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Is Development Type a Determinant of College and Graduate Students' Commute Time to School? The Case of Seoul Metropolitan Area

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Abstract: This study examines the impact of large-scale suburban new town development on the commuting time of college and graduate students in the Seoul Metropolitan Area. Household travel diary data from 2016 were analyzed to categorize residential areas and quantify the impacts on commute time to school. Multiple linear regression modeling is used to explore the relationships between development type, individual, and household characteristics and their impact on commute times. The results of the study show that students living in new urban areas have significantly longer commute times than those living in central Seoul, highlighting the differences that result from urban expansion policies targeting middle-class housing. These results suggest that the development of suburban new towns, which was intended to alleviate the housing shortage, has inadvertently lengthened the daily commute time of many students. Thus, a critical reassessment of suburban development strategies is needed to better balance the advantages of residential neighborhoods against the educational and living costs associated with increased travel time.

Keywords: commute time to school; development type; household travel diary survey; college and graduate students; multiple linear regression model

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1. Introduction

The development of new towns has been considered a key strategy for dispersing population pressure from urban centers, mitigating rent increases, and alleviating traffic congestion, among other urban challenges [1–3]. In South Korea, the urbanization process has been accelerating since the early 1960s, accompanied by severe shortages in urban housing. Typically, the development of new towns follows two strategic directions: the development of new towns within the city and suburban new town development strategies [4]. In December 1980, the Housing Land Development Promotion Act was amended to establish the development of small-scale residential lands on the outskirts of Seoul and large-scale new town development in the suburbs as the primary means to address the housing supply issue [5].

Over the past few decades, there has been intense debate regarding the necessity and impact of new town development. Among the many issues related to new town development, the primary concerns include the self-containment of suburban new towns and the associated commuting costs. For instance, Alonso argues that the shortcoming of new town development in the United States is that it underestimates the importance of social and economic integration as well as connectivity and functionality in modern societies [6]. Additionally, other scholars have noted that the failure of new towns to achieve self-containment leads to widespread cross-district commuting between new towns and old urban areas, resulting in longer travel times and distances. They argue that the development of new towns has led to the dispersion of populations from old urban areas to the suburbs [7–9]. Early criticism was directed at the problem of lengthy commute times

in new towns [10–12], but this issue appears to have been overestimated according to later research [13–15]. This discrepancy may be due to the earlier studies overlooking the impact of strict urban green belt policies for political reasons, with [16] providing a comprehensive analysis of the political purposes of urban green belts in Korean metropolitan areas, which we will not elaborate on further here. It is precisely these green belt regulations that have forced new towns to be situated far from existing cities. Studies on travel patterns under green belt regulations have been limited to work commutes [4,12].

The phenomenon of long commute times between new towns and urban areas exists not only in the context of work commutes but is likely more prevalent and severe in school commutes. According to the 2015 Korean Commuting Population Housing Census, the proportion of employees with commute times over 1 h increased from 9.5% in 1995 to 18% in 2015 (an increase of 89.47%), while the proportion of students with commute times over 1 h rose from 8.3% to 17.1% (an increase of 106.02%). Among those with commute times exceeding 1 h, the student group saw the largest increase. Urban economic theory suggests that the premise for commuters enduring longer commute distances is the difficulty in finding affordable housing near their workplaces [9]. The places of study for student groups are comparatively more fixed, and their constraints are likely to be more stringent because, from an individual perspective, their economic capability determines their inability to afford housing near schools.

Numerous studies have found a close relationship between long commute times for university students and their participation in school activities, academic performance, satisfaction, and well-being [17–25]. Excessive commute times significantly lower students' satisfaction with their schools [17]. Studies in India have shown that long commute times negatively impact academic performance, with more than half of the students believing that excessive commute times affect their attendance [18]. A detailed study revealed that commuting students in the UK must choose between the costs of commuting and the value of academic engagement [19]. Regarding academic performance, the longer the commute time, the lower the GPA and thus the higher the dropout rate [20–22]. Finally, students living alone or with family or partners are more likely to report that excessive commute times negatively affect their campus attendance rates, engagement, extracurricular activity experiences, course selection, and academic performance [21,23–25].

This study aims to fill the gap in research on school commutes for university students under the development of suburban new towns by analyzing the impact of suburban new town development on university students' commute times. Following an analysis of literature and data, the factors found to affect university students' commute times are summarized. On the basis of the empirical results, considered in combination with the actual situation of long commute times for university students in Seoul, several suggestions for improving university students' commute times are proposed.

