module, with or without adjusting for the personal and family module. Variables in the most efficient models are ranked by importance. The results indicate that, though the most efficient models vary across subjects, common risk factors include: local dialect ability, parents checking homework, parental tutoring, parents' strictness in behaviours at school, teacher criticism reported to parents, finding mathematics difficult, time spent on interest-related weekday courses, and extra sports courses. Common protective factors include: parents' highest academic requirement, parents' highest educational expectation, parents' confidence in children's future, time spent on teacher-assigned homework (weekday/weekend), extra courses on Mathematical Olympiad, playing chess, reading books, staying home during summer/winter vacations, highest self-educational expectation, and self-expectation for future job. Gender is among the top three factors for Chinese and English, but is not a representative variable for mathematics. The two modules are nearly stackable (additive).

Key words: BRPN; CEPS; FBRPN; generalized concept of relative risk; stratified Cox proportional hazards model

1. Introduction

The China Education Panel Survey (CEPS) is a longitudinal study conducted by the National Survey Research Center at Renmin University of China. The baseline survey, carried out during the 2013-2014 academic year, sampled 7th- and 9th-grade students from 112 schools across 28 counties/cities nationwide. In the 2014-2015 academic year, the 7th-grade cohort advanced to 8th grade. Data were collected via five sets of questionnaires administered to students, parents, homeroom teachers, main subject teachers (excluding homeroom teachers), and school administrators, respectively, together with students' mid-term grades in Chinese, mathematics and English (<http://ceps.ruc.edu.cn/xmjs/xmgk.htm>). Because the mid-term exams were not unified across schools, with full scores ranging from 100 to 150 points for each subject, the effects of variables collected from homeroom teachers, main subject teachers, and school administrators cannot be estimated. However, the effects of variables from students and their parents can be identified when the data are analyzed using stratified Cox proportional hazards models under the generalized concept of relative risk (Zhao, 2015).

The student-answered questionnaire consists of four modules: (A) personal and family, (B) academic development, (C) physical and mental health, and (D) social behaviour development. Due to word limits, in this paper we consider only variables in modules A and B from the students' questionnaire, and study the impact of the academic development module on students' academic performance (scores in Chinese, mathematics, and English) with or without adjusting for the personal and family module.

In building the models, we adopted two Bayesian variable screening procedures proposed by Zhao (2026) to find important and meaningful protective and risk factors associated with academic performance. Prior to applying these procedures, we conducted a literature review to gather prior information on protective or risk factors for the scores among the predictors in modules A and B, which are listed in the order they appear in Table 1.

1.1. Predictors in module A

Regarding hukou status, residency, and local dialect ability, recent studies have documented no statistically significant difference in academic performance between local-born migrant children and their local counterparts (Li and Su, 2025). Liu and Zhang (2020), however, found that mastery of the local dialect significantly improves migrant students' performance in Chinese and English. In contrast, He and Cai (2022) reported no significant effect of dialect proficiency on academic outcomes.

Regarding family structure and household composition, Chen and Liu (2014) found that being an only child is positively associated with academic performance. Tang and Jiang (2025) revealed that students from two-parent families outperform those from non-two-parent families. Additionally, Zhang and Wu (2021) reported that co-residence with grandparents has a significant positive effect on adolescents' academic performance.

Biological parents' marital status is associated with academic performance. Zhang (2020) showed that children living with divorced single mothers perform as well as children from intact families, whereas children living with divorced single fathers or stepparents exhibit lower academic scores. Wang (2020) further reported that the children from widowed families underperform those from divorced families.

Family financial situation is a well-established predictor of students' academic performance. Li et al. (2023) found that students from low-income families significantly lag behind their high-income peers in academic achievement. Wen et al. (2020) further distinguished between absolute and relative family income, reporting that both positively influence school grades, with absolute income exerting a stronger effect.

Researchers found that family-based learning infrastructures, including the number of books collected at home, the availability of a separate desk or study space, and the access to internet and computers (also conceptualised as objectified cultural capital; Bourdieu, 1986), positively influence the academic achievement of junior high school students (Yu et al., 2022).

Regarding parental influences on academic performance, Xie and Li (2025) employed a binary occupational indicator and found no significant association with academic performance. In contrast, inter-parental conflict and paternal alcoholism were found significantly and negatively associated with students' academic performance, respectively (Zhao and Zhao, 2021; Xiong et al., 2025).

Regarding parental involvement, recent evidence presents mixed findings. Li and Xue (2019) reported that frequent parental checking and instruction on homework are significantly and negatively associated with students' academic performance. Yang and Zhao (2020) found that parental strictness concerning children's school-related behaviours has a significant negative effect on performance in the three core subjects (Chinese, mathematics, and English). In contrast, Li et al. (2024) observed no significant association between parental strictness and academic outcomes.

Parent-child communication has been found to be positively associated with children's test scores in Chinese, mathematics, and English (Du and Chiang, 2026). Extending this line of inquiry, Qin et al. (2025) reported that both father-child and mother-child relationships positively predict overall and subject-specific academic achievement, with the mother-child relationship exerting a stronger effect.

Regarding family-organized activities, Eisenberg et al. (2004) reported a positive correlation between family dining frequency and student academic performance. Parent-organized educational and informal learning activities (e.g., visiting science museums and zoos) and leisure activities (e.g., watching movies in cinemas and attending concerts) both exert a significant positive influence on Chinese scores. However, only parent-organized leisure events have a significant positive influence on English scores (Peng and Zeng, 2024).

Prior research has reported a significant positive correlation between parents' long-term educational expectation and children's academic achievement (Li et al., 2019). Furthermore, Su (2012) found that short-term educational expectation is even more strongly associated with children's achievement than long-term expectation. In contrast, the pressure arising from parents' educational expectation appears

detrimental to academic performance; Zhang et al. (2026) found that it is significantly and negatively associated with academic performance. In a related finding, Xie (2023) reported a positive correlation between parents' confidence in their children's future success and children's academic performance.

Gender differences in academic performance have been widely documented. Luo and Chen (2024) found that females performed significantly better than males in mathematics based on CEPS data. In contrast, based on NCEE (National College Entrance Exam) data from a typical Chinese municipality, Zhang and Tsang (2015) reported that females outperform males in Chinese and English, while the gender gap in mathematics is not statistically significant.

1.2. Predictors in module B

Regarding perceived course difficulty, Chen et al. (2023) found that reductions in students' perceived subject difficulty lead to significant gains in mathematics and English achievement.

In terms of teacher-student interactions, both classroom interactions (e.g., frequent questioning) and emotional interactions (e.g., regular praise) with core subject teachers have been found to significantly enhance students' academic performance (Li, 2018). Similarly, Zhang and Lei (2024) reported a significant positive association between a composed measure of perceived teacher interactions and academic achievement. Regarding homeroom teachers' praise and criticism, Yao et al. (2021) found that frequent praise significantly improves academic performance, whereas frequent criticism significantly reduces Chinese performance and has no significant effects on mathematics or English.

With respect to school and classroom climate, rather than examining individual questionnaire items separately, Ma and Yao (2024) constructed an agreeableness measure using three CEPS items ("My classmates are very friendly to me; I think I am easy to get along with, and I often participate in school or class activities"), while Kang and Han (2025) developed a composite indicator of positive school life using 12 items. Both measures have been shown to exert a significant and positive effect on

academic achievement. In contrast, boredom has been repeatedly identified as a negative predictor of academic achievement (Shui and Zhu, 2026).

Time allocation across different activities may help shape adolescents' educational, social, and psychological development (Larson and Verma, 1999). Hu and Mu (2020) found that homework time positively predicts academic performance, whereas cram school time negatively predicts mid-term exam scores. Yang and Zhao (2021) identified an inverted U-shaped causal relationship between after-class learning time (including time spent on homework assigned by teachers, cram schools, or parents, and time attending cram school courses) and academic performance among Chinese junior high school students. Feng et al. (2025) reported that time spent on watching TV and using the Internet (or playing video games) is significantly and negatively correlated with the academic performance in Chinese, mathematics, and English, with watching TV showing a relatively smaller effect. Guan and Tena (2022) found that the frequency of cultural activities, including those undertaken alone or with schoolmates (e.g., visiting museums, watching films), exerts a significant positive effect on academic performance.

Extracurricular activities can be divided into course-related activities (e.g., Mathematical Olympiad, ordinary mathematics, Chinese, and English) and interest-related activities (e.g., painting, calligraphy, music, dancing, chess, and sports). Liu et al. (2026) found that course-related tutoring significantly improves students' academic performance across all subjects, whereas Guo et al. (2020) reported that significant improvements are limited to Chinese and mathematics. For interest-related activities, the impact of any single activity on academic performance has rarely been systematically examined using CEPS data. Tan et al. (2022) constructed a binary indicator for participation in one or more interest-based activities and concluded that extracurricular interest classes do not significantly affect junior high school students' academic performance. Housework has been found to effectively improve teenagers' academic performance, with a stronger impact on

students with average or below-average achievement than on high-achieving students (Zhang and Ye, 2024).

Strong evidence indicates a positive impact of boarding education on Chinese and mathematics achievement, particularly among students of low socio-economic status and rural students; however, for English performance, boarding education showed no advantage over day schooling (Canche et al., 2025). Additionally, commuting time was found to have a significant negative effect on students' academic performance in Chinese, mathematics, and English (Ding et al., 2023; Shan, 2026).

Self-related psychological factors consistently and positively predict academic performance. Specifically, self-educational expectation (Xu et al., 2025), self-occupational expectation (Li et al., 2024), and self-confidence (Lei and Li, 2021) all exert significant positive effects on students' academic performance. However, when parental expectations substantially exceed students' own, the discrepancy undermines students' academic achievement (Zhao and Zhao, 2022).

Based on the above prior knowledge regarding the predictors, in the following sections, we develop a stratified Cox proportional hazards model under the generalized concept of relative risk (Zhao, 2015) using the CEPS data, and apply the Bayesian BRPN and FBRPN procedures (Zhao, 2026) to identify important and meaningful protective and risk factors influencing students' academic performance. We then examine the individual and collective impacts of the two modules on each of the three subjects, followed by discussions and conclusions.

2. Methods

2.1 Stratified Cox regression model under the generalized concept of relative risk

In survival analysis, the outcome usually refers to survival time (T), accompanied by the occurrence of an event such as death. The Cox proportional hazards model (Cox, 1972), also known as the Cox regression model, is defined as

$$h(t | \mathbf{X}) = h_0(t) \exp(\boldsymbol{\beta}' \mathbf{X}),$$

where β is a $p \times 1$ vector of unknown parameters; $\mathbf{X}$ is a $p \times 1$ vector of covariates (which may be continuous or appropriately coded categorical). The hazard function $h(t|\mathbf{X})$ is defined as

$$h(t | \mathbf{X}) = \lim_{\Delta t \rightarrow 0} \frac{\Pr(t \leq T < t + \Delta t | T \geq t, \mathbf{X})}{\Delta t}$$

which is the instantaneous risk of death, or the hazard of living no longer longevity at survival time $T=t$ or achieving no higher score at mark $T=t$, for given $\mathbf{X}$ under the generalized concept of hazard function. The generalization is meaningful for any continuous outcome T (Zhao, 2015). When $\mathbf{X}=\mathbf{0}$, $h_0(t) = h(t | \mathbf{X} = \mathbf{0})$ is the baseline hazard function. For the CEPS data, T is the score of a subject, and the variables in $\mathbf{X}$ are from the two modules.

