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School commuting behaviors: a time-use exploration*

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Abstract

This paper explores school commuting behaviors of children who attend primary school, high-school, or University, using time use data for a set of countries obtained from the Multinational Time Use Study. We focus on the duration of school commutes, and how they correlate with individual and family characteristics. We also explore the transport modes used, and whether the commuting is done alone. The results show significant differences in school commuting times across countries. Furthermore, we find more time devoted to commuting, and higher rates of commuting done alone, as the schooling level of respondents increases. Means of transport are relatively similar within countries, although they change significantly across countries. This analysis is the first exploration of school, high-school, and University commuting behavior, using time use data that make the results comparable. Our analysis opens doors for future research, and may serve planners in terms of policies promoting specific student mobility.

Keywords: school commuting; transport mode; commuting alone; time use data; MTUS data.

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1. Introduction

This paper explores commuting by students to/from primary school, high-school, and University (which we refer to as “school commuting” for simplicity), using time use diaries from the Multinational Time Use Study (MTUS) database. Individual mobility, and more precisely worker commuting behaviors, have often been studied in recent years, given their complex relationships with urban forms, environmental issues, worker health and wellbeing, productivity, wages, and firm performance (see Gimenez-Nadal et al., 2021, 2022, for two recent reviews). But the mobility of children remains relatively ignored and the empirical findings in applied studies of student school commuting behavior are far from conclusive (McMillan, 2005; Mitra and Buliung, 2012; Marique et al., 2013). Despite that children’s mobility has received some degree of research attention in recent decades (e.g., Hillman et al., 1990), it has mostly focused on children’s mobility without adults, and on the relationship between active mobility and the obesity of children (e.g., Marique et al., 2013; Uddin et al., 2019).

Sjolie and Thuen (2002) study school trips as a mean of physical activity in Norway. Ewing et al. (2004) explore school commuting mode choices in the US, focusing on safe routes to school and travel time. Ziviani et al. (2004) analyze commutes to primary school as a physical activity, and find that it is partially correlated with parents’ beliefs in physical activity. Timperio et al. (2007) find that safe routes and child-friendly environments are important in explaining active school commutes. Yeung et al. (2008) conclude that age, safety, and supervision are relevant predictors of active school commutes in Australia. McDonald and Aalborg (2009) find that US parents drive their offspring to school for convenience and to save time, even if active commutes could be possible because of the short distances involved. Faulkner et al. (2010) find that traffic density, along with maturity and convenience, are important correlates of school commuting modes in Canada. In the same country, Mitra et al. (2010) find that school commuting distance is the strongest correlate of school commuting mode choice, but built environments also play a significant role. Marique et al. (2013) provide an exploration in Belgium and find that urban forms are another determinant of school commuting mode choice, together with the availability of education infrastructure. In a recent paper, Uddin et al. (2019) explore data from Asian countries and provide a recent review.

Other authors have explored other determinants of school commuting behaviors, such as demographics and household characteristics. For instance, McDonald (2012) uses US National Travel Surveys to examine gender differences in school commutes, finding very small differences (the opposite

to an extensive literature on commuting time gender gaps (e.g., Farré et al., 2020)). McMillan et al. (2006), conversely, find strong differences in school commuting behaviors among children in California. Other authors have shown that household location and neighborhoods are exogenous factors that determine trips to school and travel modes of students. Schlossberg et al. (2006) find divergence between US planners' predictions and student behavior, and Wong et al. (2011) report how data limitations are important when spatially studying active school commutes. Parents' mobility and mode choices have also been found to determine their offspring's school commutes in the US (Deka, 2013). Finally, recent studies have highlighted the importance of considering both social and environmental issues related to school commuting, such as McMillan (2005, 2007), who reports that social norms are as important as traffic safety or urban forms when studying school commutes, and Marique et al. (2013) who find a link between school commutes, schooling level, school concentration in certain regions, and energy consumption for travelling. (Feng et al. (2010) review the existing literature on this topic.)

In addition to studying the determinants of school commuting behavior, other authors have examined their impact on student performance, although this is a topic that remains relatively overlooked, partially because of the challenging data requirements. Arulampalam et al. (2012) use data from the UK and conclude that absenteeism (that is positively related to longer commutes) has a causal negative impact on performance among students of Economics at University. Lo Burgio and Amoroso (2012) find a negative link between commuting and University student performance, which is driven by the stress, lack of energy, irritability, and lack of concentration arriving from uncontrollable events while commuting, in certain modes of transport (e.g., public transit) in Italy. In Ireland, Denny et al. (2014) take a quasi-experimental approach to find that commuting distance affects University access programs. Van Dijk et al. (2014) analyze the academic achievements and commuting behaviors of Dutch teenagers and find that active commutes are not related to student performance in general terms, but report a positive (but weak) impact on girls' attention spans. Using Brazilian data, Tigre et al. (2016) estimate a strong and negative impact of commuting duration on the academic achievement of primary school students. In a recent paper, Khalil and Khair (2018) conclude that students with very low grades and high drop-off rate are mostly those who face longer commutes. In summary, the existing evidence points to negative impacts of commuting on student performance.

However, most of the research on children's mobility has been conducted in North America, in single-country contexts or specific regions of countries, and no cross-country analyses have been proposed, which raises questions about the generalizability of these findings to other regions (Cervero

et al., 2009; Marique et al., 2013; Uddin et al., 2019). Furthermore, cross-country analysis allows for a comparison of results, yielding conclusions about the effects of public policies, which include infrastructure planning. Within this framework, we provide a data-driven empirical exploration of school commuting behavior of students in Canada, Italy, Korea, Spain, the UK, and the US, using time use diaries from the MTUS data, and with a focus on differences by schooling level (primary school, high-school, and University), representing the first exploration of school commuting using time use diaries in a cross-country setting. We focus on the duration of school commutes, the transport modes of such trips, and the proportionrate of these trips that are done alone (vs the proportion done in company with others).

We find that school commutes increase with schooling, i.e., primary school commutes are shorter than high-school commutes, which are shorter than University commutes. This trend is consistently reported for all the analyzed countries, although there are significant cross-country differences. We also find that the use of transport modes changes little within countries, but different countries show different preferred means of transport. For instance, the preferred mean of transport in the US is the private vehicle, vs public transit in Canada, and active school commutes in Italy, Korea, Spain, and the UK. We also report increasing rates of solo school commutes as students progress through the stages of education, but large differences across countries. (These results open doors for a number of further studies of student commuting behaviors).