The remainder of this paper is organized as follows: Section 2 provides a comprehensive overview of the impact of suburban residential development on commuting patterns and previous literature on university students' commute times to and from school. Section 3 contains an explanation of the analysis methods, organization of variables, and data construction process used in this study. Additionally, validation of the research question through empirical analysis is described in Section 4. Section 5 discusses the results of the analysis and summarizes the paper, as well as provides relevant insights and recommendations in response to the findings.

2. Literature Review

2.1. Summary

The Seoul Metropolitan Area (SMA), one of the fastest-developing urban regions globally, has witnessed rapid industrialization and urbanization since the 1960s, paralleling South Korea's economic boom. Between 1960 and 1990, the population of Seoul surged from 2.45 million to 10.6 million, with a population density reaching 17,500 individuals per square kilometer, indicating extreme densification.

In December 1980, the revision of the "Act on the Promotion of Development of Residential Land" identified the development of small-scale ordinary housing land (OHLD) in Seoul's periphery and the construction of large-scale new towns in suburban areas as primary strategies to address housing supply shortages [5]. Up to 1989, many housing development projects were located on reserved lands between urban green belts [26]. However, with stricter controls on green belts and a sharp increase in the housing rent index, coupled with the political necessity of the Roh Tae-woo administration to secure votes by stabilizing middle-class housing supply, the South Korean government prioritized the development of large-scale new towns in the suburbs. These new towns were situated beyond the green belts approximately 20–45 km from Seoul's central business district, marking the initiation of various development phases [4,27].

Hence, in the late 1980s, the South Korean government focused on the massive development of new towns in the outskirts of Seoul (Figure 1), primarily to alleviate severe housing shortages and mitigate developmental pressures on Seoul city, the core of SMA. Between 1989 and 1996, five new towns were constructed (Bundang, Ilsan, Pyeongchon, Sampung, and Jungdong), targeting nearly 1.2 million people in the SMA suburbs. Despite continuing development, the government did not halt smaller OHLD projects (Table 1). According to [5], these smaller OHLD projects accommodated approximately 4.4 million people primarily concentrated around large new towns, due to the convenience of transportation systems and regional traffic networks.

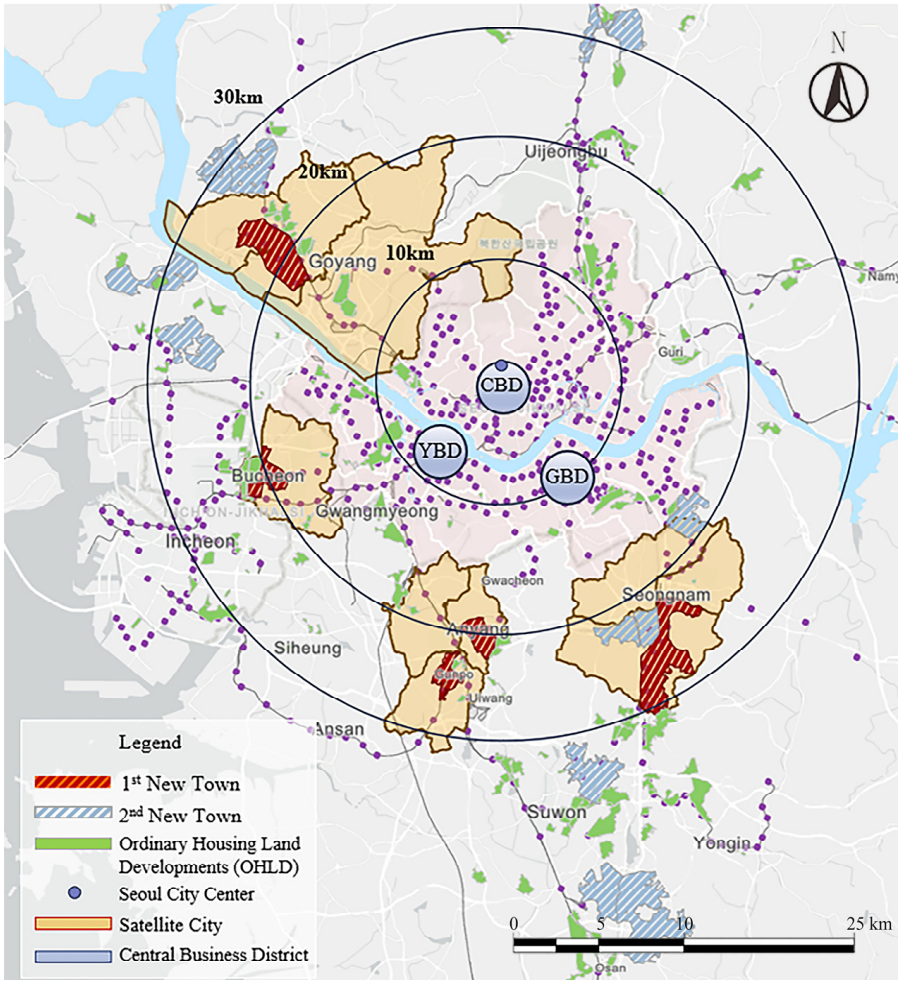

Figure 1. Urban development types in Seoul, Korea (2016). Original source: Ministry of Land, Infrastructure and Transport (2016) (created by the authors).