In a stratified Cox proportional hazards model, for each stratum,

$$h_s(t | \mathbf{X}) = h_{0s}(t) \exp(\beta' \mathbf{X}), \quad s = 1, 2, \dots, S.$$

That is, though the baseline hazards are different, the coefficients are assumed common across the strata. In other words, as long as two individuals with covariates $\mathbf{X}$ and $\mathbf{X}^*$ are observed within the same stratum, their hazard ratio is

$$RR = \frac{h_s(t | \mathbf{X}^*)}{h_s(t | \mathbf{X})} = \frac{h_{0s}(t) \exp(\beta' \mathbf{X}^*)}{h_{0s}(t) \exp(\beta' \mathbf{X})} = \exp(\beta' (\mathbf{X}^* - \mathbf{X})),$$

which is constant over different strata, and can also be explained as the relative risk of living no longer longevity or achieving no higher score under the generalized concept of relative risk. For a given covariate X_j , a positive sign of $\hat{\beta}_j$ indicates a protective factor for achieving no higher score, whereas a negative sign indicates a protective factor for achieving higher score.

Note that in a stratified Cox proportional hazards model, the partial likelihood function is constructed based on the order of the outcome variable (T) within each stratum, with the expression

$$L(\beta | X, T) = \prod_{i=1}^S \prod_{k=1}^{n_i} \frac{\exp(\beta' \mathbf{X}_{(k)}^{(i)})}{\sum_{j \in R^{(i)}(t_k^{(i)})} \exp(\beta' \mathbf{X}_{(j)}^{(i)})} \quad (1)$$

where, for each stratum (school) i , $t_1^{(i)} < t_2^{(i)} < \dots < t_{n_i}^{(i)}$ are the ordered distinct academic scores, with n_i students in the i th school; $\mathbf{X}_{(j)}^{(i)}$ is the vector of predictors for the student who scored $t_j^{(i)}$; and $R^{(i)}(t_k^{(i)})$ is the risk set of individuals with academic scores no lower than $t_k^{(i)}$ in the i th school.

For the case with tied outcomes, modifications of the partial likelihood function are proposed by Breslow (1975), Efron (1977) and Kalbfleisch and Prentice (1980). The point estimates of β and its covariance matrix are estimated using maximum likelihood estimation and Fisher information, respectively. For the case that the proportionality is not perfectly satisfied, the estimated RR from the model can be explained as an average RR at the population level (Xu and O'Quigley, 2000; Zhao, 2015).

For the CEPS data, we use the `coxph(Surv (T, event)~X+strata(schids))` in R, where all observed scores are assigned `event=1`, and each school (`schids`) is treated as one stratum. We try to find important and meaningful protective or risk factors among the two modules for each of the three subjects.

2.2 The two Bayesian variable screening procedures

The FBRPN (local significant Forward and Backward procedure with Restrictions on the Positive or Negative effects) and BRPN (Backward procedure with Restrictions on the Positive or Negative effects) variable screening procedures were proposed to obtain important and meaningful protective or risk factors in models with a linear component (such as GLMs) to avoid multicollinearity. The procedures can also be used in the stratified Cox proportional hazards model, as the partial likelihood (1) is essentially a function of linear components of all predictors.

The steps in the FBRPN procedure are: (a) put all predictors that are statistically significant ($p < 0.05$) in fitted simple stratified Cox regression models into a multiple stratified Cox regression model, and fit the data. (b) compare the estimates from the fitted simple and multiple models, remove the most significant predictor (with the smallest p-value) among those with opposite effects, and if no such predictor exists,

remove the least significant predictor ($p>0.05$) among those with the same sign of effects. Remove only one predictor. (c) put the remaining predictors in a model, and fit the data. (d) repeat the previous (b)-(c), until no predictor can be removed. For the BRPN procedure, the steps are the same as those for the FBRPN procedure, except for the first step where all predictors (including those that are not significant in the fitted simple stratified Cox regression models) are put in a multiple regression model to fit the data. The FBRPN and BRPN procedures are essentially both backward processes, and the predictors kept in each of the final fitted models are the steadiest ones that have defeated all other variables fairly and sequentially, while keeping their meanings as protective or risk factors.

Based on the common predictors in the final fitted FBRPN and BRPN models, we add each remaining predictor to the model. A new model is selected if the added predictor is significant and meaningful as a protective or risk factor, and at the same time, the model achieves the most efficient reduction in deviance ($2\loglik$), assessed via a chi-squared test. Iterating this procedure until no remaining predictor can be added, we obtain the most efficient (optimal) model. Note that due to missing observations, as predictors are added sequentially, a predictor already in the model may become insignificant. In such cases, we remove it and continue the forward procedure, which is precisely the stepwise procedure (see model K in Table 4).

The variables in the most efficient model are relatively uncorrelated, and are referred to as the representative variables (RVs) of the original variables. The absolute values of the Z -statistics (or T -statistics) of the estimates in this model reflect the importance of the RVs (Zhao, 2026). Note that in this paper all multi-categorical predictors have been reclassified into binary predictors, which can save computing time and facilitate ranking the importance of the RVs.

For each of the three subjects, we obtain the BRPN and FBRPN models, and the most efficient model for each of the two modules. For the two modules collectively, the initial step in the BRPN procedure includes all variables in the two modules, while the initial step of the FBRPN procedure includes only those predictors retained by

module-specific FBRPN models. Based on the common predictors in the final fitted BRPN and FBRPN models, we obtain the most efficient model using the forward or stepwise procedure.

Note that before using the procedures, the direction of the effects (positive or negative) for predictors in the fitted simple stratified Cox regression models needs to be verified with prior knowledge and literature reviews. If inconsistencies arise, the final model may be adjusted accordingly.

3. Descriptive statistics and box-plots for the three subjects

3.1 Descriptive statistics

In the dataset, the valid sample size for the three subjects was 9862, excluding one student whose mathematics score was reported as 164, exceeding the maximum possible score of 150. We defined the variable names and calculated the minimum, maximum, mean, and sample size for each variable in the two modules, as shown in the 2nd – 4th columns in Table 1.

Table 1 Descriptive statistics of variables and estimates with significance levels of the coefficients in simple stratified Cox regression models

Variable names	(min,max)	mean	sample size	Chinese estimates	Mathematics estimates	English estimates
Dependent: Chinese mid-term scores (chn)	(0,142.5)		9862			
Mathematics mid-term scores (mat)	(0,150)		9862			
English mid-term scores (eng)	(0,150)		9862			
Module A: personal and family module:						
not local Hukou registration (a01)	(0,1)	0.180	9505	−0.026	−0.012	0.056
non-agricultural type of Hukou (a02)	(0,1)	0.467	9312	−0.059*	−0.022	−0.082**
home not local location (a03)	(0,1)	0.033	9556	0.193**	0.044	0.132*
local dialect ability (a04)	(1,5)	4.077	9580	0.042***	0.053***	0.027*
the only child in your family (a05)	(0,1)	0.443	9546	0.010	−0.038	−0.020
number of older brother(s) (a0601)	(0,6)	0.117	9459	0.023	0.004	−0.006
number of younger brother(s) (a0602)	(0,6)	0.217	9458	−0.115***	0.016	−0.083**
number of older sister(s) (a0603)	(0,5)	0.237	9456	0.110***	0.031	0.085***
number of younger sister(s) (a0604)	(0,4)	0.151	9466	−0.018	0.042	0.046
co-resident with bio-father (a0701)	(0,1)	0.834	9604	−0.120***	−0.141***	−0.141***
co-resident with bio-mother (a0702)	(0,1)	0.874	9604	−0.163***	−0.201***	−0.121***

co-resident with stepfather (a0703)	(0,1)	0.016	9604	0.221**	0.175*	0.286***
co-resident with stepmother (a0704)	(0,1)	0.015	9604	0.178*	0.180*	0.147
co-resident with full or half sibling(s) (a0705)	(0,1)	0.428	9604	-0.118***	-0.061*	-0.079**
co-resident with grandparents (a0706)	(0,1)	0.319	9604	-0.083***	-0.078***	-0.130***
co-resident with other relative(s) (a0707)	(0,1)	0.090	9604	0.049	0.059	0.030
co-resident with other non-relative(s) (a0708)	(0,1)	0.010	9604	0.244*	0.089	0.105
married parents(a0801)	(0,1)	0.918	9632	-0.118**	-0.154***	-0.135***
divorced parents (a0802)	(0,1)	0.072	9631	0.190***	0.244***	0.188***
deceased father (a0803)	(0,1)	0.017	9632	0.222**	0.214**	0.326***
deceased mother (a0804)	(0,1)	0.012	9632	0.175	0.059	0.200*
family's financial situation (a09)	(1,5)	2.938	9626	-0.033	-0.004	-0.056**
own your writing desk (a10)	(0,1)	0.784	9611	-0.173***	-0.104***	-0.203***
amount of books your family own (a11)	(1,5)	3.067	9643	-0.128***	-0.063***	-0.134***
computer or network in your family (a12)	(0,1)	0.732	9625	-0.061*	-0.063*	-0.105***
father's less favorable job (a13)	(0,1)	0.757	9544	0.130***	0.125***	0.185***
mother's less favorable job (a14)	(0,1)	0.765	9520	0.110***	0.106***	0.160***
father drunk often (a15)	(0,1)	0.091	9632	0.127***	0.098**	0.098**
parents quarrel often (a16)	(0,1)	0.097	9589	0.074*	0.125***	0.102**
parents get along well (a17)	(0,1)	0.898	9572	-0.055	-0.159***	-0.134***
parents checking homework last week (a18)	(1,4)	2.057	9627	0.092***	0.068***	0.085***
parental tutoring last week (a19)	(1,4)	1.737	9602	0.071***	0.047***	0.057***
parents' strictness in homework and exams (a2001)	(1,3)	2.447	9660	-0.073***	-0.066***	-0.098***
parents' strictness in school behaviors (a2002)	(1,3)	2.264	9649	0.013	0.022	0.030
parents' strictness in friends to make with (a2003)	(1,3)	2.100	9653	-0.104***	-0.044**	-0.087***
parents' strictness in dressing style (a2004)	(1,3)	2.033	9638	-0.081***	-0.045**	-0.067***
parents' strictness in internet duration (a2005)	(1,3)	2.501	9609	-0.044*	-0.061***	-0.042*
parents' strictness in watching TV duration (a2006)	(1,3)	2.253	9654	-0.098***	-0.093***	-0.088***
discussing things at school with father (a2101a)	(1,3)	2.033	9527	-0.162***	-0.150***	-0.174***
discussing things at school with mother (a2101b)	(1,3)	2.348	9326	-0.249***	-0.202***	-0.242***
discussing classmates with father (a2102a)	(1,3)	1.906	9504	-0.077***	-0.091***	-0.099***
discussing classmates with mother (a2102b)	(1,3)	2.205	9314	-0.187***	-0.139***	-0.192***
discussing teachers with father (a2103a)	(1,3)	1.948	9499	-0.064***	-0.069***	-0.098***
discussing teachers with mother (a2103b)	(1,3)	2.182	9301	-0.126***	-0.102***	-0.139***
discussing concerns/troubles with father (a2104a)	(1,3)	1.822	9510	-0.069***	-0.093***	-0.087***
discussing concerns/troubles with mother (a2104b)	(1,3)	2.122	9329	-0.143***	-0.122***	-0.151***
close relationship with father (a22)	(1,3)	2.502	9626	-0.095***	-0.084***	-0.117***
close relationship with mother (a23)	(1,3)	2.700	9625	-0.188***	-0.165***	-0.204***
dinner with your parents (a24)	(1,6)	5.457	9572	-0.032**	-0.050***	-0.031**
freq of visiting museums/zoos with parents (a25)	(1,6)	2.329	9536	-0.030**	-0.007	-0.029**
freq of watching movies/sports with parents (a26)	(1,6)	2.237	9597	-0.021*	-0.008	-0.033***
parents' highest academic requirement (a27)	(1,4)	2.863	9630	-0.419***	-0.423***	-0.466***
parents' highest educational expectation (a28)	(0,1)	0.633	9583	-0.710***	-0.657***	-0.743***
pressure from parents' educational expectation (a29)	(1,5)	2.933	9613	0.099***	0.084***	0.113***
parents' expectation for your future job (a30)	(0,1)	0.529	9617	-0.401***	-0.342***	-0.426***