The contributions of the paper are as follows. First, we analyze the time spent commuting to/from primary school, high-school, and University by students, and reporting cross-country differences in school commuting times, and we contribute to the field of student wellbeing, given that commutes are typically associated with disutility and low levels of satisfaction (Kahneman and Krueger, 2006; Stutzer and Frey, 2008; Lorenz, 2018). We explore the means of transport used, which is linked to stress and wellbeing. Differences in means of transport at different stages of schooling, and across countries, may be helpful in identifying which students are at greater risk of negative consequences of their commute, which may well affect their performance. Second, we explore the rate of school commuting that is done alone, relative to commutes that are supervised or in company with others. School commuting alone may be a reflection of the social isolation of the student, especially at higher levels of formal education, which may be detrimental to academic performance. Identifying the underlying factors of social isolation, and giving a profile of which students are more likely to be socially isolated, may be helpful in increasing the educational performance of those students.

The remainder of the paper is structured as follows. Section 2 describes the data, sample, and variables used throughout the analysis, and Section 3 shows key figures and summary statistics of the time spent commuting to primary school/high-school/University, the preferred means of transport, and the proportion of school commutes that are done alone. Section 4 describes the econometric strategy and the main results, and Section 5 concludes.

2. Data and variables

We use data from the Multinational Time Use Study (MTUS), which is sponsored by the Centre for Time Use Research (CTUR) and is included as part of the Integrated Public Use Microdata Series (IPUMS) of the Institute for Social Research and Data Innovation of the University of Minnesota (Fisher et al., 2019). The MTUS includes detailed time use diaries for a range of countries, along with a series of demographic, economic, and geographic characteristics of respondents. The MTUS provides us with information on the daily behaviors of individuals based on time use diaries, where respondents report their activities during the 24 hours of the day, from 4 am to 4 am of the next day. The diaries include harmonized information about activity location, the mode of transport, and who else was present during the activities. Time use diaries have been shown to have advantages over other types of survey collecting transport times and time use variables, such as those based on stylized questionnaires, since time use diaries produce reduced measurement error, and more reliable and accurate estimates (Bianchi et al., 2000; Bonke, 2005; Yee-Kan, 2008; Gimenez-Nadal et al., 2018a, 2021). As a consequence, time use diaries have become the gold standard in studying individual daily behaviors (Aguar and Hurst, 2007; Guryan et al., 2008; Gimenez-Nadal and Sevilla, 2012; Harms et al., 2019).¹

Since we want to analyze episodes of school commuting (e.g., trips to/from primary school, high-school, or University) by students, we restrict the sample to those who filled in diaries during weekdays (i.e., we omit weekends), with non-missing information on the variables of interest. Students who filled their diaries during holidays are omitted, as well as students who did not attend any school during the

¹ Time use surveys have been used to analyze commuting and travel behaviors during recent years. See Kitamura and Fujii (1997), Axhausen et al. (2002), Gerike et al. (2015), Gimenez-Nadal and Molina (2016), Rosales-Salas and Jara-Díaz (2017), Gimenez-Nadal et al. (2018a, 2018b, 2021), Harms et al. (2018), and Aschauer et al. (2019), among others. A recent review of travel behaviors and time use diaries is shown in Gimenez-Nadal et al. (2021), and Gimenez-Nadal and Molina (2022) provided a technical report on time use surveys.

diary day, to avoid a potential source of bias arising from atypical days.² To avoid considering senior individuals who are also students and employed or unemployed workers, we keep students under 26 years old only (which is 79.49 percent of students in the sample). These restrictions generate a sample of 12,784 students, of which 874 live in Canada, 1,590 live in Italy, 3,084 live in Korea, 2,627 live in Spain, 1,151 live in the UK, and 3,458 live in the US. See Table A1 in the Appendix for details on the available years for each of the analyzed countries, and the number of individuals per country.

The first variable of interest is the time spent commuting to/from primary school, high-school, or University (which for simplicity we refer to as “school commuting”). Time use diaries in the MTUS data identify episodes of travel for different purposes and, specifically, we identify school commuting episodes as code “64: education travel”, and define school commuting time as the sum of the times spent in school commuting episodes. Among the 12,784 students in the sample, we have information on 327,414 different activity episodes (i.e., an average of 25.6 distinct activity episodes per student and diary day), of which 34,669 are school commuting episodes (i.e., 10.6% of students’ distinct activities are commutes to/from school). Furthermore, the average student in the sample spends about 56.2 minutes commuting to/from school. (See Table A2 in the Appendix for details; the density of school commuting time is shown in Figure A1 in the Appendix.)

The MTUS diaries also provide detailed information about the means of transport and information about who else was present during the activity. Specifically, the MTUS allows us to differentiate among the following means of transport used during trip episodes: 1) “travel episode by car, etc.”, 2) “public transit”, 3) “walk/on foot”, 4) “other physical transport”, and 5) “other/unspecified transport”. This way, we can identify trip episodes in private vehicle from category (1), trip episodes on public transit from category (2), active trip episodes from categories (3) and (4), and trip episodes in other/not-identified means of transport from category (6). In our sample, 34.6% of the average commute to/from school is done in private vehicle, 21.6% is done in a public transit mode, 31.8% is done actively, and the remaining 12.0% is done in other/not specified mean of transport. Regarding who else was present while traveling, the MTUS data allows us to differentiate trips alone, and trips with others. In particular, 41.4% of the average commute to/from school is done alone (See Table A2 in the Appendix for details).

² We consider that a diarist attended school during the diary day if he/she reports a minimum of 60 minutes at school doing regular schooling/education activities, in line with how work-days are identified by existing research using time use data (e.g., Gimenez-Nadal et al., 2018a, 2018b).

Another key variable in the analysis is the one that identifies the schooling level of students in the sample. The MTUS data includes harmonized information on the maximum level of education achieved by respondents, that is comparable across all samples, based on the International Classification of Education (ISCED).³ This variable allows to identify those individuals who self-report as students and have completed secondary education or are above secondary education, and we define these students as University students if they are 18 years and older. On the other hand, for individuals who have not completed secondary education, information on education does not allow to distinguish between those who have not completed primary education, and those who have. That way, we define primary education students as those under 12 years old who have not completed secondary education, and secondary education students (students attending high-school) aged 12 and older. This classification produces 2,183 primary school students, 7,886 high-school students, and 2,715 college or University students. In our sample, 17.08% of the sample are students attending primary school, 61.69% are attending high-school, and the remaining 21.24% are attending University or college.⁴

The MTUS data allows us to consider several sociodemographic characteristics of students, which have been found to be correlated with travel behaviors.⁵ We first consider the gender of respondents, defined as a dummy that takes value 1 for males, and 0 for females. The marital status of parents is defined as a dummy variable that takes value 1 for those who cohabit with two (married or unmarried) parents, and 0 otherwise. Household composition is defined by two variables: the number of individuals in the family unit, and the number of siblings (under 17 years old) in the family unit. We also define a dummy that takes value 1 for those students who reside in a home owned by the family unit, 0 otherwise. Finally, we define a dummy that takes value 1 for respondents in urban/suburban regions, and value 0 for respondents in rural areas. Summary statistics of these variables for the sample are shown in Table A2 in the Appendix.