Table 1. Development project status.

Category	Development Project	Area (Thousand m^2)	Housing (Household)	Population (Person)
Development types	1st new town	49,346 (14.3)	284,085 (13.4)	1,136,340 (15.9)
	2nd new town	132,872 (38.6)	596,263 (28.0)	1,574,435 (22.0)
	OHLD	162,298 (47.1)	1,246,085 (58.6)	4,436,841 (62.1)
Sum		344,516 (100.0)	2,126,433 (100.0)	7,147,616 (100.0)
Region	Seoul	41,236 (12.0)	363,629 (17.1)	1,345,369 (18.8)
	Incheon	30,094 (8.7)	222,196 (10.4)	722,825 (10.1)
	Gyeonggi-do	273,186 (79.3)	1,540,608 (72.5)	5,079,422 (71.1)
Sum		344,516 (100.0)	2,126,433 (100.0)	7,147,616 (100.0)

Based on the district designation, (%). Source: Ministry of Land, Transport and Maritime Affairs (2009).

Following the 1997 Asian financial crisis, housing prices began to rise in SMA, prompting the launch of the second generation of new towns. Despite aiming for greater self-sufficiency than their predecessors [13,15], these new towns remained dependent on Seoul. The choice of more distant locations for the second-generation new towns also resulted in longer commutes for workers.

The suburban development of the first and second generations of new towns transformed SMA into a more dispersed, polycentric urban form [28]. The government-led large-scale housing supply was an effective short-term solution to stabilize the housing market. However, the reduction in self-sufficiency resulted in longer commuting times. Moreover, as the focus was on middle-class suburban development projects, the growing demand for affordable housing among low-income families was not addressed.

2.2. Suburbanization, New Towns Development, and Commuting

In the 1990s, South Korea initiated construction of its first batch of new towns, leading to widespread discussion on the issue of suburbanization caused by these new developments. On one hand, this development strategy expanded housing supply, stabilizing the market and prices, and on the other hand, it offered a living environment superior to that of older urban areas, enhancing the quality of life for residents [29,30].

However, the development of new towns also brought challenges. It led to a more concentrated population in the capital region and major urban areas, intensifying reliance on residential locations and causing transportation and environmental issues [31]. Particularly in large urban areas, the construction of new towns increased the mismatch between residents' commuting distances and their workplaces [32], normalizing long commutes and thereby exacerbating traffic congestion and environmental pollution [4,10,11]. Studies have shown that residents of large urban areas face commutes that far exceed the ideal distance between their residences and workplaces [32]. The authors of [11] found that new town residents primarily sought employment in Seoul, leading to significantly longer commuting distances than those of residents in older urban areas. Further research uncovered that suburbanization in the Seoul Metropolitan Area resulted in a decade-long increase in commuting distances by 2 km [10]. The commuting costs of new town construction outside urban green belts were quantified in [12], finding that leapfrog development generates USD 250 million in annual commuting costs, exacerbating job/residence imbalances and

especially increasing commuting distances for central city residents and the commuting dependency of new town residents. A counterfactual scenario analysis in [4] comparing situations with and without new towns revealed that while new town development alleviated traffic congestion in central cities, saving nearly USD 600 million in annual transportation costs, although these positive effects were offset by negative impacts, such as extended commuting and shopping times and increased vehicle emissions.

These findings collectively illustrate how suburbanization and new city development can lead to a series of issues, including increases in commuting distances and costs, job mismatch, traffic congestion, environmental pollution, and energy wastage. At present, comprehensive research is lacking on how new town development affects the suburbanization issues facing student populations.

2.3. Research on University Student Commuting

Existing research on the travel patterns of university students is focused on the purposes and characteristics of trips, the influence of the built environment, socio-demographic characteristics, as well as how public policies and incentives affect their choices regarding mode of transportation [33–40]. It has been found that students residing on or near campus are more inclined toward walking or cycling rather than driving [33]. Moreover, the road network density and urban sidewalk planning significantly impact students' choices of transportation mode. While an increase in road density positively affects the efficiency of automobiles and public transit, it may be influenced by increases in sidewalk density [34]. The socio-economic backgrounds of students, such as gender, education level, age, income, and living situation (e.g., living alone or with parents) also play crucial roles in determining their choice of transportation [36,37,41]. Typically, female students are less likely to choose walking over cycling compared to male students, but they prefer walking to driving [38,39]. Students not living with family members are more inclined to walk to school compared to cycling [33,41]. Policy measures, such as public transit discounts or increased parking fees, can effectively reduce driving behaviors and encourage students to utilize public transit more [39]. If the distance to school is short, students are equally likely to use public transit or drive, but the proportion choosing to drive increases if the travel time exceeds 10 min. Additionally, the accessibility of transportation in the surrounding areas also influences students' choice of travel mode [33]. Research by [40] highlighted that students' preferred transportation modes vary according to gender, grade level, family members, and whether they work full-time.