parents' expectation for your job location (a31)	(0,1)	0.438	9644	-0.184***	-0.076***	-0.180***
parents' confidence in the student's future (a32)	(1,4)	3.065	9612	-0.330***	-0.333***	-0.392***
male gender (<i>gender</i>)	(0,1)	0.522	9263	0.590***	0.129***	0.524***
Module B: academic development module						
amount of students in your 6th grade class (b01)	(0,99)	48.423	9390	-0.005***	-0.002	-0.004***
finding mathematics difficult (b02)	(1,4)	2.552	9646	0.291***	0.663***	0.350***
finding Chinese difficult (b03)	(1,4)	2.176	9645	0.335***	0.027	0.128***
finding English difficult (b04)	(1,4)	2.668	9646	0.400***	0.261***	0.684***
attention from mathematics teacher (b0501)	(1,4)	2.701	9660	-0.051***	-0.103***	-0.078***
attention from Chinese teacher (b0502)	(1,4)	2.739	9656	-0.105***	-0.077***	-0.090***
attention from English teacher (b0503)	(1,4)	2.747	9647	-0.115***	-0.114***	-0.176***
being asked questions by mathematics teacher (b0504)	(1,4)	2.467	9646	-0.018	-0.046***	-0.042***
being asked questions by Chinese teacher (b0505)	(1,4)	2.545	9652	-0.111***	-0.066***	-0.093***
being asked questions by English teacher (b0506)	(1,4)	2.564	9635	-0.155***	-0.131***	-0.226***
being praised by mathematics teacher (b0507)	(1,4)	2.339	9654	-0.056***	-0.145***	-0.103***
being praised by Chinese teacher (b0508)	(1,4)	2.423	9637	-0.127***	-0.054***	-0.097***
being praised by English teacher (b0509)	(1,4)	2.372	9645	-0.111***	-0.107***	-0.214***
school's praises to parents (b0601)	(1,4)	2.234	9651	-0.114***	-0.102***	-0.136***
teacher criticism reported to parents (b0602)	(1,4)	1.865	9637	0.231***	0.179***	0.207***
being praised by homeroom teacher(b0603)	(1,4)	2.321	9635	-0.132***	-0.099***	-0.156***
being criticized by homeroom teacher (b0604)	(1,4)	1.875	9626	0.182***	0.131***	0.151***
nice classmates (b0605)	(1,4)	3.291	9641	-0.171***	-0.122***	-0.182***
class in good atmosphere (b0606)	(1,4)	3.114	9638	-0.059***	-0.032*	-0.052***
participating in school/class activities (b0607)	(1,4)	2.843	9631	-0.078***	-0.030*	-0.068***
closeness to people in school (b0608)	(1,4)	2.950	9618	-0.105***	-0.090***	-0.114***
bored in school (b0609)	(1,4)	1.764	9624	0.125***	0.118***	0.138***
the hope of transferring to other school (b0610)	(1,4)	1.586	9643	0.062***	0.081***	0.063***
time spent on weekday homework by teachers (b07a)	(1,6)	3.509	9658	-0.088***	-0.076***	-0.081***
time spent on weekday hw by parents/cram school (b07b)	(1,6)	1.761	9642	0.013	0.025*	0.005
time spent on cram school weekday courses (b07c)	(1,6)	1.603	9617	0.056***	0.048***	0.048***
time spent on interest-related weekday courses (b07d)	(1,6)	1.377	9626	0.044***	0.057***	0.043***
time spent on watching TV weekdays (b07e)	(1,6)	2.467	9648	0.088***	0.087***	0.083***
time spent on internet/video games weekdays(b07f)	(1,6)	2.242	9635	0.105***	0.104***	0.100***
time spent on weekend hw by teachers (b08a)	(1,6)	3.005	9646	-0.105***	-0.107***	-0.113***
time spent on weekend hw by parents/cram school (b08b)	(1,6)	1.603	9630	-0.014	-0.002	-0.025
time spent on cram school weekend courses (b08c)	(1,6)	1.686	9613	-0.009	-0.022*	-0.025*
time spent on interest-related weekend courses (b08d)	(1,6)	1.375	9625	-0.001	0.027*	-0.006
time spent on watching TV weekends (b08e)	(1,6)	2.764	9635	0.048***	0.037***	0.050***
time spent on internet/video games weekends (b08f)	(1,6)	2.613	9613	0.085***	0.061***	0.080***
freq of visiting museums/zoos alone/with classmate (b09)	(1,6)	2.121	9641	-0.017	0.017	-0.011
freq of watching movies/sports alone/with classmate (b10)	(1,6)	2.431	9652	-0.016	0.019*	-0.014
no extra courses (b1100)	(0,1)	0.498	9649	0.104***	0.071**	0.121***
extra courses on Mathematical Olympiad (b1101)	(0,1)	0.030	9649	-0.224***	-0.345***	-0.231***
extra courses on ordinary mathematics (b1102)	(0,1)	0.240	9649	-0.070**	-0.020	-0.070**

extra courses on Chinese/composition (b1103)	(0,1)	0.107	9649	-0.119***	-0.193***	-0.100**
extra courses on English (b1104)	(0,1)	0.228	9649	-0.136***	-0.198***	-0.185***
extra courses on painting or drawing (b1105)	(0,1)	0.064	9649	-0.066	0.085*	-0.010
extra courses on calligraphy (b1106)	(0,1)	0.036	9649	-0.174**	-0.071	-0.107
extra courses on music or musical instrument (b1107)	(0,1)	0.111	9649	-0.197***	-0.069*	-0.202***
extra courses on dancing (b1108)	(0,1)	0.035	9649	-0.142*	0.082	-0.107
extra courses on chess (b1109)	(0,1)	0.017	9649	0.223**	0.059	0.106
extra sports courses (b1110)	(0,1)	0.075	9649	0.234***	0.145***	0.182***
extra courses on others (b1111)	(0,1)	0.051	9649	-0.105*	-0.110*	-0.156**
no enjoyed hobbies (b1200)	(0,1)	0.134	9638	0.307***	0.099**	0.270***
playing musical instruments (b1201)	(0,1)	0.187	9638	-0.321***	-0.162***	-0.306***
enjoying vocal practices/dancing/acting(b1202)	(0,1)	0.338	9638	-0.156***	0.062**	-0.156***
enjoying calligraphy (b1203)	(0,1)	0.114	9638	-0.437***	-0.253***	-0.369***
painting or drawing/animation (b1204)	(0,1)	0.354	9638	-0.180***	-0.075***	-0.112***
playing chess (b1205)	(0,1)	0.179	9638	-0.131***	-0.308***	-0.104***
enjoying sports (b1206)	(0,1)	0.355	9638	0.088***	-0.025	0.054*
other hobbies (b1207)	(0,1)	0.072	9638	-0.165***	-0.100*	-0.104*
no other hobbies (b1300)	(0,1)	0.048	9622	0.314***	0.149**	0.293***
reading books (b1301)	(0,1)	0.529	9622	-0.477***	-0.332***	-0.419***
doing handcrafts (b1302)	(0,1)	0.205	9622	-0.207***	-0.103***	-0.165***
playing mobile phones (b1303)	(0,1)	0.583	9622	0.086***	0.142***	0.087***
playing video games (b1304)	(0,1)	0.335	9622	0.329***	0.058*	0.263***
other types of hobbies (b1305)	(0,1)	0.102	9622	-0.091**	-0.002	-0.084*
going to cram school in the vacations (b1401)	(0,1)	0.298	9597	-0.131***	-0.106***	-0.153***
attending summer/winter camps (b1402)	(0,1)	0.094	9597	-0.033	-0.002	-0.053
helping housework in the vacations (b1403)	(0,1)	0.460	9597	-0.102***	-0.055*	-0.098***
going back to hometown in the vacations (b1404)	(0,1)	0.211	9597	0.035	-0.059*	0.034
staying home during summer/winter vacations (b1405)	(0,1)	0.628	9597	-0.197***	-0.120***	-0.175***
other activities in summer/winter vacations (b1406)	(0,1)	0.150	9597	-0.174***	-0.103***	-0.178***
boarding at school from Monday to Thursday (b15)	(0,1)	0.696	9483	-0.011	0.071	0.052
transportation to school from home (b16)	(0,1)	0.639	9623	-0.007	0.001	-0.007
commuting time from home to school (b17)	(0,999)	24.413	9331	0.002***	0.0004	0.001***
highest self-educational expectation (b18)	(0,1)	0.639	9595	-0.771***	-0.705***	-0.814***
self-expectation for future job (b19)	(0,1)	0.491	9645	-0.322***	-0.405***	-0.383***
self-expectation for job location (b20)	(0,1)	0.541	9592	-0.230***	-0.127***	-0.274***
self-confidence about your future (b21)	(1,4)	3.111	9537	-0.174***	-0.196***	-0.223***

Notes: Symbols '***', '**' and '*' represent significant at levels of 0.1%, 1% and 5%, respectively

In Table 1, the personal and family module includes 58 variables, defined as follows: a01 (0=local, 1=not local county/district); a02 (0=agricultural, 1=non-agricultural or residential Hukou, with 23 students without hukou registration treated as missing); a03 (0=local, 1=not local county/district); a04 (1=don't understand to

5=can speak fluently); a05 (0=no,1=yes); a0601 – a0604 (0 if a05=1); a0701 – a0708 (0=no, 1=yes); a0801 – a0804 (0=no,1=yes); a09 (1=very poor to 5=very rich); a10 (0=no, 1=yes); a11 (1=very few to 5=a great number); a12 (0=no, 1=yes); a13 – a14 (0=government administrator, administrator of public institutions and corporations, scientist, engineer, university professor or other professionals, doctor, lawyer, high/primary school teacher, accountant, nurse, computer programmer or other technical staff, and ordinary staff or worker; 1=ordinary staff or worker in business or service field, technical worker, ordinary worker, farmer, herdsman, fisherman, elementary worker, self-employed worker, unemployed or laid-off worker, and others); a15 – a17 (0=no, 1=yes); a18 – a19 (1=never to 4=almost every day); a2001 – a2006 (1=don't care to 3=very strict); a2101a – a2104b (1=never to 3=often); a22 – a23 (1=not close to 3=very close); a24 – a26 (1=never to 6=more than once a week); a27 (1=no special requirement to 4=one of the top five in the class); a28 (0=don't care, drop out now, junior, technical school, vocational, and senior high school; 1=junior college and above); a29 (1=not at all to 5=very much); a30 (0=others; 1=government official, staff of public institutions, civil servant, manager or administrator of enterprises, corporations, scientist, engineer, doctor, programmer, pilot, spaceman, teacher, lawyer, accountant, and translator); a31 (0=others; 1=Beijing, Shanghai, Guangzhou, and abroad); a32 (1=not at all to 4=Very confident). *gender* (0=female, 1=male) is assigned from fitness test responses: pull-ups ($c14a \geq 0$) for males and sit-ups ($c14b \geq 0$) for females. Students reporting only pull-ups ($c14a > 0$, $c14b = 0$) are classified as males; only sit-ups ($c14a = 0$, $c14b > 0$) as females; others as missing.