3. The picture of school commuting

³ The MTUS includes the following education categories: 1) Secondary education or less, 2) completed secondary, and 3) above secondary education. See details on how the maximum level of education is defined in the MTUS data in: https://www.mtusdata.org/mtus-action/variables/EDTRY#description_section.

⁴ An appealing remark is that, due to national time use characteristics, primary school students are not represented in Canada and in the US; only high-school and University students are represented in these countries.

⁵ Because schooling is partially determined by age, we cannot control for respondents' age to avoid collinearity.

Figure 1 shows the average time spent commuting to/from school of students in the analyzed countries, along with averages for each schooling category (i.e., primary school, high-school, and University students separately). Students in the US show the shortest school commuting times, as the average US student spends about 34 minutes commuting to/from school. This is followed by Canada and the UK, where the corresponding average student devotes about 52 minutes to this activity. In Italy, students spend about 60 minutes going to/from school, while this factor is of about 65 minutes in Spain. The average Korean student spends 84 minutes commuting to school. When focusing on average school commuting times by schooling categories, Figure 1 shows that, for each country with available data in the sample, primary school students consistently report the shortest commutes, and University students the longest commutes, with high-school students in between. This has certain implications. For instance, it may be that the availability of primary schools is greater than the availability of high-schools and of Universities, thus producing the observed trend. Another (perhaps complementary) explanation is linked to household responsibilities, according to which parents of younger kids need to escort them and thus optimize the school commuting time of young kids, while high-school and University students may go alone and therefore their school commutes are not driven by optimizing time, but by other settings (e.g., seeking more prestigious high-schools or Universities).

Certain conclusions can be drawn from Figure 1. First, results for Canada and the US do not include the youngest students, who are consistently the group with the shortest school commutes, and thus the average picture for these countries is likely biased upward. Second, despite such potential bias, the US shows by far the shortest commutes in the analyzed countries. Third, University students spend more time commuting to University than the similar school commuting of high-school students, who also spend more time commuting to high-school than do primary school students. This trend is consistently reported for all the countries in the sample, though quantitative differences by schooling categories vary widely across countries.

Figure 2 shows the composition of school commutes in terms of the average transport modes used in these trips. We show the time spent commuting to/from school in each of the available transport modes, and the picture is one of heterogeneity. Note that about 45% of the time spent commuting to/from school in Spain happens in a means of transport either different than private vehicle, public transit, and active, or not identified. This is also the case in other countries, but to a much lesser extent (e.g., less than the 8.4% of the time of school commuting in the UK is in a not-identified mean of transport). The reason behind this issue is unclear, and the MTUS data does not provide details. Setting

this data limitation aside, Figure 2 shows that the preferred mean of transport for school commutes differs significantly across countries. Almost two-thirds (61.4%) of the time commuting to/from school in the US occurs in private vehicles, in line with existing research on commutes to/from work (Wong et al., 2018). However, the US is the only country in which the private vehicle is the most common means of school commuting. The results show that public transit services are the most common transport mode for school commutes in Canada, and are also very much used in Spain and Italy, compared to low rates of usage in the UK and the US. Oppositely, active school commuting is preferred in the UK, Spain (aside from not-identified transport modes), Korea, and Italy, and are also common in Canada, but quite uncommon in the US.

Figure 3 shows similar descriptive statistics to Figure 2, but focusing on the rates of transport modes while commuting to/from school, by schooling categories. Three main conclusions emerge. First, private vehicles for school commuting increases with schooling level in Canada, Spain, and the US, but decreases in Italy, Korea, and the UK. Second, the use of public transit for school commuting increases with schooling level for all the analyzed countries but the US. And third, active commutes to school are similar for all schooling categories in Canada, and Spain, decrease with schooling in Italy and Korea, but increase in the UK and the US. Such divergence may be explained by factors such as parents' chores and care responsibilities, traffic characteristics, urban forms, or travel patterns, and a deeper exploration is left for further research. The availability of public transit may be crucial, and enhancing access to secure public transit services for students may be important in improving school commuting, as well as encouraging activities like walking from home to the bus/train stop, and back, especially in a world concerned with the increased emissions generated by commuting in non-green modes of transport (e.g., Coria and Zhang, 2015, 2017; Long and Szeto, 2019; Vosough et al., 2020; Echeverría et al., 2022).

Figure 4 exploits the information on time use diaries regarding activities done alone, vs activities done with someone else, and shows the time commuting to/from school that takes place alone. These amounts are very low (below 10%) for primary school students in Italy and the UK, and moderately low in Spain (about 18%). Conversely, about 67% of the time commuting to/from school is reported as time alone for school students in Korea. The specific reason for such a high number remains unclear, and future research will determine if it is driven by some misspecification in the diaries, or by specific travel patterns in Korea. As expected, the time spent commuting to University is higher than for high-school students, which is itself higher than the rate for primary school students. However, there are

again important country differences. Solo commutes to/from school are especially low, in general terms, in Italy and the UK (with averages under 20%), and especially high in Korea, where almost 70% of the time commuting to/from school is reported as students being alone.

4. Empirical strategy and results

The figures shown above represent a descriptive exploration of school commuting behaviors, but represent only descriptive averages. However, the differences reported can be driven by factors such as gender, age, household composition, tenure, or urban forms, along with systematic country differences, or year and day effects. Thus, to partially account for the observed heterogeneity of individuals, we now focus on studying the conditional correlates of school commuting time, the use of transport mode for school commuting, and the rate of solo school commutes. This may shed light on differences across countries net of observed inter-individual differences in socio-demographic characteristics, and may help us to understand differences in school commuting behaviors of students (e.g., male and female students, younger and older students, students in urban vs rural areas, etc.).

School commuting duration

We first explore the duration of school commuting (in minutes per day), for the whole sample of students. For each student i , in country c , surveyed in year t , and day d , we estimate by OLS the following equation:

$$C_{ictd} = \beta_0 + \beta_1 S_{ictd}^{high} + \beta_2 S_{ictd}^{Univ} + \beta_3' \mathbf{X}_{ictd} + \alpha_c + \gamma_t + \delta_d + \varepsilon_{ictd}, \quad (1)$$

where C_{ictd} represents the time spent commuting to/from school; S_{ictd}^{high} is a dummy variable that takes value 1 for high-school students (0 otherwise); S_{ictd}^{Univ} is a dummy variable that takes value 1 for University students (0 otherwise); \mathbf{X}_{ictd} is a column-vector of student demographics (gender dummy, two-parent dummy, family size, number of siblings, home ownership dummy, and urban area dummy); α_c , γ_t , and δ_d represent country, year, and day fixed effects, respectively; and ε_{ictd} is the error term. The reference category for education is basic education (i.e., primary school), and β_1 (β_2) represents the difference in school commuting time of high-school (University) students, relative to primary school students, and net of demographic observables, and country, year, and day fixed effects.