However, there is a scarcity of research on the commuting time of university students to school. The existing studies only explore the impact of individual travel characteristics and different education level categories on university students' commuting time. The choice of commuting mode and time slots for going to and from school was examined in [42] using a nested logit model, finding that grade, gender, arrival time at school, and the distance to parking lots, bus stations, and lecture halls significantly influence the choice of time slot. The determinants of commuting time were analyzed for higher education attendees in Mexico City using an OLS regression model [43], and the findings indicated that under higher educational levels, the impact of demographic variables weakens, while the relevance of regional urban form variables increases.

In summary, the research field of commuting times for university students to school warrants further exploration. Unlike work activities that can be carried out in multiple locations, schooling activities are confined to specific educational infrastructures. As a result of this limitation, long-distance commuting becomes inevitable when residences are far from schools. Long-distance commuting to school imposes a "tax" on household resources, necessitating the allocation of resources in terms of time or budget for students' commuting arrangements. However, the magnitude of this "tax" is influenced by the students' household income, housing affordability, and access to transportation resources.

3. Model and Survey

3.1. Hypothesis and Analysis Model

The spatial scope of this study was the Seoul Metropolitan Area, as it comprises more than half of South Korea's population and has heavy urban traffic. University and graduate students in higher education were the study targets.

Accordingly, the research aims to address the following research hypothesis: (1) Do students living in new towns have a longer commute to school than those living in Seoul? (2) Are there differences in school commute time among college students with different family income types? (3) Do residential development type characteristics strongly influence college students' school commute time when controlling for socio-demographic and economic characteristics?

In this study, multiple linear regression analysis models were applied in analyzing the personal, family, development, choice of transportation means, and mass transit proximity condition characteristics that affect college and graduate students' commute time to school. The model is as follows:

$$Y_i = \beta_0 + \beta_1 x_1 \quad (1)$$

$$Y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 \quad (2)$$

$$Y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 + \beta_{10} x_{10} + \beta_{11} x_{11} \quad (3)$$

where *Yi* represents the dependent variable, which is the commute time to school; *I* represents the *i*th data (or the *i*th student); β represents the coefficient of each explanatory variable; and *Xs* is the independent variable. The model controls variables related to personal characteristics, household characteristics, and transportation characteristics regarding commute time to school. x_1 is development type; x_2 (sex), x_3 (age), x_4 (driver's license), x_5 (no. of family members), x_6 (car ownership), x_7 (housing type), and x_8 (monthly household income) are the personal and household characteristics; x_9 (main transportation means), x_{10} (proximity to bus stop), and x_{11} (proximity to subway station) represents the transportation characteristics.

3.2. Study Area and Data

In this study, data from the 2016 Household Travel Diary Survey were used to analyze factors affecting commute times for undergraduate and graduate students. This survey is conducted every five years and is based on individual and household statistics and include data on the number of household members, type of residence, income level, household vehicle ownership, personal circumstances of household members, and transportation travel. Considering that the study population comprises college and graduate students, data from this survey and on college and graduate students' enrollment in formal educational institutions were selected to determine the purpose of commuting to school. In addition, anomalous data that were far from most of the sample points and out of context were excluded from this study. Therefore, outliers with commute times exceeding 240 min (N = 21) and distant samples exceeding 80 min in the public transportation proximity characteristic (N = 3) were excluded from the analysis to ensure data authenticity. Finally, a total of 7471 survey data were available for analysis.

3.3. Variables

The dependent variable in this study was the students' commute time to school. School commute time is defined as the time taken from the place of residence to the destination. The entire school commute process did not include cases in which other purposeful activities were conducted during the commute. The calculation of time use included the time spent moving to the point of a chosen transportation mode, time spent using transportation, and time spent waiting for transportation.

