Probit Analysis of School Closures in Hamilton Ontario

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Abstract

Does the process of school closures and amalgamation negatively affect students from poorer socioecoomic backgrounds? This study uses census data and historical school catchment maps to study the distributional effects of school closures in Hamilton, Ontario from 2006 to 2016.

Introduction

School closures in the city of Hamilton became a contentious issue in 2002, when the Harris government appointed Jim Murray as special supervisor to oversee a rationalization of the Hamilton-Wentworth District School Board (HWDSB) in the face of trustee opposition to closure of under-utilized schools (Honey (2002); Prokaska (2012)). The following years saw a wave of public board school closures and replacements in Hamilton, aiming to reduce per-pupil education costs in the face of urban demographic change, and to access new provincial construction funding. Resistance to the consolidation process eventually relented, and this accommodation review system has since become institutionalized at the HWDSB; the Hamilton Catholic board (HWCDSB), facing similar overcapacity issues, has followed suit.

Given the wave of school reorganizations that occurred over the past twenty years, it makes sense to look at whether these closures had a social equity effect: neighbourhoods certainly didn't suddenly find themselves without any school at all, but distance to schools would have increased in areas where school closures occurred. Did this increase in walking distance disproportionately affect the poor?

This paper will examine the likelihood of a HWDSB or HWCDSB school being closed between the years of 2006 and 2016, dependent on the income and deprivation characteristics and trends of each census dissemination area over that same period of time.

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Data

Census Data

First, a compact set of Hamilton dissemination area level census data and GIS dissemination area shapefiles for census years 2006 and 2016 were downloaded from CHASS; areas with NA or zero values for Average After-Tax Income, and NA values for Percent Children 0-5 Low Income, were dropped from the dataset. Since this paper's analysis is performed at the 2006 dissemination area level of support, 2016 data was appended to the 2006 data frame; the 23 dissemination areas of 2006 which were split by the time of the 2016 census were identified in R, verified manually in ArcGIS, and 2016 data was then manipulated to append to the data frames for those subsequently-split 2006 DAs. Then, the 2006 and 2016 data was used to calculate each DA's percent change in average household after-tax income, and absolute change in population ages 0 to 14.

Flagging DAs for school closure

An incomplete set of shapefiles was received from the HWDSB for primary, middle school, and secondary school catchments from the years 2005 to 2019; this set of files was checked for veracity against the archive of the HWDSB website available at archive.org, as well as against news reports of school closures throughout that period, to produce a complete and checked set of HWDSB school catchment GIS files. For this paper, the 2005-6 primary-school catchment file was then modified to add a flag for all primary school catchments where the primary school was subsequently closed by 2016.

A spatial join was then done in ArcGIS between the flagged 2006 HWDSB elementary school catchment file and the 2006 dissemination area shapefile, in order to add a flag to each 2006 DA to identify whether its public school had closed by 2016. The file created was then manually verified for the condition of each DA, and a flag was created for each DA to identify whether it was (mostly or completely) inside the catchment of a subsequently closed school. The resulting map, showing wwhich Hamilton DAs experienced a school closure between 2006 and 2016, is shown in Figure 1. (Note that the closure of Bell Stone school in south Glanbrook is not shown, in order to show more detail for the rest of the city.)

For Catholic school closures, the same work was performed in ArcGIS: a spatial join was performed between closed Catholic elementary catchments and DAs, and it was manually verified. In the case of Catholic schools, however, lack of hard data between 2006 and 2010 meant that some pre-2010 boundaries had to be assumed. The map showing which Hamilton DAs experienced a Catholic primary school closure from 2006 to 2016 is shown in Figure 2.