Column (1) in Table 1 shows the main estimates of Equation (1). Estimates indicate that, net of observable factors, the average high-school student spends about 17.9 more minutes in school commuting than the similar primary school student, and the average University student spends about 20.6 more minutes in school commuting than the primary school student counterpart. Regarding demographics, family size is positively correlated with school commuting time. The remaining set of variables are found to be not statistically significant. This, along with the fact that we estimate a relatively low R^2 , indicates that school commutes are complex trips, that may be linked to unobserved characteristics such as weather conditions, traffic congestion, or infrastructure availability, among others.

Columns (2), (3), and (4) of Table 1 show estimates of Equation (1), restricted to primary school, high-school, and University students, and thus omit schooling dummies. The main takeaway of these three columns is that almost every explanatory variable is not significantly correlated with school commuting times, and thus student demographics do not explain school commuting times, once we separate students by schooling category, even when we isolate systematic country, year, and day differences by controlling for the corresponding fixed effects.

Despite that Table 1 suggests that demographics do not explain school commuting time, even when controlling for country fixed effects, it may be the case that country differences mask how demographics correlate with school commuting time. To partially account for such a case, Table 2 shows estimates of Equation (1) separately for each of the analyzed countries (thus omitting country fixed effects). Note that, for Canada and the US where we do not observe primary school students, the reference category is high-school students.

We report a positive correlation between schooling and school commuting time, since in general terms high-school students devote more minutes per day to school commuting than primary school students, and University students spend more time in school commuting than high-school students. The only exception is Spain, where primary school and high-school students spend similar times in school commuting, but University students devote more time to commuting to University.

Females spend more (less) time in school commuting than male counterparts in Spain (the UK). Living in a two-parent household is positively (negatively) related to school commuting time in Korea and the UK (Italy and the US). Family size is positively related to school commuting time in Korea and the US, while the number of siblings is negatively related to school commuting time in Korea and Spain.

Home ownership is positively related to school commuting time in Canada and Korea. Finally, students in urban areas spend less time in school commuting in Canada and Spain, but more time in Korea.

The mode of transport

We study the mean of transport used by students for commuting.⁶ For each student i , surveyed on year t , and day d , we estimate country-by-country, and by OLS, the following equation:

$$R_{itd}^j = \beta_0 + \beta_1 S_{itd}^{high} + \beta_2 S_{itd}^{univ} + \beta_3' \mathbf{X}_{itd} + \gamma_t + \delta_d + \varepsilon_{itd}, \quad (2)$$

where R_{itd}^j represents the time spent commuting to/from school by mean of transport $j = \{\text{private vehicle, public transit, actively}\}$. Note that the subscript c , that represented the country of residence of individual i in the sample, is no longer in Equation (2), because the equation is estimated country-by-country, and country fixed effects α_c are missing, for the same reason. All the remaining elements of Equation (2) are defined as in Equation (1).

The results of estimating Equation (2) are shown in Table 3, by country. Panel A shows the estimates of the time spent commuting to/from school by private vehicle, while Panel B shows estimates for public transit, and Panel C shows the estimates for active commuting. Demographic controls are omitted for the sake of brevity, but are available upon request.

Estimates show that schooling is not related to the use of private vehicle in Canada. That is to say, school commuting done by car is not related to the schooling level, net of observable factors, in Canada. On the other hand, University students are more likely to commute by private vehicle than their primary school and high-school counterparts in Spain and the US. In Italy and the UK, we find a negative correlation between schooling and the use of private vehicle, since the higher the schooling level, the lower the time in private vehicle, with differences being statistically significant between all three schooling categories. In Korea, University students make less use of private vehicles for school commuting than similar primary school and high-school students, with differences between the two latter groups being not significant.

⁶ As the previous results show that pooled estimates provided not significant results, this analysis is shown only by country. Pooled estimates on the rate of time by transport mode are available upon request.

Public transit services are not correlated with schooling at a statistically significant level in Canada. Conversely, among Italian, Korean, and Spanish students, the use of public transit is positively correlated with schooling, since those attending high-school are more likely to use public transit than those in primary school, and those at University are more likely to use the public transit than their high-school counterparts. In the UK, students at high-school and University are more likely to use public transport than students at primary school, but we find no difference between high-school and University students. Finally, US University students are less likely to use public transit for school commuting than their high-school student counterparts.

University students in Canada are less likely to commute actively than non-University students, and this is also the case for Spanish University students. The case of the US is the opposite, as University students are more likely to commute actively, net of observable heterogeneity. In Italy, active school commuting does not depend on schooling categories in a statistically significant way, while in Korea (the UK), the higher the schooling level of students, the lower (higher) the rate of school commuting that is done actively.

To sum up, results in Table 3 provide certain conclusions. In Canada, transport modes seem to be quite similar for primary school, high-school, and University students. In Italy, a shift from private vehicle to public transit emerges with schooling, while in Korea we find a similar shift from private vehicle and active school commutes to the use of public transit. Conversely, students in Spain appear to stop active commuting at certain schooling categories, and the shift is towards the use of private vehicles and public transit. The case of the UK is different, as students stop school commuting in private vehicle as they age, and begin using public transit, but also commute to school more actively. In the US, there is a shift from using the public transit to using private vehicles or active modes when beginning University. These results, net of observable heterogeneity, complement the descriptive results in Figures 2 and 3 and provide a complex scenario for transport modes across countries and also across school categories.

With whom commute children

We analyze the school commuting time that is done alone (vs the time done with others) by students in the sample, in all six countries.⁷ For each student i , in year t , on day d , we estimate country-by-country and by OLS the following equation:

$$A_{itd} = \beta_0 + \beta_1 S_{itd}^{high} + \beta_2 S_{itd}^{Univ} + \beta_3' \mathbf{X}_{itd} + \gamma_t + \delta_d + \varepsilon_{itd}, \quad (3)$$

where A_{itd} represents the time commuting to/from school alone. All the remaining elements of Equation (3) are defined as in Equations (1) and (2), and the results are shown in Table 3.

Estimates indicate that, for all the analyzed countries, the amount of school commuting that is done alone increases with the schooling category, as expected, and in line with descriptive results in Figure 4. Specifically, Canadian University students spend about 33.5% more time commuting alone, compared to their high-school student counterparts, and net of observable factors. In Italy, high-school (University) students spend about 11.3% (36.2%) more time school commuting alone than their primary school counterparts. In Korea, the school commuting done alone is similar for primary school and high-school students, but University students spend about 6.6% more time commuting alone than their counterparts. In Spain, high-school (University) students spend about 11.7% (30.6%) more time commuting alone than their primary school counterparts. In the UK, high-school (University) students spend 7.5% (22.0%) more time commuting alone than their primary school counterparts. In the US, school commuting time alone is about 39.1% higher among University students than among high-school students.