Through the consolidation of previous research, it has been observed that studies on the commuting time of university students to school are insufficiently comprehen-

sive [42,43], being primarily limited to the individual level of students and lacking comprehensive consideration of their family situations. Given the absence of direct analysis on the factors affecting commuting time for university students in current research, we drew upon studies related to the commuting time of employees for selecting the variables in our empirical analysis. In the existing research on socio-economic factors affecting employees' commuting time, gender emerged as a significant factor influencing commuting behaviors. Numerous studies have indicated that due to family responsibilities and shorter returns from work, women have shorter commuting distances and times compared to men [44–51], leading them to choose work locations closer to home [49,50]. However, in cases where women's working hours aligned with men's, their commuting distances match or even exceed those of men. Páez and Farber [52] identified a non-linear relationship between an individual's age and their commuting time, with middle-aged individuals experiencing longer commuting times compared to younger and older people. Moreover, an individual's commuting distance increases with age, peaking between 40 and 44 years [53]. In contrast, [49] found a weaker relationship between age and commuting distance. Household income could influence an individual's commuting time through a trade-off effect [44,45,48,50,54,55]. Some studies suggest a positive correlation between income and commuting time [44,45,50,54]. However, Zhao and Lyu [51] note that recent evidence, consistent with other research [48,55], indicates that higher household incomes are associated with shorter commuting times, likely due to higher-income families' ability to choose housing locations with shorter commutes. Compared to students living in apartments, those residing in multi-family and single-family homes, residential–commercial complexes (i.e., officetels as defined by Korean law), and other types of residences have shorter commuting times [44,45]. Additionally, mixed-use complexes are closer to public transportation [56]. Moreover, compared to temporary workers and other occupations, formal workers and salespeople have shorter commuting times [47]. Lastly, individuals either living in dual-income households or that own their own homes have shorter commuting times to and from work [44,45,47,57].

Therefore, the independent variables in this study were development, personal, family, and transportation characteristics. Development characteristics refer to the five main development types (i.e., new towns, ordinary housing land development (OHLD), Seoul, Incheon (other areas excluding new towns and general housing land development), and Gyeonggi-do (other areas excluding new towns and general housing land development)). Personal characteristics include sex, age, and possession of a driver's license. Household characteristics include the number of household members, number of valuable vehicles owned by the household, housing type, and average monthly household income. The housing types are classified as apartments, multi-family, single-family, and residential–commercial complexes. Condominiums are distinguished from other housing types by their physical nature and appearance, as they are generally required to have five or more stories by law. Multi-family, single-family, and detached houses, which are low-rise buildings (i.e., five stories or less), differ slightly from a legal aspect but have similar physical characteristics. Thus, they are grouped in this study. Residential–commercial complexes are generally close to subway station areas; hence, occupants have an advantage in terms of their proximity to public transportation. The physical characteristics and availability of transportation facilities vary by development type. Transportation characteristics describe the main transportation options for students' commute to school, including non-motorized travel (i.e., walking, cycling), private vehicles, public transportation, and other modes. This study focused on commuting to school and designated the mode of transportation that takes the longest throughout the entire commute as the primary mode of transportation. For example, in the case of a student who starts from their residence, walks to the subway station, takes the subway, goes to the subway station near their destination, and then continues to walk to their destination, mass transit mode was designated as the primary mode of transportation in this study. As free transfer between the subway and bus within a short time is possible, the subway and bus were classified as mass transit trips when used together in the same

period. Finally, the proximity characteristics included two variables: time spent walking to the nearest subway station and the nearest bus stop (Table 2).

Table 2. Definition of variables.

Variable	Description
Dependent variable	Commute time to school
Development characteristics	
X_1 Development type	New towns (ref.), Seoul, ordinary housing land development (OHLD), other Gyeonggi-do areas, other Incheon areas
Personal Characteristics	
X_2 Sex	Male (ref.), female
X_3 Age	Year
X_4 Driver's license	Yes (ref.), no
Household characteristics	
X_5 No. of family members	Person
X_6 Car ownership	Yes (ref.), no
X_7 Housing type	Apartment (ref.), multi-family housing, single-family housing, residential commercial complex (e.g., officetel), other
X_8 Monthly household income	Less than KRW 3 million (ref.), between KRW 3–5 million, more than KRW 5 million
Transportation characteristics	
X_9 Main transportation means	Public transportation (ref.), non-motorized travel, private vehicle, and other
X_{10} Proximity to bus stop (walking)	Minutes
X_{11} Proximity to subway station (walking)	Minutes

Note: KRW 1022 ≈ USD 1 as of December 2016.

