# Supplemental materials: Exploration of the differences with the previous key study arising from (i) changes in country context and (ii) changes in model specification

These supplemental materials are presented in two parts, which trace back from the models in the current study to the models in the preceding study using English data (Rasbash et al., 2010) to explore the differences arising from (i) changes in country context and (ii) changes in model specification.

Section 1 of the supplemental materials shows the effects of the change in country context between Sweden and England by comparing the estimates from the 'single-cohort twins' approach models (Table 2 in the main text) fitted to the 2007 cohort of Swedish students with estimates from a similar specification on English data (Table A1).

Section 2 of the supplemental materials shows the differences in results arising from the change in model specification due to the availability of variables in Swedish vs. English datasets by comparing estimates (both using English data) from a model which uses only variables that are also available in Swedish data (Table A1) vs. a specification which exploits all measures available in English data (Table A2)

## *1 Identifying differences arising from change in model country context*

Table 2 in the main text presents results for the single-cohort twins approach models 1.1, 1.2, 1.3, and 1.4 (see Section 4.1) fitted to the 2007 cohort of Swedish students. Table A1 presents results from a similar model specification for the English data (i.e., without the additional variables available in the English dataset); these are given the corresponding model names 3.1, 3.2, 3.3, and 3.4. Comparison between these two sets of estimates facilitates an understanding of how the change in country context affects model estimates. The structure and text of this section replicate that of the main text Section 5.1.

Model 1.1, the simple students-within-schools model, shows 9% of the variation in student achievement that is between schools. This figure is low compared to what we might expect in many other European countries but is typical for Nordic countries (OECD 2014). Indeed, the corresponding estimate based on the English data is 22% (Table A1, Model 3.1). Thus, achievement differences between schools appear far less pronounced in Sweden than in England.

Model 1.2, the simple students-within-families model, shows that 67% of the variation in twin student achievement that is between families. This result corresponds to an estimate of 72% when the same model is fitted to the English data (Table A1, Model 3.2), and so in terms of the relative importance of families, we find broadly similar results across the two countries.

Model 1.3, which simultaneously accounts for schools, families, and neighborhoods, shows that just 8% of the variation in student achievement lies between schools and 4% between neighborhoods. In contrast, 55% of the variation lies between families, with the remaining 33% between the students themselves. Thus, the substantial importance of families persists, even after accounting for school and neighborhood effects. The low relative importance of residential neighborhoods is consistent with the English data, where only 6% of the variation in student achievement was found to lie between areas (Table A1, Model 3.3).

The results imply that 62% [0.477/(0.477+0.289)] of the variation in student achievement which a standard school effectiveness model would otherwise be described as between students, is better described as variation that is between families. This corresponds with the estimate of 65% for the equivalent model for England (Table A1, Model 3.3).

Model 1.4, which extends Model 1.3 by adjusting for student age and gender (the only student background characteristics that appear in both the Swedish and English data), shows

that adding these two covariates makes little difference to the estimated school, family, and neighborhood variance components, but slightly reduces the estimate of the student variance component. This is what we would expect at the school and neighborhood levels, where there is little variation in average age and proportion of female students across units. The results for student age show that being born in the first month of the academic year is associated with achievement 0.132 SD [0.012 × 11] higher than being born in the last month of the academic year. This is very similar to that of 0.143 SD [0.013 × 11] seen for English students (Table A1, Model 3.4). The results for student gender show female students score 0.369 SD higher than male students. This gender gap is considerably larger than the corresponding gap of 0.229 SD seen among English students (Table A1, Model 3.4) but is consistent with the large gender gap reported for PISA (Programme for International Student Assessment) scores for Sweden (OECD 2014).

### *A2 Identifying differences arising from change in model specification*

Table A2 shows the estimates for Models 4.1-4.4, which are modifications of Models 1.1-1.4 using the twin definition of families on English data. These models replicate those of Rasbash et al. (2010, Models A, B, C, and D in Tables 6 and 7); our models use updated English data, hence the very slight changes in estimates from Rasbash et al. 2010. Models 4.3 and 4.4 include the additional variable student prior achievement and its interaction with the twin-family dummy variable and also primary school and school district (local education authority) random effects.