The academic development module includes 76 variables, defined as follows: b01 (integer); b02 – b04 (1=not difficult to 4=very difficult); b0501 – b0509 (1=strongly disagree to 4=strongly agree); b0601 – b0610 (1=strongly disagree to 4=strongly agree); b07a – b07f (1=0 hour to 6=more than 4 hours); b08a – b08f (1=0 hour to 6=more than 8 hours); b09 – b10 (1=never to 6=more than once a week); b1100 – b1111 (0=no, 1=yes); b1200 – b1207 (0=no, 1=yes); b1300 – b1305 (0=no, 1=yes); b1401 – b1406 (0=no, 1=yes); b15 (0=yes, 1=no); b16 (0=on foot, 1=others);

b17 (minutes); b18, b19, and b20 (the same response options with a28, a30, and a31, respectively); b21 (1=not at all to 4=very confident).

Note that since valid observations vary across different variables, the sample sizes of the fitted models built using these variables also differ.

3.2 Box-plots of the scores for the three subjects

Distributions of the scores within each school are mostly left-skewed, as shown in the box-plots in Figures 1(a)–(c) for Chinese, mathematics and English respectively.

The figures also show the different full scores of the 112 schools.

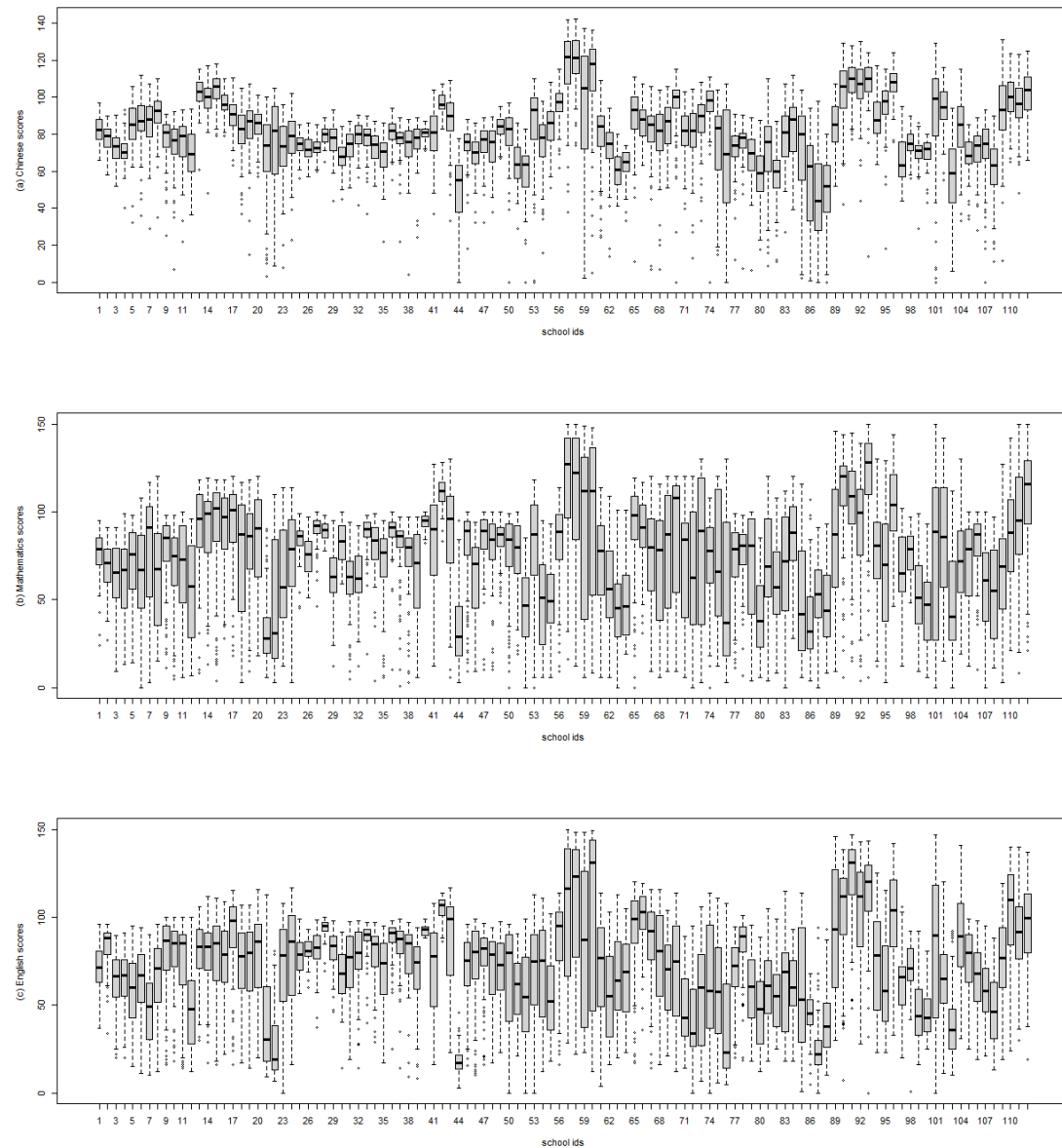


Figure 1. Box-plots of the scores for the three subjects

4. Impact of the modules individually on the scores of the subjects

4.1 Impact of the personal and family module on the scores

For each predictor in the personal and family module, the estimates and significances of the coefficients in the simple stratified Cox regression models are presented in the 5th – 7th columns in Table 1. The results show no obvious violations of prior knowledge regarding protective or risk factors.

For Chinese, using the BRPN procedure, variables a09, a2001, a25, a17, a16, a05, a0602, a26, a0801, a2005, a2104a, a24, a2102a, a2103a, a2103b, a01, a0604, a23, a12, a0704, a10, a0804, a0708, a2006 and a0707 were removed due to opposite effects, and a2004, a0803, a2102b, a31, a0701, a2104b, a2003, a14, a22, a02, a15, a0706, a0705, a0703 and a0702 were removed due to insignificant effects. Using the FBRPN procedure, variables a2001, a16, a25, a0801, a2005, a2103b, a26, a23, a0602, a24, a2103a, a2104a, a2102a, a2006, a2003, a2004, a0704, a12, a10 and a0708 were removed due to opposite effects, and a0803, a2104b, a31, a2102b, a0701, a14, a0802, a15, a22, a02, a0705, a0703 and a0706 were removed due to insignificant effects. The estimates with significances in the two models are shown in Table 2.

The BRPN model reduced the deviance (2loglik) by 2498 using 18 parameters, while the FBRPN model reduced the deviance by 2460 using 16 parameters. Based on the predictors common to the BRPN and FBRPN models and using the forward procedure, we obtained the most efficient model (model A), which yielded a reduced deviance of 2511 using 16 parameters. Similarly, for the subjects of mathematics and English, we obtained the BRPN and FBRPN models, and then the most efficient models B and C, respectively, as presented in Table 2. The absolute Z-values of the estimates in these most efficient models are reported to reflect the importance of the RVs.

By comparing the three most efficient models, we found five common risk factors: a04, a18, a19, a2002, and a29; and six common protective factors: a2101a, a2101b, a27, a28, a30, and a32. In descending order of importance, the top ten most important RVs are a27, *gender*, a28, a32, a29, a30, a2002, a18, a19, and a11 for

Chinese; and a27, a28, a32, a2002, a29, a18, a30, a04, a19, and a0702 for mathematics; and a27, *gender*, a28, a32, a29, a2002, a30, a18, a11, and a2101a for English. Among them, the common protective factors are a27 (parents' highest academic requirement), a28 (parents' educational expectation), a32 (parents' confidence in the student's future), and a30 (parents' expectation for your future job); the common risk factors are a29 (pressure from parents' educational expectation), a2002 (parents' strictness in school behaviors), and a18 (parents checking homework). The variable *gender* is not a RV for mathematics, but is the second most important RV for Chinese and English.

Note that in the most efficient models A, B and C in Table 2, the risk factor a2002 is the only RV that is insignificant in the 5th–7th columns in Table 1. Based on each of the most efficient models, we calculated the relative changes of the effects with and without a2002 (e.g., $R=100 \times (\text{optimal} - (\text{optimal} - \text{a2002})) / \text{optimal}$), and found that all $|R| < 5\%$ except for a18 (–14.6%), a19 (–8.9%), a2101a (12.5%), a2101b (19.8%), and a29 (–7.4%) for Chinese; a04 (–7.1%), a0702 (–5.5%), a0706 (–5.9%), a0803 (5.4%), a18 (–13.5%), a19 (–13.2%), a2006 (48.9%), a2101a (21.3%), a2101b (29.0%), a29 (–6.5%), and a30 (6.0%) for mathematics; a04 (–12.5%), a0706 (–10.2%), a0803 (6.1%), a11 (6.1%), a18 (–17.6%), a19 (–13.9%), a2101a (17.5%), a2101b (33.6%), and a29 (–6.6%) for English. From these results, we can draw conclusions similar to those in Section 5.

Table 2 Estimates with significance (or $|Z|$ -values) in the stratified Cox regression (A)

Module A: personal and family Variable	Chinese			Mathematics			English		
	BRPN	FBRPN	model A	BRPN	FBRPN	Model B	BRPN	FBRPN	Model C
not local Hukou registration (a01)							.084*		
home not local location (a03)	.229***	.212**	.217(3.2)						
local dialect ability (a04)	.050***	.051***	.051(4.4)	.052***	.053***	.049(4.4)	.036**	.032**	.029(2.5)
the only child in your family (a05)				–.120**			–.063*		
number of older brother(s) (a0601)	.066*								
number of older sister(s) (a0603)	.062*	.056*	.059(2.4)						
living with bio-mother (a0702)		–.086*		–.132**	–.153***	–.148(3.6)			
co-resident with full or half sibling(s) (a0705)				–.088*					
co-resident with grandparents (a0706)				–.052*	–.066**	–.064(2.5)	–.065*	–.085***	–.076(3.0)
divorced parents (a0802)	.122**			.127**	.125*	.124(2.5)	.141**	.121*	.124(2.6)

deceased father (a0803)						.232(2.3)	.309**	.309**	.334(3.2)
amount of books your family own (a11)	-.059***	-.060***	-.062(5.0)				-.060***	-.051***	-.059(4.7)
father's less favorable job (a13)	.066*	.072*	.067(2.2)					.078*	
mother's less favorable job (a14)							.100**	.075*	.104(3.3)
parents checking homework (a18)	.073***	.088***	.075(5.4)	.085***	.094***	.086(6.4)	.087***	.097***	.082(6.0)
parental tutoring (a19)	.080***	.085***	.078(5.2)	.060***	.063***	.056(3.8)	.051***	.064***	.054(3.6)
parents strictness in behaviors at sch (a2002)	.150***		.150(6.9)	.178***		.174(8.1)	.187***		.185(8.5)
parents strictness in watching TV dur (a2006)				-.052**		-.053(2.9)			
discussing things at school with fa (a2101a)	-.097***	-.084***	-.097(4.6)	-.072***	-.056**	-.070(3.5)	-.093***	-.075***	-.094(4.5)
discussing things at school with mo (a2101b)	-.086***	-.070**	-.092(4.3)	-.058**	-.048*	-.063(3.1)	-.058**	-.046*	-.066(3.1)
parents' highest academic requirement (a27)	-.357***	-.346***	-.357(26.0)	-.360***	-.350***	-.358(27.2)	-.406***	-.387***	-.400(29.6)
parents' highest educational expectation (a28)	-.388***	-.383***	-.388(13.7)	-.379***	-.374***	-.378(13.9)	-.401***	-.388***	-.395(14.1)
pressure from parents' edu expectation (a29)	.081***	.089***	.081(7.2)	.085***	.091***	.086(8.0)	.100***	.108***	.102(9.2)
parents' expectation for your future job (a30)	-.179***	-.170***	-.178(7.1)	-.119***	-.114***	-.120(5.0)	-.205***	-.200***	-.207(8.4)
parents' confidence in the student's future (a32)	-.193***	-.184***	-.193(10.0)	-.228***	-.214***	-.225(12.3)	-.255***	-.247***	-.259(13.5)
male gender (<i>gender</i>)	.510***	.516***	.507(21.0)				.456***	.448***	.437(18.3)
concordance, sample size (n)	.708,8099	.708,8114	.708,8153	.684,8624	.683,8739	.684,8725	.714,8090	.713,8281	.714,8298
deviance(=2loglik) (df)	2498(18)	2460(16)	2511(16)	1989(17)	1928(13)	1994(16)	2788(19)	2774(17)	2840(17)

Notes: Symbols '***', '**' and '*' represent significant at levels of 0.1%, 1% and 5%, respectively

4.2 Impact of the academic development module on the scores

For each predictor in the academic development module, the estimates and significances of the coefficients in the simple stratified Cox regression models are presented in the 5th–7th columns in Table 1. The results show no obvious violations of prior knowledge regarding protective or risk factors.