4. Results

4.1. Descriptive Statistics

The descriptive analysis results from Table 3 drew from a sample of 7471 college students within the Seoul Metropolitan Area, providing multidimensional insights into their commuting times, driver's license ownership rates, family characteristics, living conditions, and modes of transportation. The distribution of the samples included 470 students from new towns, 1177 from ordinary housing land development (OHLD) areas, 2886 from existing urban areas in Seoul, 2317 from Other Gyeonggi-do areas, and 621 from other Incheon areas. College students had an average one-way trip commute of 69.7 min to school. Notably, 42.90% of students possessed a driver's license, despite typically being from lower-income groups; this reflects a growing trend among South Korean college students to acquire practical skills, such as driving, in a competitive job market. A significant majority, 80.5%, of families in the sample owned at least one car. In terms of housing, 61.9% of students lived in apartments, 20.6% in multi-family homes, and 15.3% in single-family houses. Over three-quarters of the families reported a monthly income above KRW 3 million, surpassing the average household income of KRW 3.71 million as reported in 2016. A large proportion of students resided in Seoul (38.6%), and only a small fraction commuted from new towns or various other housing types (6.3%). Public transportation was the primary commuting method for 86.9% of students, with an average walking time of 5.2 min to the nearest bus stop and 11.0 min to the nearest subway station, highlighting the convenience of public transport options.

Table 4 presents a descriptive analysis of commute times to school, highlighting the relationship between various characteristics and travel duration. An initial examination of the developmental type revealed a significant disparity in commute times, with residents of new towns experiencing the longest average travel time, of 80.4 min, and Seoul inhabitants the shortest, at 57.6 min. This variance underscores the substantial impact of residential area development type on commute duration, as confirmed by the F-test results ($F = 146.971$, $p < 0.001$) indicating statistically significant differences. Such findings

suggest that suburban new town developments contribute to extended travel times to school, notably longer by an average of nearly two minutes compared to similarly distant areas such as in other Gyeonggi-do areas.

Table 3. Descriptive analysis.

Variable		Mean/n	SD/Ratio	Min.	Max.
Commute time to school		69.7	36.1	2.0	240.0
Development characteristics					
X_1 Development type	New towns	470	6.3		
	Seoul	2886	38.6		
	OHLD	1177	15.8		
	Other Gyeonggi-do areas	2317	31.0		
	Other Incheon areas	621	8.3		
Personal characteristics					
X_2 Sex	Male	3807	51.0		
	Female	3664	49.0		
X_3 Age		22.1	3.0	15	84
X_4 Driver's license	Yes	3204	42.9		
	No	4267	57.1		
Household characteristics					
X_5 No. of family members		3.5	1.0	1.0	5.0
X_6 Car ownership	Yes	6017	80.5		
	No	1454	19.5		
X_7 Housing type	Apartment	4622	61.9		
	Multi-family	1538	20.6		
	Single-family	1141	15.3		
	Residential–commercial complex	170	2.3		
X_8 Monthly household income	<KRW 3 million	1833	24.5		
	KRW 3–5 million	2903	38.9		
	>KRW 5 million	2735	36.6		
Transportation characteristics					
X_9 Main transportation means	Non-motorized travel	638	8.5		
	Private vehicle	317	4.2		
	Public transportation	6492	86.9		
	other	24	0.3		
X_{10} Proximity to bus stop (min)		5.2	2.7	1.0	30.0
X_{11} Proximity to subway station (min)		11.0	8.6	1.0	80.0

Table 4. Descriptive analysis of commute time to school between characteristics.

Variable		Mean	SD	F-Test /T-Test
Development characteristics				
X_1 Development type	New towns	80.4	37.0	F= 146.971 p = 0.000 ***
	Seoul	57.6	28.9	
	OHLD	76.8	35.8	
	Other Gyeonggi-do areas	77.8	38.2	
	Other Incheon areas	75.0	38.0	
Personal characteristics				
X_2 Sex	Male	69.8	36.6	t = 0.036
	Female	69.7	35.5	p = 0.972
X_4 Driver's license	Yes	69.5	36.8	t = −0.538
	No	69.9	35.5	p = 0.591

Table 4. *Cont.*

Variable		Mean	SD	F-Test /T-Test
Household characteristics				
X_6 Car ownership	Yes	72.9	35.0	t = 15.850
	No	56.5	37.3	p = 0.000 ***
X_7 Housing type	Apartment	74.0	34.9	F = 68.959 p = 0.000 ***
	Multi-family	63.2	35.6	
	Single-family	64.4	37.8	
	Residential–commercial complex	48.2	38.8	
X_8 Monthly household income	<KRW 3 million	62.7	39.9	F = 47.861 p = 0.000 ***
	KRW 3–5 million	72.5	34.8	
	>KRW 5 million	71.5	33.9	
Transportation characteristics				
X_9 Main transportation means	Non-motorized travel	18.7	12.9	F = 687.407 p = 0.000 ***
	Private vehicle	47.7	26.4	
	Public transportation	76.0	33.5	
	other	32.7	19.1	

Note: *** $p < 0.001$.