Our estimates indicate that males are more likely to commute alone in Canada, Korea, Spain, and the US. Living in a two-parent household seems not to be related to school commuting alone, but in the UK those in two-parent households are less likely to commute alone. Family size is negatively (positively) related to school commuting alone in Canada (Korea), while the number of siblings is related to decreased time commuting alone in Korea, Spain, the UK, and the US, while students in urban areas of Korea and Spain are more likely to commute alone than their counterparts in rural areas.

5. Conclusions

⁷ Pooled estimates are available upon request.

This paper analyzes the commuting behavior of primary school, high-school, and University students in Canada, Italy, Korea, Spain, the UK, and the US, using data from the MTUS. We focus on differences in the duration of school commutes, the transport modes of school commuting trips, and the portion of these trips that are done alone (vs with others). We conclude that commuting times increase with the level of schooling in the analyzed countries, as does the amount of commuting that is done alone. We find significant differences across countries in the time of school commuting, in the rate of such commutes that is done alone, and in the means of transport used to commute to/from school.

The results open doors for a number of further studies of student school commuting behaviors, such as exploring channels for country differences (e.g., student transport infrastructure, school availability and services, and social norms regarding children's education), studying the impact of parents' time allocation to children mobility behaviors, or analyzing the differential impact of school commuting transport modes on the environment and student health. Planners may consider our results for the design of further student mobility policies. For instance, recent efforts have been made to enhance students' physical activity, and promoting active school commuting may be important in countries with especially low rates of this activity, such as the US. Similarly, promoting public transit services for students may be important in countries with low use of public transit for these purposes, while in other countries public transit is already the preferred means of school commuting.

The analysis is subject to certain limitations. First, the database is cross-sectional and thus we cannot study causal effects, so the analysis is limited to conditional correlations. Second, results may be driven by unobserved heterogeneity, which cannot be controlled for with cross-sectional data. Future studies using panel data could address these limitations, although longitudinal time use information is not readily available. Third, the data structure of time use surveys does not allow for a detailed analysis of the causes of country differences, given that samples are not homogeneous across time and space, i.e., the years of surveys are not the same for all the countries in the MTUS data. Other sources of homogenized time use data, such as the Harmonised European Time Use Surveys (HETUS), may provide additional insights (despite that the HETUS is not publicly available).

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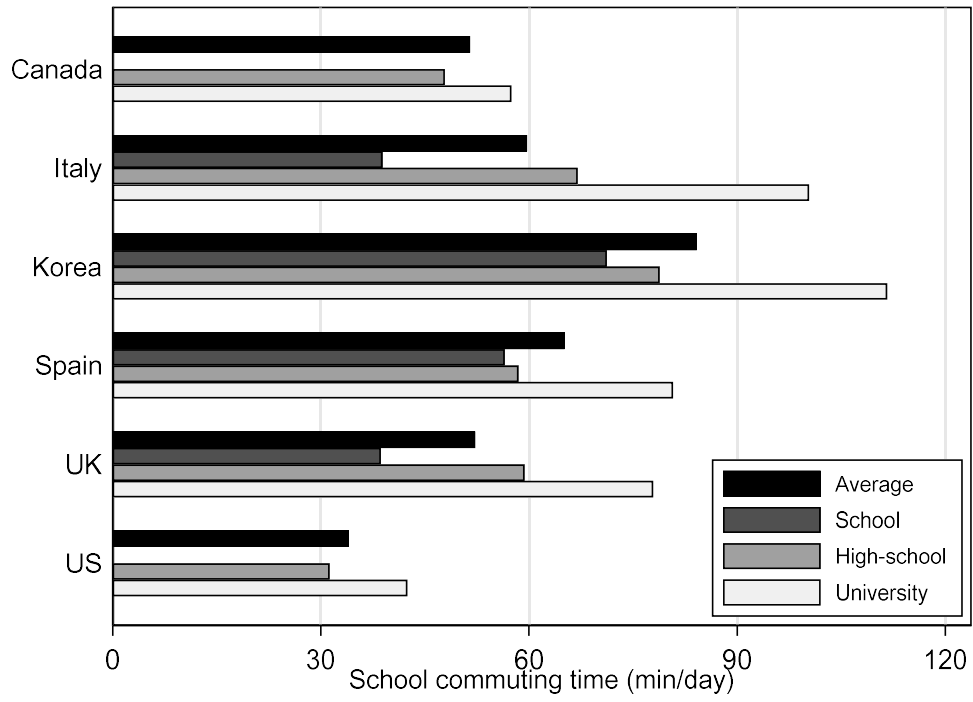
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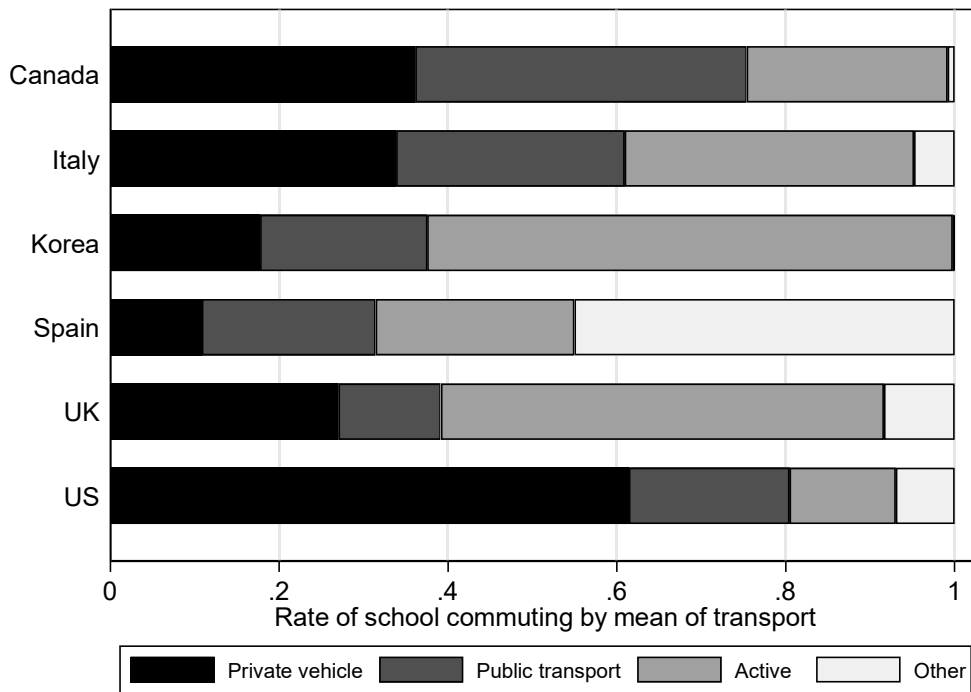
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Figure 1. School commuting, by country