We contrast Table A2 with Table A1, which also presents modifications of Models 1.1-1.4, again using a twin definition of families, estimated on English data, but with a specification comparable across Swedish and English data (i.e., excluding prior achievement, and the primary school and school district random effects).

We see that failing to control for prior achievement increases the overall unexplained variation from 0.474 to 1.044 for Model 4.1 vs. Model 3.1, 0.398 to 0.945 for Model 4.2 vs. Model 3.2, and 0.416 to 0.982 for Model 4.3 vs. Model 3.3. We also see an increase in the proportion of this unexplained variation which is between -schools, -families, and -neighborhoods. For example, comparing Model 3.3 to 4.3, we find that the proportion of residual variation that is between secondary schools increases from 10% to 21%, when we fail to control for prior achievement (and school district and primary school effects though these are far less important sources of the variation in student achievement). The proportion of residual variability that is between families increases from 40% to 48%, and the proportion of residual variation that is between neighborhoods increases from 2% to 6%. In other words, a substantial proportion of the variation in achievement that is identified as between schools is actually the result of differences in prior achievement between schools when students start their secondary schooling. Models 3.4 and 4.4 use additional student characteristics to account for some of the between cluster variation observed in Models 3.3 and 4.3. Omitting the variables not available in both the English and Swedish data increases the unexplained variation from 0.374 to 0.968 and this increase is again primarily related to omitting student prior achievement.

***Table A1.***

***Single-cohort twins approach models fitted to the England 2007 data. Models include only variables and levels of analysis available in both the Swedish and English data.***

| | Model 3.1 | | Model 3.2 | | Model 3.3 | | Model 3.4 | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Est. | SE | Est. | SE | Est. | SE | Est. | SE |
| Regression coefficients | | | | | | | | |
| Intercept | 0.001 | (0.009) | -0.003 | (0.001) | 0.011 | (0.008) | -0.102*** | (0.008) |
| Twin-family | 0.121*** | (0.009) | 0.140*** | (0.013) | 0.112*** | (0.011) | 0.105*** | (0.011) |
| Age within year (months) | | | | | | | 0.013*** | (<0.001) |
| Female | | | | | | | 0.229*** | (0.003) |
| Variance components | | | | | | | | |
| School | 0.228*** | (0.006) | | | 0.203*** | (0.005) | 0.199*** | (0.005) |
| Neighborhood | | | | | 0.056*** | (0.001) | 0.057*** | (0.001) |
| Family (twins only) | | | 0.683*** | (0.016) | 0.471*** | (0.013) | 0.463*** | (0.012) |
| Student (twins only) | | | 0.263*** | (0.005) | 0.258*** | (0.005) | 0.254*** | (0.005) |
| Family + Student (non-twins) | | | 1.001*** | (0.002) | 0.765*** | (0.002) | 0.752*** | (0.001) |
| Student | 0.816*** | (0.002) | | | | | | |
| Total | 1.044 | | 0.945 | | 0.982 | | 0.968 | |
| Variance partition coefficients (VPCs)[a] | | | | | | | | |
| School | 22% | | | | 21% | | 20% | |
| Neighborhood | | | | | 6% | | 6% | |
| Family | | | 72% | | 48% | | 48% | |
| Student | 78% | | 28% | | 26% | | 26% | |
| Model summary | | | | | | | | |
| Number of schools | 3099 | | | | 3099 | | 3099 | |
| Number of neighborhoods | | | | | 32404 | | 32404 | |
| Number of non-singleton families | | | 5116 | | 5116 | | 5116 | |
| Number of students | 551220 | | 551220 | | 551220 | | 551220 | |
| Deviance information criterion | 1455533 | | 1555280 | | 1429258 | | 1419367 | |

Note.

All models are fitted by MCMC. The estimates and standard errors are the means and SDs of the parameter chains.

In Models 4.2, 4.3, and 4.4, VPCs are derived from twin-family estimates of the family and student variance components.

* p<0.05, ** p<0.01, and *** p<0.001.