Regarding personal and household characteristics, although no significant differences were noted in commute times based on gender (t = 0.036, p = 0.972) or driver's license possession (t = −0.538, p = 0.591), car ownership and housing type were closely associated with commute durations. Vehicle owners reported an average commute time of 72.9 min, significantly longer than that of non-owners at 56.5 min, as evidenced by t-test (t = 15.850, $p < 0.001$). This finding highlights a significant correlation between car ownership and increased commute times. Moreover, substantial variations in travel time were observed across different housing types (F = 68.959, $p < 0.001$) with students residing in mixed-use complexes experiencing the shortest commute times (48.2 min). This is attributed to such housing types typically being located within "station influence areas" in South Korea, offering optimal access to public transportation. Conversely, students living in apartments reported the longest school commute times (74.0 min), a consequence of the development of new towns in the urban periphery, which predominantly supply large-scale apartment housing.

Lastly, the relationship between monthly household income and commute time draws particular attention. The cohort with monthly earnings of KRW 3–5 million exhibited the longest average commute time of 72.5 min, with F-test results (F = 47.861, $p < 0.001$) indicating significant differences in commute times across income levels. This phenomenon likely reflects the tendency of middle-class families to reside in newly developed towns situated farther from urban centers, subsequently facing longer travel times to school. This analysis underscores the complexities of urban development and its implications for commute times, necessitating a nuanced approach to city planning and transportation policy aimed at mitigating the travel burden of students.

4.2. Multiple Linear Regression Analysis

Empirical analysis (Table 5) investigated the impact of developmental characteristics on the commuting time to school for undergraduates and postgraduates. Model 2 incorporated individual and household socio-economic factors, with further extension in Model 3 by including critical transportation characteristics. These models were tested for the efficacy and robustness of the variables, with all models demonstrating statistical significance. Moreover, no multicollinearity was observed among the variables, as the variance inflation factor (VIF) values for all variables in Model 3 were below 5 (the threshold for determining multicollinearity).

Table 5. Multiple regression analysis of college and graduate student's commute time to school (dep. variable = commute time to school).

		MODEL 1		MODEL 2		MODEL 3		
		Coef.	**β**	**Coef.**	**β**	**Coef.**	**β**	**VIF [(a)]**
Constant		80.366 ***		63.921 ***		78.543 ***		
Development type (ref. = new towns)	Seoul	−22.828 ***	−0.308	−20.028 ***	−0.270	−21.785 ***	−0.294	4.590
	Ordinary housing land development (OHLD)	−3.602 ***	−0.036	−3.896 **	−0.039	−4.606 ***	−0.047	2.980
	Other Gyeonggi-do areas	−2.556 ***	−0.033	−0.586	−0.008	1.589	0.020	4.252
	Other Incheon areas	−5.380 ***	−0.041	−4.854 **	−0.037	−7.597 ***	−0.058	2.231
Sex (male = 0, female = 1)				−0.654	−0.009	−1.039	−0.014	1.080
Age				−0.039	−0.003	0.136	0.011	1.107
Driver's license (yes = 0, no = 1)				0.799	0.011	−0.888	−0.012	1.161
No. of family members				5.144 ***	0.139	1.567 ***	0.042	1.569
Car ownership (yes = 0, no = 1)				−6.452 ***	−0.071	−2.582 **	−0.028	1.563
Housing type (ref. = apartment)	Multi-family housing			−3.119 ***	−0.035	−0.987	−0.011	1.237
	Single-family housing			−5.667 ***	−0.057	−1.900 *	−0.019	1.175
	Officetels and others			−12.218 ***	−0.051	−2.339	−0.010	1.107
Monthly household income (ref. = under KRW 3 million)	KRW 3–5 million			1.806	0.024	−1.073	−0.015	2.149
	More than KRW 5 million			−0.600	−0.008	−1.737	−0.023	2.359
Main transportation means (ref. = public transportation)	Non-motorized					−55.060 ***	−0.427	1.185
	Private vehicle					−33.508 ***	−0.187	1.048
	Other					−43.316 ***	−0.068	1.006
Time spent walking to the nearest bus stop						−0.197	−0.015	1.037
Time spent walking to the nearest subway station						−0.216 ***	0.051	1.082
N		7471		7471		7471		
R2		0.073		0.121		0.305		
Adjusted R2		0.072		0.119		0.304		
F		146.971 ***		73.328 ***		172.350 ***		

Note: [(a)] VIF is for Model 3, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.001$.

Transitioning from Model 1, which solely comprised development characteristic variables, to Model 3, development types such as Seoul, ordinary housing land development (OHLD), and other Incheon areas exhibited significantly shorter commuting times to school compared to new towns. In Model 1, the adjusted R-squared value (0.072) was not notably high. However, as more socio-economic and transportation characteristic variables were added, the adjusted R-squared value increased. With the inclusion of individual and household socio-economic factors in Model 2, the adjusted R-squared value was 0.119. Model 3, which is an expansion including transportation characteristics, has the highest explanatory power, with an adjusted R-squared value of 0.304. This indicates that even after controlling for other variables, students residing in Seoul spend 29.4% less time commuting compared to those in new towns, while those in OHLD and other Incheon areas spend 4.7% and 5.8% less time, respectively.