Using the BRPN and FBRPN procedures, we obtained the BRPN and FBRPN models and the most efficient models for each of the three subjects, as shown in Table 3. For Chinese and mathematics, the most efficient models coincide with the BRPN models.

By comparing the three most efficient models, we found seven common risk factors: b02, b04, b0602, b07b, b07d, b07f, and b1110; and twelve common protective factors: b0506, b07a, b08a, b1101, b1201, b1203, b1207, b1301, b1405, b1406, b18, and b19. In descending order of importance, the top ten most important RVs are b18, b04, b0602, b03, b1405, b02, b1301, b1304, b19, and b1203 for Chinese; and b02, b18, b0602, b19, b1405, b07a, b04, b1301, b1205, and b1404 for mathematics; and

b04, b18, b0602, b02, b19, b1405, b0506, b1301, b1203, and b07a for English. Among them, the common protective factors are b18 (highest self-educational expectation), b1405 (staying home during summer/winter vacations), b1301 (reading books), and b19 (self-expectation for future job); and the common risk factors include b02 (finding mathematics difficult), b04 (finding English difficult), and b0602 (teacher criticism reported to parents). Risk factor b03 (finding Chinese difficult) is the fourth most important predictor for Chinese, but is not a RV for mathematics and English.

Note that in Table 3, for Chinese and English, b07b (time spent on weekday homework by parents/cram school) is the only RV that is insignificant in the 5th and 7th columns in Table 1. We calculated $R_d = 100 \times (BRPN - (BRPN - b07b)) / BRPN$ for Chinese, and $R_f = 100 \times (\text{Model F} - (\text{Model F} - b07b)) / (\text{Model F})$ for English, and found that all $|R_d| < 5\%$ except for b07a (7.4%), b07d (-26.4%), b08a (5.7%), and b1101 (5.6%) for Chinese, and all $|R_f| < 5\%$ except for b0603 (7.2%), b07a (8.5%), b07d (-16.6%), b08a (5.1%), and b1101 (6.0%) for English. The results show that the inclusion of b07b weakens the impact of risk factor b07d (time spent on interest-related weekday courses) on scores, and strengthens the impact of protective factors b07a (time spent on weekday homework by teachers), b08a (time spent on weekend homework by teachers), b1101 (extra courses on Mathematical Olympiad), and b0603 (being praised by homeroom teacher).

For mathematics, b09 (frequency of visiting museums/zoos alone/with classmate) is the only RV that is insignificant in the 6th column in Table 1. We calculated the relative change $R_e = 100 \times (BRPN - (BRPN - b09)) / BRPN$, and find that all $|R_e| < 5\%$ except for b0506 (5.0%), b07b (-6.3%), b07d (-5.9%), b07f (-9.3%), b1202 (-5.0%), and b1303 (-7.1%). The results show that the inclusion of b09 strengthens the impact of protective factor b0506 (being asked questions by English teacher) on scores, and weakens the impact of risk factors b07b (time spent on weekday homework by parents/cram school), b07d (time spent on interest-related weekday courses), b07f (time spent on internet/video games weekdays), b1202 (enjoying vocal

practices/dancing/acting), and b1303 (playing mobile phones).

Overall, time spent on weekday homework by parents/cram school (b07b) and frequency of visiting museums/zoos alone/with classmate (b09) impede better scores in the subjects, and they become significant risk factors after adjusting for other RVs.

Table 3 Estimates with significances (or $|Z|$ -values) in the stratified Cox regression models (B)

Module B: academic development	Chinese		Mathematics		English		
Variables	BRPN	FBRPN	BRPN	BRPN	BRPN	FBRPN	Model F
amount of students in your 6th grade class (b01)	-.004(3.6)	-.004***				-.003*	
finding mathematics difficult (b02)	.131(8.9)	.130***	.578(38.3)	.575***	.144***	.141***	.141(9.8)
finding Chinese difficult (b03)	.157(9.5)	.157***					
finding English difficult (b04)	.211(14.6)	.213***	.066(4.8)	.066***	.561***	.562***	.556(38.0)
being asked questions by English teacher (b0506)	-.046(3.3)	-.046**	-.045(3.4)	-.044***	-.083***	-.085***	-.088(6.4)
being praised by Chinese teacher (b0508)	-.040(2.9)	-.038**					
teacher criticism reported to parents (b0602)	.147(11.2)	.147***	.122(9.5)	.121***	.132***	.133***	.133(10.3)
being praised by homeroom teacher(b0603)					-.032*	-.035*	-.030(2.1)
time spent on weekday homework by teachers (b07a)	-.076(6.1)	-.073***	-.059(4.8)	-.060***	-.060***	-.064***	-.065(5.3)
time spent on weekday hw by parents/cram sch (b07b)	.034(2.9)		.043(3.7)	.045***	.028*		.031(2.7)
time spent on cram school weekday courses (b07c)		.021*					
time spent on interest-related weekday courses (b07d)	.031(2.4)	.030*	.041(3.2)	.041**	.045***	.056***	.049(3.8)
time spent on watching TV weekdays (b07e)	.026(2.9)	.026**	.029(3.2)	.030**		.021*	
time spent on internet/video games weekdays (b07f)	.029(3.1)	.029**	.031(3.4)	.032***	.046***	.037***	.043(5.2)
time spent on weekend homework by teachers (b08a)	-.038(2.8)	-.036**	-.061(4.5)	-.060***	-.055***	-.048***	-.049(3.6)
freq of visiting museums/zoos alone/w classmate (b09)			.037(3.7)				
freq of watching movies/sports alone/w classmate(b10)				.021*			
extra courses on Mathematical Olympiad (b1101)	-.276(4.1)	-.259***	-.222(3.4)	-.227***	-.217***	-.184**	-.222(3.4)
extra courses on English (b1104)			-.105(3.6)	-.108***			
extra courses on chess (b1109)	.280(3.2)	.286**					
extra sports courses (b1110)	.164(3.6)	.174***	.167(3.9)	.163***	.230***	.214***	.228(5.3)
playing musical instruments (b1201)	-.151(5.1)	-.154***	-.073(2.5)	-.073*	-.120***	-.112***	-.119(4.1)
enjoying vocal practices/dancing/acting (b1202)			.061(2.5)	.064**			
enjoying calligraphy (b1203)	-.225(6.3)	-.223***	-.093(2.7)	-.092**	-.190***	-.179***	-.189(5.4)
painting or drawing/animation (b1204)	-.066(2.8)	-.064**					
playing chess (b1205)	-.094(3.0)	-.095**	-.134(4.6)	-.132***			
enjoying sports (b1206)	.073(2.9)	.072**					
other hobbies (b1207)	-.144(3.3)	-.141**	-.106(2.5)	-.104*	-.120**	-.122**	-.126(2.9)
reading books (b1301)	-.206(8.7)	-.205***	-.110(4.7)	-.110***	-.130***	-.127***	-.132(5.7)
playing mobile phones (b1303)			.064(2.8)	.063**			
playing video games (b1304)	.207(8.3)	.202***			.111***	.101***	.108(4.4)
going back to hometown in the vacations (b1404)			-.129(4.5)	-.131***			
staying home during summer/winter vacations (b1405)	-.211(8.9)	-.211***	-.170(7.1)	-.173***	-.187***	-.186***	-.185(7.9)
other activities in summer/winter vacations (b1406)	-.118(3.6)	-.116***	-.093(2.9)	-.099**	-.145***	-.135***	-.137(4.3)

boarding at school from Monday to Thursday (b15)					.096*		
highest self-educational expectation (b18)	-.473(17.6)	-.471***	-.437(16.7)	-.438***	-.443***	-.451***	-.443(16.7)
self-expectation for future job (b19)	-.165(7.0)	-.164***	-.210(9.2)	-.207***	-.206***	-.194***	-.203(8.8)
self-expectation for job location (b20)	-.050(2.1)	-.049*			-.051*	-.051*	-.054(2.3)
concordance, sample size (n)	.700,8918	.699,8900	.717,9222	.717,9232	.731,9031	.731,8942	.730,9176
2loglik (df)	2773(29)	2761(29)	3394(26)	3390(26)	3959(23)	3920(23)	3995(22)

Notes: Symbols '***', '**' and '*' represent significant at levels of 0.1%, 1% and 5%, respectively

5. Impact of the modules collectively on the scores of the subjects

Using the BRPN procedure, we put all 134 variables in the two modules in the first step, and the obtained BRPN model is presented in Table 4. Using the FBRPN procedure, we put the variables in the FBRPN columns in Tables 2 – 3 in the first step, and the obtained FBRPN model is presented in Table 4. Based on the common predictors to the BRPN and FBRPN models, we identified the most efficient models I and J using the forward procedure for Chinese and mathematics, respectively; and the most efficient model K using the stepwise procedure for English. Specifically, for English, we first added a2002 and found that the effect of a29 changed from a significant 0.025 ($Z=2.2$) to an insignificant 0.019 ($Z=1.7$). After removing a29, we found a07f the most efficient to add; after adding a07f, we found b1205 the most efficient to add. The estimates with Z-values of the most efficient models I, J, and K are shown in Table 4.

By comparing the three most efficient models, we found eight common risk factors: a04, a18, a19, a2002, b02, b0602, b07d, and b1110; and thirteen common protective factors: a27, a28, a32, b07a, b08a, b1101, b1205, b1207, b1301, b1405, b1406, b18, and b19. In descending order of importance, the top fifteen most important RVs are a27, *gender*, b04, b03, b18, b0602, b02, a2002, b1301, a18, b1405, a19, a28, b07a, and a32 for Chinese; b02, a27, b18, a2002, b0602, a32, b19, a18, b1405, a2101b, a28, b07e, b1205, b07a, and a0702 for mathematics; b04, a27, *gender*, a2002, b02, b18, b0506, a32, a18, b0602, b19, b1405, b07a, a28, and a19 for English. Among them, the common risk factors are finding mathematics difficult (b02), teacher criticism reported to parents (b0602), parents' strictness in school behaviors

(a2002) and parents checking homework (a18), and the common protective factors are parents' highest academic requirement (a27), parents' highest educational expectation (a28), time spent on weekday homework by teachers (b07a), highest self-educational expectation (b18), parents' confidence in the student's future (a32), and staying home during summer/winter vacations (b1405). Risk factor b04 (finding English difficult) is the most important for English and the third most important for Chinese, but is not a RV for mathematics. Risk factor b03 (finding Chinese difficult) is the fourth most important for Chinese, but is not a RV for mathematics or English. Still, *gender* is not a RV for mathematics, but is the second most important for Chinese and the third most important for English.

Note that in each of the most efficient models I, J and K in Table 4, risk factor a2002 (parents' strictness in school behaviors) is the only RV that is insignificant in the 5th, 6th, and 7th columns in Table 1. Based on each of the most efficient models, we calculated the relative changes of the coefficients with and without a2002.