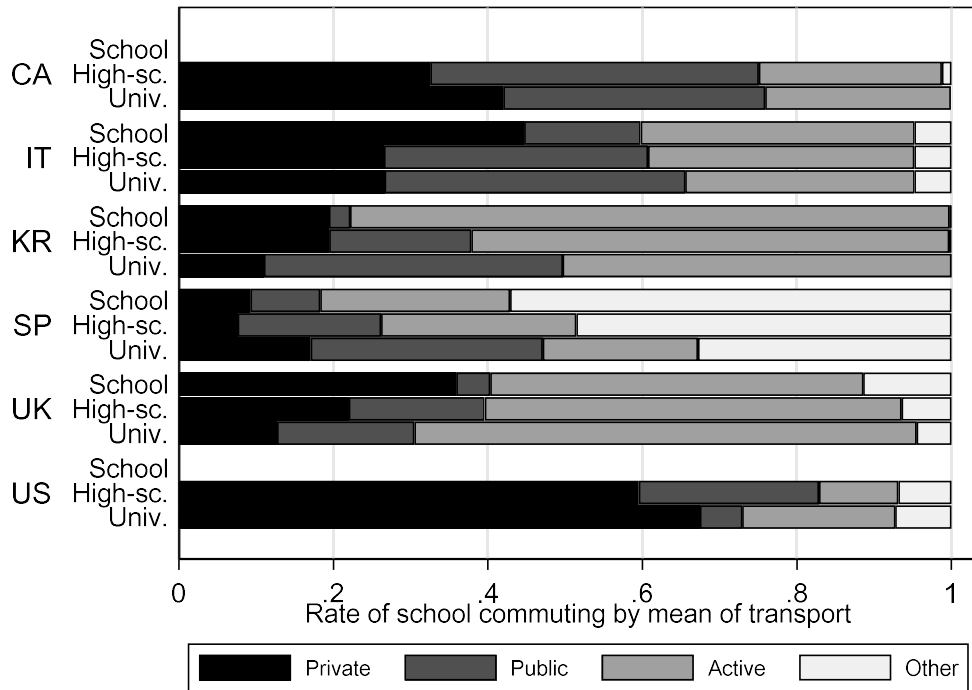
Note: The sample (MTUS 2000-2018) is restricted to student respondents who attended school and report positive school commuting during the diary day. School commuting time is measured in minutes per day.

Figure 2. Transport modes while commuting to/from school, by country



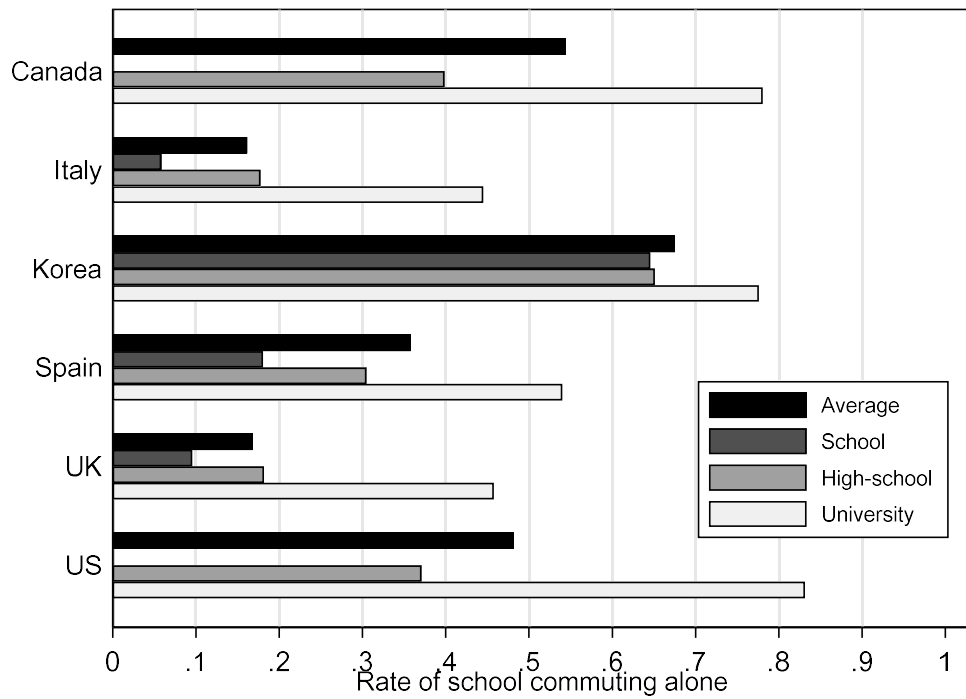
Note: The sample (MTUS 2000-2018) is restricted to student respondents who attended school and report positive school commuting during the diary day. The rates of time spent commuting by transport mode are defined as the time spent commuting to/from school using a certain mode of transport, divided by the total time spent commuting to/from school. Countries are sorted alphabetically for simplicity.

Figure 3. Transport modes, by schooling level and country



Note: The sample (MTUS 2000-2018) is restricted to student respondents who attended school and report positive school commuting during the diary day. The rates of time spent commuting by transport mode are defined as the time spent commuting to/from school using a certain mode of transport, divided by the total time spent commuting to/from school. Countries are sorted alphabetically for simplicity.

Figure 4. Rates of school commuting alone, by country



Note: The sample (MTUS 2000-2018) is restricted to student respondents who attended school and report positive school commuting during the diary day. The rate of time commuting alone is defined as the time spent commuting to/from school alone, divided by the total time spent commuting to/from school. Countries are sorted alphabetically for simplicity.

Table 1. Estimates on school commuting time, pooled sample

VARIABLES	School commuting time (min/day)			
	(1) Baseline	(2) School	(3) High-school	(4) University
Schooling:				
High-school	17.913** (6.893)	-	-	-
University	36.735*** (8.487)	-	-	-
Demographics:				
Being male	-0.459 (1.399)	1.305 (0.994)	0.533 (1.574)	-4.720 (3.373)
Two-parents	1.162 (3.621)	-3.873 (3.313)	-2.428 (1.921)	15.758 (9.551)
Family size	2.089** (0.637)	2.300** (0.718)	0.497 (0.252)	1.940 (1.345)
N. siblings	-1.775 (0.885)	-1.409 (1.439)	-0.171 (0.660)	-4.318* (2.009)
Home owned	2.046 (1.067)	-1.434 (1.961)	-0.730 (1.247)	8.317** (2.327)
Urban area	-3.182 (1.917)	-0.911 (1.180)	-3.382 (2.196)	-1.414 (5.414)
Constant	6.375 (9.745)	64.628*** (3.762)	35.255*** (2.404)	38.461** (10.392)
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Day fixed effects	Yes	Yes	Yes	Yes
Observations	12,784	2,183	7,886	2,715
R-squared	0.232	0.211	0.217	0.242

Note: Robust standard errors clustered at the country level in brackets. The sample (MTUS 2000-2018) is restricted to student respondents who attended school and report positive school commuting during the diary day. The dependent variable is the time spent commuting to/from school, measured in minutes per day. Age is measured in years. Age squared is divided by 100 for legibility.