***Table A2.***

***Single-cohort twins approach models fitted to England 2007 data. Models include the additional variables and levels of analysis available only in the English data.***

| | Model 4.1 | | Model 4.2 | | Model 4.3 | | Model 4.4 | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Est. | SE | Est. | SE | Est. | SE | Est. | SE |
| Regression coefficients | | | | | | | | |
| Intercept | 0.002 | (0.004) | -0.003*** | (0.001) | 0.001 | (0.008) | -0.039*** | (0.007) |
| Twin-family | 0.172*** | (0.006) | 0.177*** | (0.008) | 0.162*** | (0.007) | 0.154*** | (0.007) |
| KS2 score | 0.689*** | (0.001) | 0.730*** | (0.001) | 0.701*** | (0.001) | 0.641*** | (0.001) |
| KS2 score × Twin-family | 0.007 | (0.006) | -0.040*** | (0.007) | -0.027*** | (0.006) | -0.020*** | (0.006) |
| Age within academic year (months) | | | | | | | -0.012*** | (0.000) |
| Female | | | | | | | 0.184*** | (0.002) |
| FSMs | | | | | | | -0.248*** | (0.003) |
| SENs | | | | | | | -0.231*** | (0.003) |
| Ethnicity (reference, white) | | | | | | | | |
| Black | | | | | | | 0.429*** | (0.005) |
| Asian | | | | | | | 0.225*** | (0.006) |
| Chinese | | | | | | | 0.556*** | (0.015) |
| Mixed | | | | | | | 0.045*** | (0.005) |
| Other | | | | | | | 0.403*** | (0.010) |
| IDACI | | | | | | | -0.103*** | (0.001) |
| Variance components | | | | | | | | |
| Local education authority (LEA) | | | | | 0.005*** | (0.001) | 0.005*** | (0.001) |
| Secondary school | 0.057*** | (0.002) | | | 0.043*** | (0.001) | 0.035*** | (0.001) |
| Primary school | | | | | 0.035*** | (0.001) | 0.025*** | (0.000) |
| Neighborhood | | | | | 0.008*** | (0.000) | 0.002*** | (0.000) |
| Family (twins only) | | | 0.238*** | (0.007) | 0.168*** | (0.005) | 0.157*** | (0.005) |
| Student (twins only) | | | 0.160*** | (0.003) | 0.157*** | (0.003) | 0.150*** | (0.003) |
| Family + Student (non-twins only) | | | 0.468*** | (0.001) | 0.383*** | (0.001) | 0.357*** | (0.001) |
| Student | 0.417*** | (0.001) | | | | | | |
| Total | 0.474 | | 0.398 | | 0.416 | | 0.374 | |
| Variance partition coefficients (VPCs) [a] | | | | | | | | |
| LEA | | | | | 1% | | 1% | |
| Secondary school | 12% | | | | 10% | | 9% | |
| Primary school | | | | | 8% | | 7% | |
| Neighborhood | | | | | 2% | | 1% | |
| Family | | | 60% | | 40% | | 42% | |
| Student | | | 40% | | 38% | | 40% | |
| Confounded family and student | 88% | | | | | | | |
| Model summary | | | | | | | | |
| Number of LEAs | | | | | 149 | | 149 | |
| Number of secondary schools | 3099 | | | | 3099 | | 3099 | |
| Number of primary schools | | | | | 14765 | | 14765 | |
| Number of neighborhoods | | | | | 32404 | | 32404 | |
| Number of non-singleton families | | | 5116 | | 5116 | | 5116 | |
| Number of students | 551220 | | 551220 | | 551220 | | 551220 | |
| Deviance information criterion | 1085480 | | 1138628 | | 1049148 | | 1005886 | |

Note.

These results replicate those of Rasbash et al. (2010, Tables 6 and 7).

Totals for variance components do not include the combined family and student variance for non-twins; the purpose of the total is to show the denominator for the subsequent VPC.

All models are fitted by MCMC. The estimates and standard errors are the means and SDs of the parameter chains.

In Models 3.2, 3.2, and 3.4, VPCs derived from twin-family estimates of the family and student variance components.

* $p<0.05$, ** $p<0.01$, and *** $p<0.001$.

## References

OECD (2014) Resources, Policies and Practices in Sweden's Schooling System: An in-depth analysis of PISA 2012 results.