For Chinese, we calculated $R_I = 100 \times (\text{Model I} - (\text{Model I} - a2002)) / (\text{Model I})$, and found that all $|R_I| < 5\%$ except for a0802 (5.7%), a18 (-13.9%), a19 (-7.0%), a2101a (23.4%), a29 (-22.9%), a32 (9.4%), b0505 (6.0%), b0508 (8.7%), b0602 (-6.9%), b07f (10.9%), b08a (9.2%) and b1405 (-8.0%). The results show that the inclusion of a2002 weakens the impact of the risk factors a18 (parents checking homework), a19 (parental tutoring last week), a29 (pressure from parents' educational expectation) and b0602 (teacher criticism reported to parents) on scores, and strengthens the impact of the risk factors a0802 (divorced parents) and b07f (time spent on internet/video games weekdays); the inclusion also weakens the impact of the protective factor b1405 (staying home during summer/winter vacations), and strengthens the impact of the protective factors a2101a (discussing things at school with father), a32 (parents' confidence in the student's future), b0505 (being asked questions by Chinese teacher), b0508 (being praised by Chinese teacher) and b08a (time spent on weekend homework by teachers).

For mathematics, we calculated $R_J = 100 \times (\text{Model J} - (\text{Model J} - a2002)) / (\text{Model J})$,

and found that all $|R_j| < 5\%$ except for a04 (−5.7%), a18 (−14.0%), a19 (−8.8%), a2101b (24.5%), a32 (6.8%), b0506 (9.5%), b0602 (−10.4%), b07b (−11.1%), b07e (9.4%), b1103 (−7.1%), b1104 (6.6%), b1202 (−5.1%), b1405 (−7.6%) and b1406 (−7.1%). The results show that the inclusion of a2002 weakens the impact of risk factors a04 (local dialect ability), a18, a19, b0602, b07b (time spent on weekday homework by parents/cram school) and b1202 (enjoying vocal practices/dancing/acting) on scores, and strengthens the impact of risk factor b07e (time spent on watching TV weekdays); the inclusion also weakens the impact of protective factors b1103 (extra courses on Chinese/composition), b1405, and b1406 (other activities in summer/winter vacations), and strengthens the impact of protective factors a2101b, a32, b0506 (being asked questions by English teacher) and b1104 (extra courses on English).

For English, we calculated $R_K = 100 \times (\text{Model K} - (\text{Model K} - a2002)) / (\text{Model K})$, and found that all $|R_K| < 5\%$ except for a04 (−7.9%), a0706 (−11.8%), a0802 (6.2%), a18 (−16.5%), a19 (−11.8%), a28 (6.8%), a32 (10.1%), b0506 (5.0%), b0602 (−10.2%), b07f (10.6%), b08a (8.2%), b1101 (5.1%), b1205 (−6.1%), b1207 (9.8%), b1301 (7.6%), b1405 (−10.1%), and b1406 (−9.1%). The results show that the inclusion of a2002 weakens the impact of risk factors a04, a18, a19, and b0602 on scores; and strengthens the impact of risk factors a0802 (divorced parents) and b07f. The inclusion also weakens the impact of protective factors a0706 (co-resident with grandparents), b1205 (playing chess), b1405, and b1406; and strengthens the impact of protective factors a28 (parents' highest educational expectation), a32, b0506, b08a, b1101 (extra courses on Mathematical Olympiad), b1207 (other hobbies), and b1301 (reading books).

Overall, among the RVs of the three subjects, though the common risk factors such as parents checking homework (a18), parental tutoring (a19), and parents' strictness in school behaviors (a2002) seem protective, they are actually risk factors. This is because they often represent passive interventions in response to low scores or misconduct by troubled teenagers. Also, local dialect ability (a04) appears protective,

but actually is an indication of lacking access to college education and having missed the opportunities to leave the countryside and to work in a Mandarin-dominated environment for the parents' generation.

Table 4. Estimates with significances (or $|Z|$ -values) in the stratified Cox regression models (A+B)

Two modules (A+B) Variables	Chinese			Mathematics			English		
	BRPN	FBRPN	model I	BRPN	FBRPN	model J	BRPN	FBRPN	model K
male gender (<i>gender</i>)	.372***	.388***	.378(13.1)	.163***			.289***	.284***	.303(11.3)
home not local location (a03)	.259***	.250***	.272(3.9)						
local dialect ability (a04)	.052***	.050***	.049(4.1)	.049***	.046***	.044(3.9)	.044***	.045***	.040(3.4)
number of younger brother(s) (a0602)				.079**					
number of older sister(s) (a0603)	.058*	.061*	.060(2.5)						
number of younger sister(s) (a0604)							.104**		
co-resident with bio-mother (a0702)				-.172***	-.166***	-.160(4.2)			
co-resident with grandparents (a0706)							-.062*	-.076**	-.067(2.6)
divorced parents (a0802)			.145(3.1)				.123*	.128**	.135(3.0)
deceased father (a0803)						.253(2.8)	.328**	.303**	.320(3.4)
father's less favorable job (a13)							.077*	.074*	.079(2.6)
parents checking homework (a18)	.077***	.085***	.078(5.6)	.080***	.093***	.083(6.1)	.086***	.095***	.083(6.0)
parental tutoring (a19)	.070***	.077***	.074(4.8)	.052***	.064***	.060(4.0)	.065***	.066***	.059(3.9)
parents' strictness in school behaviors (a2002)	.143***		.142(6.4)	.161***		.155(7.2)	.169***		.156(7.3)
discussing things at school with father (a2101a)	-.068**	-.069***	-.080(4.0)						
discussing things at school with mother (a2101b)	-.063**			-.092***	-.069***	-.094(4.8)	-.050*		
parents' highest academic requirement (a27)	-.281***	-.264***	-.277(19.0)	-.295***	-.276***	-.288(20.8)	-.334***	-.314***	-.323(22.9)
parents' highest educational expectation (a28)	-.144***	-.159***	-.162(4.6)	-.144***	-.140***	-.160(4.8)	-.160***	-.155***	-.157(4.6)
pressure from parents' edu expectation (a29)	.026*	.029*	.023(2.0)				.024*	.025*	
parents' expectation for your future job (a30)	-.117***	-.121***	-.125(4.4)				-.085**	-.082**	-.084(3.0)
parents' confidence in the student's future (a32)	-.096***	-.085***	-.089(4.5)	-.126***	-.103***	-.118(6.3)	-.113***	-.110***	-.124(6.4)
amount of students in your 6th grade class (b01)	-.005***	-.005***	-.005(3.7)				-.004**	-.004**	-.004(2.9)
finding mathematics difficult (b02)	.106***	.115***	.110(6.8)	.567***	.542***	.548(35.1)	.095***	.112***	.112(7.1)
finding Chinese difficult (b03)	.140***	.147***	.158(9.0)						
finding English difficult (b04)	.155***	.153***	.156(10.0)		.029*		.551***	.535***	.540(33.9)
being asked questions by Chinese teacher (b0505)	-.055**		-.057(3.4)						
being asked questions by English teacher (b0506)				-.047**	-.044**	-.052(3.8)	-.084***	-.088***	-.094(6.7)
being praised by Chinese teacher (b0508)	-.038*	-.056***	-.033(2.1)						
teacher criticism reported to parents (b0602)	.107***	.104***	.099(7.1)	.080***	.106***	.096(7.1)	.080***	.085***	.077(5.5)
being praised by homeroom teacher (b0603)							-.033*		
time spent on weekday hw by teachers (b07a)	-.056***	-.059***	-.058(4.5)	-.048***	-.053***	-.054(4.3)	-.057***	-.064***	-.062(4.9)
time on weekday hw by parents/cram sch (b07b)	.028*			.050***	.041***	.043(3.5)			
time on interest-related weekday courses (b07d)	.031*	.033*	.033(2.4)	.036**	.037**	.033(2.4)	.052***	.053***	.049(3.7)
time on internet/video games weekdays (b07f)	.026**	.030***	.031(3.4)					.027**	.029(3.3)
time spent on watching TV weekdays (b07e)				.032***	.033***	.039(4.7)	.023*		

time spent on weekend hw by teachers (b08a)	-.048**	-.036*	-.040(2.7)	-.062***	-.052***	-.052(3.7)	-.060***	-.044**	-.046(3.2)
freq of visiting mus/zoos alone/w classm (b09)				.041***					
freq of watching mov/sports alone/w classm (b10)					.024**	.023(2.6)			
extra courses on Mathematical Olympiad (b1101)	-.276***	-.267***	-.256(3.7)	-.206**	-.180**	-.151(2.2)	-.195**	-.194**	-.199(2.9)
extra courses on Chinese/composition (b1103)						-.085(2.1)			
extra courses on English (b1104)				-.116***	-.106***	-.095(3.0)			
extra courses on painting or drawing (b1105)				.151**		.129(2.7)			
extra courses on chess (b1109)	.322***	.294**	.306(3.3)						
extra sports courses (b1110)	.164***	.174***	.194(4.1)		.121**	.137(3.1)	.155**	.157***	.154(3.3)
playing musical instruments (b1201)	-.095**	-.110***	-.109(3.4)					-.062*	
enjoying vocal practices/dancing/acting (b1202)				.078**	.067**	.063(2.6)			
enjoying calligraphy (b1203)	-.163***	-.159***	-.157(4.1)				-.144***	-.136***	-.137(3.7)
playing chess (b1205)	-.155***	-.151***	-.145(4.4)	-.155***	-.136***	-.132(4.4)	-.067*		-.069(2.2)
other hobbies (b1207)	-.134**	-.133**	-.129(2.7)	-.108*	-.094*	-.094(2.1)	-.104*	-.100*	-.106(2.3)
reading books (b1301)	-.152***	-.148***	-.154(6.0)	-.051*	-.077**	-.083(3.4)	-.075**	-.072**	-.073(2.9)
playing mobile phones (b1303)				.092***	.085***	.090(3.7)			
playing video games (b1304)	.086**	.075**	.075(2.7)						
going back to hometown in the vacations (b1404)				-.112***	-.118***	-.115(3.9)			
staying home during sum/win vacations (b1405)	-.135***	-.147***	-.134(5.3)	-.133***	-.166***	-.154(6.1)	-.135***	-.141***	-.127(5.1)
other activities in summer/winter vacations(b1406)	-.084*	-.105**	-.100(2.9)	-.096**	-.121***	-.115(3.4)	-.082*	-.097**	-.094(2.7)
highest self-educational expectation (b18)	-.291***	-.273***	-.272(7.6)	-.260***	-.259***	-.258(7.6)	-.236***	-.230***	-.235(6.7)
self-expectation for future job (b19)	-.066*	-.068*	-.069(2.4)	-.168***	-.149***	-.149(6.1)	-.137***	-.143***	-.146(5.3)
concordance, sample size (n)	.732,7752	.731,8033	.732,7992	.739,8123	.736,8611	.737,8581	.76,7810	.759,8242	.759,8263
2loglik (df)	3212(39)	3278(35)	3328(38)	3647(33)	3748(31)	3807(34)	4433(36)	4594(32)	4646(32)

Notes: Symbols '***', '**' and '*' represent significant at levels of 0.1%, 1% and 5%, respectively.

6. Discussion and Conclusions

6.1 The choice of the stratified Cox proportional hazards model

Note that in the CEPS data, the exams are not unified, and the scores across the 112 schools are not comparable. Only among the questionnaires answered by students and parents can we apply the Bayesian FBRPN and BRPN procedures in the stratified Cox proportional hazards model to search for meaningful protective or risk factors. The effects of questionnaires completed by homeroom teachers, main subject teachers, or school administrators cannot be identified.