Table 2. Estimates on school commuting time, by country

VARIABLES	School commuting time (min/day)					
	(1) Canada	(2) Italy	(3) Korea	(4) Spain	(5) UK	(6) US
Schooling:						
High-school	-	28.466*** (2.026)	7.629*** (1.578)	0.817 (1.893)	21.915*** (2.060)	-
University	13.063*** (4.482)	63.336*** (5.798)	41.249*** (4.087)	18.839*** (2.953)	50.610*** (9.936)	10.720*** (1.595)
Demographics:						
Being male	2.516 (2.705)	2.242 (2.185)	-1.131 (1.738)	-6.402*** (1.614)	3.715* (2.187)	-0.005 (1.083)
Two-parents	-3.483 (4.987)	-7.018* (4.157)	21.045*** (3.098)	3.026 (2.861)	6.783** (3.249)	-2.831* (1.454)
Family size	1.591 (1.341)	1.702 (1.695)	3.693** (1.512)	0.597 (0.945)	-1.774 (1.995)	1.972*** (0.671)
N. siblings	0.316 (4.335)	0.898 (1.832)	-4.124** (1.628)	-3.440*** (1.166)	3.334 (2.304)	-1.099 (0.773)
Home owned	6.625* (3.772)	-0.612 (2.604)	3.568* (1.831)	2.381 (2.081)	-0.300 (2.472)	-0.367 (1.403)
Urban area	-8.545** (3.769)	-0.908 (2.204)	9.367** (4.006)	-7.229*** (1.857)	-7.827 (4.856)	0.246 (1.621)
Constant	40.160*** (7.385)	36.134*** (6.442)	35.585*** (6.627)	66.086*** (4.720)	42.198*** (7.021)	25.849*** (3.771)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Day fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	874	1,590	3,084	2,627	1,151	3,458
R-squared	0.036	0.192	0.138	0.082	0.128	0.035

Note: Robust standard errors in brackets. The sample (MTUS 2000-2018) is restricted to student respondents who attended school and report positive school commuting during the diary day. The dependent variable is the time spent commuting to/from school, measured in minutes per day. Age is measured in years. Age squared is divided by 100 for legibility. Countries are sorted alphabetically for simplicity.

Table 3. Estimates on transport mode, by country

VARIABLES	Rate by transport mode					
	(1) Canada	(2) Italy	(3) Korea	(4) Spain	(5) UK	(6) US
A) PRIVATE VEHICLE						
Schooling:						
High-school	-	-0.190*** (0.024)	0.002 (0.015)	-0.014 (0.014)	-0.148*** (0.026)	-
University	0.078 (0.057)	-0.228*** (0.044)	-0.066*** (0.024)	0.101*** (0.022)	-0.170*** (0.055)	0.105*** (0.022)
Constant	0.249*** (0.083)	0.494*** (0.060)	0.285*** (0.056)	0.044 (0.035)	0.385*** (0.069)	0.536*** (0.058)
All controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	874	1,590	3,084	2,627	1,151	3,458
R-squared	0.063	0.060	0.026	0.033	0.068	0.061
B) PUBLIC TRANSPORT						
Schooling:						
High-school	-	0.188*** (0.020)	0.154*** (0.010)	0.083*** (0.016)	0.132*** (0.016)	-
University	0.004 (0.055)	0.227*** (0.039)	0.335*** (0.027)	0.141*** (0.025)	0.132** (0.053)	-0.177*** (0.014)
Constant	0.304*** (0.088)	0.068 (0.051)	-0.033 (0.052)	0.236*** (0.041)	0.156*** (0.052)	0.203*** (0.040)
All controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	874	1,590	3,084	2,627	1,151	3,458
R-squared	0.033	0.086	0.124	0.067	0.083	0.076
C) ACTIVE						
Schooling:						
High-school	-	-0.000 (0.022)	-0.156*** (0.017)	0.005 (0.022)	0.064** (0.028)	-
University	-0.076** (0.038)	-0.013 (0.039)	-0.267*** (0.031)	-0.060** (0.028)	0.121* (0.073)	0.074*** (0.016)
Constant	0.454*** (0.072)	0.349*** (0.056)	0.724*** (0.066)	0.174*** (0.044)	0.383*** (0.076)	0.140*** (0.044)
All controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	874	1,590	3,084	2,627	1,151	3,458
R-squared	0.068	0.013	0.065	0.030	0.039	0.052

Note: Robust standard errors in brackets. The sample (MTUS 2000-2018) is restricted to student respondents who attended school and report positive school commuting during the diary day. The dependent variables are the rates of time spent commuting by transport mode, defined as the time spent commuting to/from school using a certain mode of transport, divided by the total time spent commuting to/from school. Countries are sorted alphabetically for simplicity.

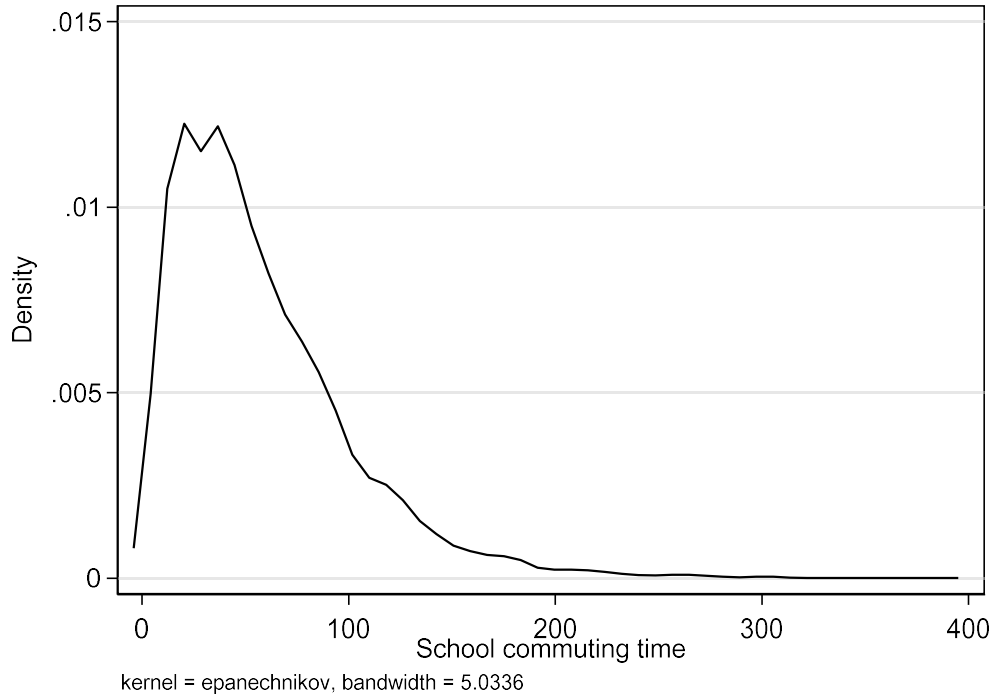
Table 4. Estimates on commuting alone, by country