Specifically, Model 3 revealed that students living in Seoul experienced significantly shorter travel times to and from school compared to those in new towns, even after adjusting for other variables. This consistent effect across all models highlights the impact of development type on commuting time. Regarding socio-demographic factors, the number of family members was positively correlated with commuting time, indicating that larger family sizes are associated with longer commuting times. Interestingly, car

ownership was negatively correlated with commuting time, suggesting that owning a car can reduce commuting times. In terms of transportation characteristics, the choice of transportation mode significantly influenced commuting time. Notably, commuting by non-motorized transport, private car, and other modes substantially reduced commuting time compared to public transport. This finding emphasizes the importance of transportation mode choice on commuting time. Lastly, regarding proximity to public transport, the relationship between the time spent walking to the nearest bus station or subway station and commuting time was mixed: while walking time to the nearest bus station had a negligible impact on commuting time, walking time to the nearest subway station was associated with reduced commuting times, highlighting the value of choosing efficient public transportation options nearby.

The empirical analysis demonstrated that development type, especially suburban new town developments targeting the middle class, significantly affects the commuting times of undergraduates and postgraduates, thereby supporting the research hypothesis. This effect persists even when considering socio-demographic and transportation characteristics, indicating the challenges of long commuting times to school presented by suburban residential development projects.

5. Discussion and Conclusions

This study utilized multiple regression analysis to examine the determinants of commuting time among college students and graduate students in the Seoul Metropolitan Area, focusing on whether urban development characteristics influence students' travel time. It confirmed the hypothesis that the development of new towns promotes suburbanization, leading to longer times for commuting to school.

The push toward suburbanization due to new town development is evident not only in work commutes [4,28] but also in college and university students' commutes. In particular, significant differences in commute times were observed between students of new towns and other development types (such as ordinary housing land development (OHLD), Seoul, other Incheon areas). Furthermore, the study found that socio-economic characteristics have a negligible impact on commute time to school, suggesting that physical location and types of urban development play a more critical role in determining the commute times of college students and graduate students.

As primary participants in higher education and advocates for future societal development, college students possess a heightened ability to rationally understand and judge, enabling them to respond to and actively practice policies and regulations beneficial for environmental improvement. Hence, analyzing the commuting behaviors of college students can contribute to achieving the goals of the "Seoul 2030 Transportation Vision", which aims to increase the proportion of green transportation (such as walking, cycling, and using public transit) from the current 70% to 80% by 2030 and to reduce per capita greenhouse gas emissions from 1.2 tons/year to 0.8 tons/year.

This research challenges traditional expectations regarding the impact of socio-economic factors on commuting behavior and highlights the importance of urban planning and residential development strategies in addressing commuting-related issues. Given the minimal influence of socio-demographic factors on commuting time, this underscores the necessity for comprehensive transportation planning that caters to the needs of all student groups, regardless of their socio-economic backgrounds. To narrow the gap in college students' commuting times, it is suggested that policymakers, urban planners, and transportation planners should develop and implement plans focusing on the influencing factors, such as road construction, public transit, or policy housing. Improving public transportation efficiency is crucial but often requires significant time and financial investment. Thus, school-related policies may offer quicker and more efficient solutions. For example, schools could expand on-campus housing facilities, giving priority to students from distant new towns by offering reasonably priced campus accommodation to reduce their commuting burden and enhance their academic participation and overall well-being. Commuting

distances could be decreased by encouraging higher education institutions to establish branches or learning centers in new towns or densely populated areas. Providing flexible course schedules, including evening and weekend classes, to accommodate students with long commutes, as well as encouraging online and blended learning models could reduce the time and energy students spend on commuting. However, recent studies on the impact of online versus in-person learning on educational quality suggest that online learning could have negative effects due to reduced engagement; thus, the last recommendation should be approached with caution and rationality.

In future research, improvements could be incorporated in the following three areas. First, by expanding the sample size of surveyed data regarding actual enrollment conditions and including more variables related to student enrollment characteristics. Second, by analyzing the 2021 data on household travel in the Seoul Metropolitan Area to examine the impact of youth housing and happiness housing policies on commuting times. Third, addressing data limitations related to the analysis being restricted to 2016, before the completion of the second phase of new town construction, which may have resulted in extended commuting times due to the lack of basic transportation infrastructure. This issue should be investigated in future research.

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