From another perspective, if the exams are unified, we can apply the FBRPN and BRPN procedures in the GLM with Gaussian distribution (or the stratified Cox proportional hazards model for heavily skewed data, by treating *schids* as strata) to

search for important and meaningful protective or risk factors from the questionnaires responses provided by students, parents, homeroom teachers, main subject teachers, and school administrators, where the variable *schids* is ignored. In fact, we usually do not treat *schids* as a categorical variable with 111 df, as it wastes too many parameters that we are not interested in. To reflect the difference between two types of schools, we can create a new binary variable (e.g., key vs. ordinary) based on the enrollment of the 112 schools, and this difference can be estimated in both types of models.

Note that most published papers based on CEPS data use standardized scores at the school level as the response variable, treating all scores across the 112 schools as comparable. This approach differs from the stratified semi-parametric proportional hazards model, where comparisons are made only within each of the 112 schools. Thus, some empirical results in the literature are slightly different from those we obtained in Tables 1–4, although our results are more reliable.

6.2 Stackability

For each of the three subjects, the RVs of modules A, B and A+B presented in Tables 2–4 are compared, and the relations among the RVs are found.

For Chinese, the RVs of A+B are (RVs of module A–a11–a13–a2101b) +(RVs of module B–b0506–b07b–b07e–b1204–b1206–b20)+a0802+b0505. To gain further insights into the relations among predictors, based on model I, we calculated the relative changes of effects with and without each of the eliminated variables. For example, $R_{I(b0506)} = 100 \times ((\text{Model I} + b0506) - \text{Model I}) / (\text{Model I} + b0506)$. We found that all $|R_{I(b0506)}| < 5\%$ except for b0508 (–8.2%) and b0505 (–9.6%), which indicate that the effect of b0506 is mainly absorbed by that of b0505 and b0508. Furthermore, among the correlations between b0506 and the RVs in model I, the largest value was 0.574 (with b0505), followed by 0.416 (with b0508). That is, b0506 (being asked questions by English teacher) is less representative than b0505 (being asked questions by Chinese teacher) and b0508 (being praised by Chinese teacher). Similarly, when b0506 is replaced with each of the following variables: a13, a2101b, b07b, b07e, b1206, b20, a11 and b1204, we find that the effect of a13 (father’s less favorable job)

is mainly absorbed by that of a29 (pressure from parents' educational expectation) and a0603 (number of older sister(s)); the effect of b07b (time spent on weekday homework by parents/cram school) is absorbed by that of b07d (time spent on interest-related weekday courses); the effect of b07e (time spent on watching TV weekdays) is absorbed by that of b07f (time spent on internet/video games weekdays); the effect of b1206 (enjoying sports) is absorbed by that of b1110 (extra sports courses); the effect of b20 (self-expectation for job location) is absorbed by that of b07d (time spent on interest-related weekday courses) and a29 (pressure from parents' educational expectation); the effect of a2101b (discussing things at school with mother) is mainly absorbed by that of b07f (time spent on internet/video games weekdays), a2101a (discussing things at school with father) and a0802 (divorced parents). Furthermore, a11 (amount of books your family own) and b1204 (painting or drawing/animation) are relatively independent of the RVs of A+B, and are eliminated due to their low importance.

For mathematics, the RVs of A+B are (RVs of module A–a0706–a0802–a2006–a2101a–a29–a30)+(RVs of module B–b04–b07f–b09–b1201–b1203)+b10+b1103+b1105. Based on the relative changes of effects of model J with and without each of the eliminated variables, we find that the effect of a0802 (divorced parents) is mainly absorbed by that of a0702 (co-resident with bio-mother); the effect of a29 (pressure from parents' educational expectation) is absorbed by that of b07b (time spent on weekday homework by parents/cram school); the effect of a30 (parents' expectation for your future job) is absorbed by that of b19 (self-expectation for future job); the effect of b04 (finding English difficult) is absorbed by that of b0506 (being asked questions by English teacher); the effect of b07f (time spent on internet/video games weekdays) is absorbed by that of b07e (time spent on watching TV weekdays); the effect of b09 (frequency of visiting museums/zoos alone/with classmate) is absorbed by that of b10 (frequency of watching movies/sports alone/with classmate); the effect of b1201 (playing musical instruments) is absorbed by that of b1202 (enjoying vocal practices/dancing/acting); the effect of a2101a (discussing things at school with father)

is absorbed by that of a0803 (deceased father), a2101b (discussing things at school with mother), and b07e (time spent on watching TV weekdays). Furthermore, a0706 (co-resident with grandparents), a2006 (parents' strictness in watching TV duration) and b1203 (enjoying calligraphy) are relatively independent of the RVs of A+B, and are eliminated due to their low importance.

For English, the RVs of A+B are (RVs of module A–a11–a14–a2101a–a2101b–a29) +(RVs of module B–b0603–b07b–b1201–b1304–b20)+a13+b01+b1205. Based on the relative changes of effects in model K with and without each of the eliminated variables, we find that the effect of a11 (amount of books your family own) is mainly absorbed by that of a13 (father's less favorable job); the effect of a14 (mother's less favorable job) is absorbed by that of a13 (father's less favorable job); the effect of b0603 (being praised by homeroom teacher) is absorbed by that of b0506 (being asked questions by English teacher); the effect of b07b (time spent on weekday homework by parents/cram school) is absorbed by that of b07d (time spent on interest-related weekday courses); the effect of b20 (self-expectation for job location) is absorbed by that of b01 (amount of students in your 6th grade class); the effect of a2101a (discussing things at school with father) is absorbed by that of b07f (time spent on internet/video games weekdays), b1110 (extra sports courses), and a04 (local dialect ability); the effect of a2101b (discussing things at school with mother) is absorbed by that of b07f (time spent on internet/video games weekdays), a0706 (co-resident with grandparents), and b1406 (other activities in summer/winter vacations). Furthermore, a29 (pressure from parents' educational expectation), b1201 (playing musical instruments) and b1304 (playing video games) are relatively independent of the RVs of A+B, and are eliminated due to their low importance.

Overall, through the analyses of relative changes, we find the connections among the RVs of modules A, B and A+B. The RVs of A+B are obviously more compact than the collection of the RVs of modules A and B. The modules are nearly stackable.

6.3 The change in significance due to unbalanced covariate structure

For Chinese, when the two modules are considered together, predictor a2002 and the

remaining RVs (including the more relevant a27) correspond to the *defendant* and *victim*, respectively, in the Simpson's paradox case discussed in Zhao (2026). The significant positive effect of a2002 (or *defendant*) in the most efficient model is intrinsic, whereas its insignificance in the simple regression model is attributed to unbalanced covariate structure. Specifically, the effect of (*defendant*=black) is -0.369 ($Z=-1.2$) in the simple regression, and 0.834 ($Z=2.4$) after adjusting for the *victim* race. Similarly, based on the sample in model I ($n=7992$), the effect of a2002 is 0.009 ($Z=0.43$) in the simple stratified regression, and changes to 0.118 ($Z=5.7$) after adjusting for a27, and to 0.142 ($Z=6.4$) after adjusting for the remaining RVs. On the other hand, the (*victim*=white) group is more prone to the death penalty than the (*victim*=black) group. However, the percentage of black defendants in the (*victim*=white) group is disproportionately low, leading to a lower death penalty rate for black defendants overall, which is the source of the unbalanced covariates structure. Whereas *defendant* and *victim* are binary variables, predictor a2002 and some of the remaining RVs (including a27) are continuous, making the unbalanced covariate structure more complex. The same pattern holds for mathematics and English.

Similarly, for module B, the significant effects of b07b (time spent on weekday homework by parents/cram school) for Chinese and English, and of b09 (frequency of visiting museums/zoos alone/with classmate) for mathematics, in the most efficient models are intrinsic. In contrast, the insignificant effects observed in the unadjusted simple stratified Cox regression models are attributed to unbalanced covariate structures.

6.4 Conclusions

As listed in Tables 2–4, for the two modules together, the concordances are 0.732, 0.737, and 0.759, and the reduced loglik (df) values are 3328(38), 3807(34), and 4646(32) in the most efficient models for Chinese, mathematics, and English, respectively, which are better than the corresponding 0.708, 0.684, and 0.714, and 2511(16), 1994(16), and 2840(17) for module A, and 0.700, 0.717, and 0.730, and

2773(29), 3394(26), and 3995(22) for module B. Therefore, we can expand the study by including modules C and D, or by including the two sets questionnaires filled by students and parents. These studies enable us to view the impact of scores from more comprehensive aspects.

Furthermore, the model building strategies are general, and can be applied in many research fields. The Bayesian variable screening procedures can be used in models with a linear component to find the most efficient model with important (significant) and meaningful protective and risk factors, no matter how complex the multicollinearity is.

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Reference:

- [1] Bourdieu, P. (1986). *Forms of Capital*, Greenwood Press.
- [2] Breslow, N. E. Analysis of survival data under the proportional hazards model. *International Statistical Review*, 1975, 43 (1): 45-58. <http://doi.org/10.2307/1402659>.
- [3] Canche, M. S. G., Liang, Y., Zhang, C. To live or not to live at school? Boarding school impact on standardized academic outcomes for left-behind, rural, and low-income students in China. *International Journal of Chinese Education*, 2025, 14 (1): 1-24. <https://doi.org/10.1177/2212585x251316334>.
- [4] Chen, Q., Pei, C., Guo, Y., Zhai, S. What drives academic peer effects in middle school classrooms in China: Peer composition or peer performance? *Heliyon*, 2023, 9 (6): e16840. <https://doi.org/10.1016/j.heliyon.2023.e16840>.
- [5] Chen, Z.-y., Liu, R. X. Comparing adolescent only children with those who have siblings on academic related outcomes and psychosocial adjustment. *Child Development Research*, 2014, 3: 578289. <https://doi.org/10.1155/2014/578289>.
- [6] Cox, D. R. Regression models and life-tables (with discussion). *Journal of the Royal Statistical Society*, 1972, 34 (2): 187-202. <https://doi.org/10.1111/j.2517-6161.1972.tb00899.x>.
- [7] Ding, P., Li, Y., Feng, S., Pojani, D. Do long school commutes undermine teenagers' wellbeing? Evidence from a nationwide survey in China. *Journal of Transport & Health*, 2023, 30: 101605. <https://doi.org/10.1016/j.jth.2023.101605>.
- [8] Du, S., Chiang, Y.-L. Selective Reciprocity: Children's Academic Achievement and Parent-Child Communication in China. *Sociological Forum*, 2026, 1-14. <https://doi.org/10.1111/socf.70071>.
- [9] Efron, B. The efficiency of Cox's likelihood function for censored data. *Journal of the American*