VARIABLES	Rate commuting alone					
	(1) Canada	(2) Italy	(3) Korea	(4) Spain	(5) UK	(6) US
Schooling:						
High-school	-	0.113*** (0.014)	-0.001 (0.017)	0.117*** (0.018)	0.075*** (0.018)	-
University	0.335*** (0.044)	0.362*** (0.036)	0.066** (0.027)	0.306*** (0.027)	0.220*** (0.062)	0.391*** (0.019)
Demographics:						
Being male	0.077*** (0.030)	0.004 (0.014)	0.080*** (0.013)	0.057*** (0.014)	0.007 (0.018)	0.048*** (0.015)
Two-parents	-0.004 (0.051)	-0.016 (0.026)	0.002 (0.024)	-0.030 (0.027)	-0.060** (0.030)	0.003 (0.020)
Family size	-0.028** (0.013)	-0.003 (0.010)	0.022** (0.010)	-0.011 (0.008)	0.021 (0.017)	-0.001 (0.010)
N. siblings	-0.016 (0.045)	-0.014 (0.012)	-0.048*** (0.011)	-0.031*** (0.011)	-0.053*** (0.019)	-0.058*** (0.011)
Home owned	-0.044 (0.037)	0.021 (0.015)	-0.018 (0.014)	-0.010 (0.020)	-0.002 (0.022)	-0.013 (0.019)
Urban area	0.064 (0.039)	0.009 (0.014)	0.099** (0.044)	0.061*** (0.016)	0.047 (0.029)	-0.007 (0.021)
Constant	0.486*** (0.075)	0.079** (0.037)	0.520*** (0.058)	0.262*** (0.047)	0.116** (0.053)	0.546*** (0.055)
All controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	874	1,590	3,084	2,627	1,151	3,458
R-squared	0.187	0.163	0.045	0.130	0.108	0.213

Note: Robust standard errors in brackets. The sample (MTUS 2000-2018) is restricted to student respondents who attended school and report positive school commuting during the diary day. The dependent variable is the rate of time spent commuting alone, defined as the time spent commuting to/from school alone, divided by the total time spent commuting to/from school. Age is measured in years. Age squared is divided by 100 for legibility. Countries are sorted alphabetically for simplicity.

Appendix A: Additional results

Figure A1. Density of school commuting time



Note: The sample (MTUS 2000-2018) is restricted to student respondents who attended school and report positive school commuting during the diary day. School commuting time is measured in minutes per day.

Table A1. Sample composition

COUNTRY	Years	N. observations
Canada (CA)	2005, 2010	874
Italy (IT)	2008, 2009	1,590
Korea (KR)	2009	3,084
Spain (SP)	2002, 2003	2,627
United Kingdom (UK)	2000, 2001	1,151
United States (US)	2003-2018	3,458

Note: The sample (MTUS 2000-2018) is restricted to student respondents who attended school and report positive school commuting during the diary day.

Table A2. Summary statistics

VARIABLES	Mean	St.Dev.
School commuting time	56.230	44.037
Rate in private vehicle	0.346	0.438
Rate in public transport	0.216	0.364
Rate actively	0.318	0.413
Rate in other mean of transport	0.120	0.301
Rate alone	0.414	0.432
Schooling		
Attending primary school	0.170	0.375
Attending high-school	0.610	0.488
Attending University	0.220	0.414
Demographics		
Being male	0.505	0.500
Age	15.6	4.00
Two-parent household	0.754	0.430
Family size	4.021	1.233
Number of siblings	1.531	1.083
Home owned	0.726	0.446
Part-time worker	0.125	0.331
Full-time worker	0.019	0.138
Urban/suburban area	0.784	0.412
Observations	12,784	

Note: The sample (MTUS 2000-2018) is restricted to student respondents who attended school and report positive school commuting during the diary day. School commuting time is measured in minutes per day. Rates are defined as the time spent commuting to/from school in certain transport mode or alone, divided by total school commuting time. Age is measured in years.

Table A3. Country averages

VARIABLES	Canada	Italy	Korea	Spain	UK	US
<i>A) All school categories</i>						
School commuting time	51.5	59.7	84.2	65.1	52.2	34.0
Rate in private vehicle	0.361	0.339	0.177	0.108	0.270	0.614
Rate in public transport	0.392	0.271	0.198	0.206	0.121	0.190
Rate actively	0.238	0.343	0.622	0.235	0.525	0.126
Rate in other mean of transport	0.008	0.048	0.002	0.450	0.084	0.070
Rate alone	0.544	0.162	0.675	0.358	0.168	0.482
Observations	874	1,590	3,084	2,627	1,151	3,458
<i>B) Primary School students</i>						
School commuting time	-	38.867	71.222	56.495	38.652	-
Rate in private vehicle	-	0.447	0.194	0.093	0.359	-
Rate in public transport	-	0.151	0.027	0.090	0.044	-
Rate actively	-	0.354	0.776	0.246	0.483	-
Rate in other mean of transport	-	0.048	0.002	0.571	0.114	-
Rate alone	-	0.059	0.646	0.180	0.095	-
Observations	-	651	598	433	501	-
<i>C) High-school students</i>						
School commuting time	47.851	66.999	78.821	58.464	59.348	31.240
Rate in private vehicle	0.326	0.265	0.195	0.076	0.220	0.595
Rate in public transport	0.425	0.342	0.184	0.185	0.176	0.233
Rate actively	0.237	0.345	0.619	0.253	0.540	0.103
Rate in other mean of transport	0.013	0.048	0.003	0.486	0.065	0.069
Rate alone	0.399	0.177	0.651	0.305	0.182	0.371
Observations	554	751	2,007	1,395	577	2,602
<i>D) University students</i>						
School commuting time	57.469	100.350	111.617	80.750	77.865	42.486
Rate in private vehicle	0.420	0.266	0.110	0.171	0.127	0.674
Rate in public transport	0.339	0.389	0.387	0.300	0.178	0.055
Rate actively	0.240	0.297	0.503	0.201	0.650	0.198
Rate in other mean of transport	0.001	0.048	0.000	0.328	0.045	0.073
Rate alone	0.781	0.445	0.776	0.540	0.458	0.831
Observations	320	188	479	799	73	856

Note: The sample (MTUS 2000-2018) is restricted to student respondents who attended school and report positive school commuting during the diary day. School commuting time is measured in minutes per day. Rates are defined as the time spent commuting to/from school in certain transport mode or alone, divided by total school commuting time. Countries are sorted alphabetically for simplicity.