- Statistical Association*, 1977, 72 (359): 557-565.
<https://doi.org/10.1080/01621459.1977.10480613>.
- [10] Eisenberg, M. E., Olson, R. E., Neumark-Sztainer, D., Story, M., Bearinger, L. H. Correlations between family meals and psychosocial well-being among adolescents. *JAMA Pediatrics*, 2004, 158 (8): 792–796. <http://doi.org/10.1001/archpedi.158.8.792>.
 - [11] Feng, X., Ren, S., Shi, P. The relationship and mechanism of screen time and academic performance among adolescents: an empirical study based on CEPS. *Frontiers in Public Health*, 2025, 13: 1533327. <https://doi.org/10.3389/fpubh.2025.1533327>.
 - [12] Guan, J., Tena, J. D. Physical activity, leisure-time, cognition and academic grades: Connections and causal effects in Chinese students *Journal of Asian Economics*, 2022, 78: 101423. <https://doi.org/10.1016/j.asieco.2021.101423>.
 - [13] Guo, Y., Chen, Q., Zhai, S., Pei, C. Does private tutoring improve student learning in China? Evidence from the China Education Panel Survey. *Asia & the Pacific Policy Studies*, 2020, 7: 322-343. <https://doi.org/10.1002/app5.310>.
 - [14] He, G., Cai, C. Local Dialect Ability and School Adjustment of Migrant Children. *Contemporary Youth Research*, 2022, 2: 85-99 (In Chinese).
 - [15] Hu, S., Mu, Z. Some Time is Better Spent than Other Time: Chinese Adolescents' Time Use and Developmental Outcomes. *Child Indicators Research*, 2020, 13: 1739–1765. <https://doi.org/10.1007/s12187-020-09718-8>.
 - [16] Kalbfleisch, J. D., Prentice, R. L. (1980). *The Statistical Analysis of Failure Time Data*. New York, John Wiley & Sons Inc.
 - [17] Kang, X., Han, W. Exploring the role of ecological systems and intersectionality in shaping the academic performance of Chinese adolescents. *Children and Youth Services Review*, 2025, 172: 108266. <https://doi.org/10.1016/j.childyouth.2025.108266>.
 - [18] Larson, R. W., Verma, S. How children and adolescents spend time across the world: Work, play, and developmental opportunities. *Psychological Bulletin*, 1999, 125 (6): 701–736. <https://doi.org/10.1037/0033-2909.125.6.701>.
 - [19] Lei, W., Li, Z. The Effect of the Non-Cognitive Ability on Middle School Students Academic Achievement: An Empirical Analysis Based on CEPS. *Journal of Central China Normal University (Humanities and Social Sciences)*, 2021, 60 (6): 154-163 (In Chinese).
 - [20] Li, J., Xue, H. The Relationship among Parental Involvement, Private Tutoring and Secondary Students' Academic Achievement. *Research in Educational Development*, 2019, 39 (2): 15-22 (In Chinese). <http://doi.org/10.14121/j.cnki.1008-3855.2019.02.005>.
 - [21] Li, J., Xue, E., You, H. Parental Educational Expectations and Academic Achievement of Left-Behind Children in China: The Mediating Role of Parental Involvement. *Behavioral Sciences*, 2024, 14 (5): 371. <https://doi.org/10.3390/bs14050371>.
 - [22] Li, L., Zhang, F., Zhou, L. Family income, non-cognitive skills and academic performance. *Asia Pacific Education Review*, 2023, 27: 1–15. <https://doi.org/10.1007/s12564-023-09872-y>.
 - [23] Li, M. Influences Factors on Academic Performances of Middle School Students and Its Gender Effects. *Journal of Schooling Studies*, 2018, 15 (1): 99-108 (In Chinese).
 - [24] Li, Y., Pan, X., He, X. Junior high school students' positive psychology, educational expectations and academic achievement: An empirical study based on CEPS data. *Modern Primary and Secondary Education*, 2024, 40 (8): 41-48 (In Chinese).
 - [25] Li, Y., Hu, T., Ge, T., Auden, E. The relationship between home-based parental involvement,

- parental educational expectation and academic performance of middle school students in mainland China: A mediation analysis of cognitive ability. *International Journal of Educational Research*, 2019, 97 (1): 139-153. <https://doi.org/10.1016/j.ijer.2019.08.003>.
- [26] Li, Z., Su, Y. Identity segregation or educational resources disadvantage? The academic achievement of migrant children in China. *Children and Youth Services Review*, 2025, 170: 108134. <https://doi.org/10.1016/j.childyouth.2025.108134>.
- [27] Liu, B., Li, M., Chen, S. The heterogeneous effects of extracurricular tutoring on academic performance and cognitive ability among Chinese junior high school students. *International Journal of Educational Development*, 2026, 121: 103527. <https://doi.org/10.1016/j.ijedudev.2026.103527>.
- [28] Liu, J., Zhang, Y. Dialect Ability and Academic Performance of Migrant Children: Evidence from the China Education Panel Survey. *Chinese Journal of Sociology*, 2020, 5 (40): 213-236 (In Chinese). <https://doi.org/10.15992/j.cnki.31-1123/c.2020.05.009>.
- [29] Luo, Y., Chen, X. The Impact of Mathematics-Gender Stereotypes on Students' Academic Performance: Evidence from China. *Journal of Intelligence*, 2024, 12 (8): 75. <https://doi.org/10.3390/jintelligence12080075>.
- [30] Ma, H., Yao, L. Study on the Mechanism of the Impact of Non cognitive Abilities on Academic Achievement: The Chain Mediating Role of Teacher Support and Parent Participation. *International Journal of Education and Humanities*, 2024, 13 (2): 223-231. <https://doi.org/10.54097/zmqw3g77>
- [31] Peng, S., Zeng, C. Family Dinner Frequency, Parent-Organised Informal Learning Activities, and Student Academic Performance: Evidence from Chinese Eighth-Grade Students. *The Asia-Pacific Education Researcher* 2024, 33: 625-633. <https://doi.org/10.1007/s40299-023-00759-5>.
- [32] Qin, S., Jia, S., Su, S. Parent-child relationship and junior high academic performance: Differentiated impacts of fathers and mothers with self- efficacy as a mediator. *Acta psychological*, 2025, 253: 104723. <https://doi.org/10.1016/j.actpsy.2025.104723>.
- [33] Shan, K. The influence of commuting time on students' academic performance and its internal mechanism: an empirical analysis based on CEPS data. *Frontiers in psychology*, 2026, 17: 1672841. <https://doi.org/10.3389/fpsyg.2026.1672841>.
- [34] Shui, J., Zhu, Y. Unveiling the relationship between boredom and academic achievement: A three-level meta-analysis. *Social Psychology of Education* 2026, 29 (29). <https://doi.org/10.1007/s11218-026-10192-3>.
- [35] Su, W. (2012). Explaining the link between parental educational expectations and Chinese high school students' academic achievement: The roles of psychological distress, parental involvement, and filial piety. *Doctoral dissertation, All ETDs from UAB*. 3060. <https://digitalcommons.library.uab.edu/etd-collection/3060>.
- [36] Tan, M., Cai, L., Bodovski, K. An active investment in cultural capital: structured extracurricular activities and educational success in China. *Journal of Youth Studies*, 2022, 25 (8): 1072–1087. <https://doi.org/10.1080/13676261.2021.1939284>.
- [37] Tang, L., Jiang, X. Family structure and children's academic performance in China: the roles of economic capital, social capital, and cultural capital. *Asia Pacific Education Review*, 2025, 26: 973–983. <https://doi.org/10.1007/s12564-024-09995-w>.
- [38] Wang, S. (2020). A Study on Academic Achievement of Children in Single-parent Families—Evidence from CEPS. *Master, Central China Normal University*.

- [39] Wen, M., Wang, W., Wan, N., Su, D. Family Income and Student Educational and Cognitive Outcomes in China: Exploring the Material and Psychosocial Mechanisms. *Social Sciences*, 2020, 9 (12): 225. <https://doi.org/10.3390/socsci9120225>.
- [40] Xie, S. (2023 of Conference). The Influence of External Factors on Children's Academic Performance Under High Educational Expectations by Both Parents and Children. Proceedings of the 2nd International Conference on Education, Language and Art (ICELA 2022), Sanya, China, Atlantis Press. https://doi.org/10.2991/978-2-38476-004-6_74.
- [41] Xie, Y., Li, Y. Parental Educational Responsibility Beliefs, Parenting Efficacy Beliefs, and Adolescents' Academic Achievement in China: Evidence From CEPS. *Psychology in the Schools*, 2025, 62 (2): 4967-4980. <https://doi.org/10.1002/pits.70055>.
- [42] Xiong, M., Liu, Q., He, Y. Interparental Conflict and Academic Performance in Chinese High School Students: A Serial Mediation Model. *Psychology in the Schools*, 2025, 62 (9): 2942-2954. <https://doi.org/10.1002/pits.23514>.
- [43] Xu, G., Liu, Y., Tu, Z., Yang, X. A Study on the Differences in Parental Educational Expectations and Adolescents' Academic and Psychological Development: A Comparative Analysis of Only Children and Non-Only Children. *Behavioral Sciences*, 2025, 15 (4): 402. <https://doi.org/10.3390/bs15040402>.
- [44] Xu, R., O'Quigley, J. Estimating average regression effect under non proportional hazards. *Biostatistics*, 2000, 1 (4): 423-439. <https://doi.org/10.1093/biostatistics/1.4.423>.
- [45] Yang, J., Zhao, X. Parenting styles and children's academic performance: Evidence from middle schools in China. *Children and Youth Services Review*, 2020, 113: 105017. <https://doi.org/10.1016/j.childyouth.2020.105017>.
- [46] Yang, J., Zhao, X. Does all work and no play make elite students? Evidence from the China education panel survey. *International Journal of Educational Development*, 2021, 80: 102321. <https://doi.org/10.1016/j.ijedudev.2020.102321>.
- [47] Yao, D., Xu, Y., Li, H., Guo, H. How Teachers Praise and Criticism Affect Students Academic Performance: A Mediator Analysis Based on CEPS Database. *Peking University Education Review*, 2021, 19 (1): 109-133+192 (In Chinese).
- [48] Yu, S., Liu, Y., Guo, R. "How does my family affect me?" The family cultural capital impact on Chinese junior high school students' academic achievement. *Thinking Skills and Creativity*, 2022, 46: 101146. <https://doi.org/10.1016/j.tsc.2022.101146>.
- [49] Zhang, C. Are Children from Divorced Single-Parent Families Disadvantaged? New Evidence from the China Family Panel Studies. *Chinese Sociological Review*, 2020, 52 (1): 84-114. <https://doi.org/10.1080/21620555.2019.1654366>.
- [50] Zhang, F., Wu, Y. Living with grandparents: Multi-generational families and the academic performance of grandchildren in China. *Chinese Journal of Sociology*, 2021, 7 (3): 413-443. <http://doi.org/10.1177/2057150X211028357>.
- [51] Zhang, Y., Qiao, J., Deng, Z., Zheng, P., Dong, Y., Ren, Y., Liu, G., You, J. Parents' Beliefs about Academic Performance and Academic Stress among Chinese Adolescents: Evidence from the China Education Panel Study. *Journal of Youth and Adolescence*, 2026, 55: 1697-1712. <https://doi.org/10.1007/s10964-026-02345-6>.
- [52] Zhang, Y., Tsang, M. Gender gap in the national college entrance exam performance in China: a case study of a typical Chinese municipality. *Asia Pacific Education Review*, 2015, 16: 27-36. <https://doi.org/10.1007/s12564-014-9351-8>.

- [53] Zhang, Z., Lei, W. Factors Influencing Academic Achievement of Disadvantaged Students and Their Mechanisms of Action. *Educational Research and Experiment*, 2024, 1: 98-106 (In Chinese).
- [54] Zhang, Z., Ye, B. Can home labor education boost teenagers' academic performance? A Comparative analysis. *Heliyon*, 2024, 10 (3): e25770.
<https://doi.org/10.1016/j.heliyon.2024.e25770>.
- [55] Zhao, B. B. Generalized Concept of Relative Risk and Wider Applications of the Proportional Hazards Model and the Kaplan-Meier Estimator. *Communications in Statistics–Theory and Methods*, 2015, 44 (24): 5254-5266. <https://doi.org/10.1080/03610926.2013.815213>.
- [56] Zhao, B. B. Two Bayesian variable screening procedures. *Communications in Statistics - Theory and Methods*, 2026, 55 (4): 1176-1188. <https://doi.org/10.1080/03610926.2025.2517276>.
- [57] Zhao, L., Zhao, W. Impacts of family environment on adolescents' academic achievement: The role of peer interaction quality and educational expectation gap. *Frontiers in Psychology*, 2022, 13: 911959. <https://doi.org/10.3389/fpsyg.2022.911959>.
- [58] Zhao, L., Zhao, Z. Disruptive Peers in the Classroom and Students' Academic Outcomes: Evidence and Mechanisms. *Labour Economics*, 2021, 68: 101954.
<https://doi.org/10.1016/j.labeco.2020.101954>.