Exploratory Analysis

An initial investigation can use density plots to determine whether there is a difference in catchments, between those with a school closure and those without,

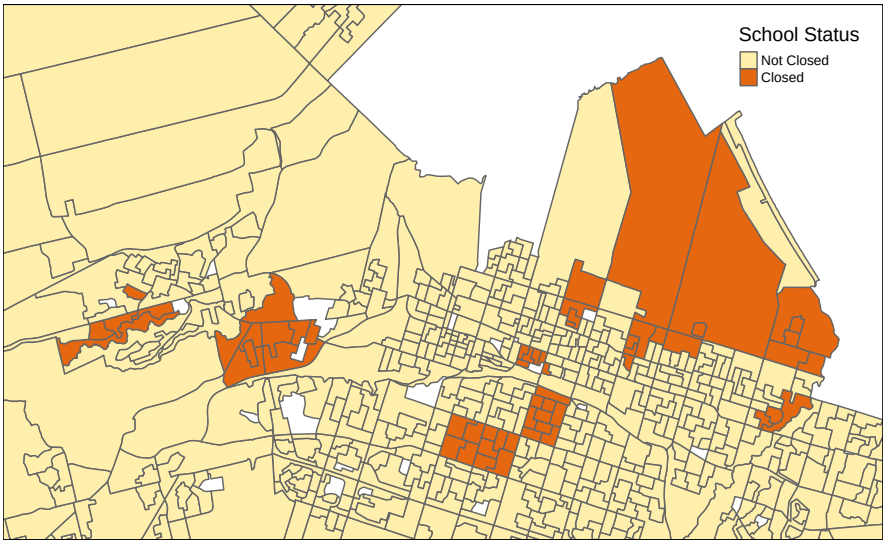

Figure 1: map of DAs with public primary school closures

for various variables in the census data. In Figure 3, for example, it can be seen that for both the HWDSB and HWCDSB, schools from catchments with a lower average after-tax household income were more likely to be closed; this, however, could certainly be due to the difference in incomes across Hamilton, since areas seeing housing growth (and thus high utilization of schools) are less likely to see school closures, while older areas with no housing growth (and thus possible under-utilization of schools that were built for a larger child population) would be more likely to see schools close. Contrast this with the density plots for DA delta income in Figure 4, for example: neighbourhoods showing lower income growth from 2006 to 2016 seem to be marginally *less* likely to see their school close.

Probit Analysis

A probit of the form

$$Pr(Y = 1|X) = \Phi(X^T\beta)$$

can be used to determine whether or not any socioeconomic factors for a DA are correlated with the binary outcome of school closure. In this case, Y is a vector of binary (1/0) flags for school closure, X is a vector of socioeconomic characteristics for each DA, and β is the coefficient vector to be solved.

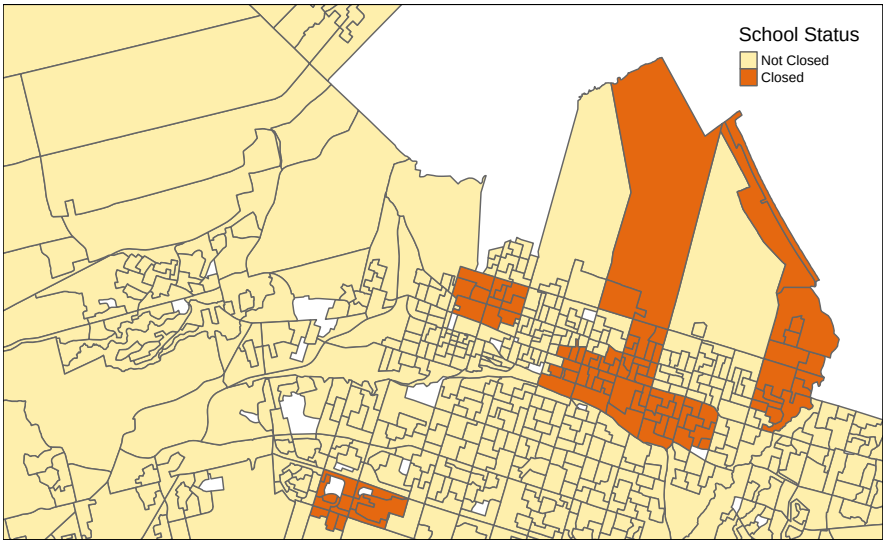

Figure 2: Map of DAs with Catholic primary school closures

Table 1: Regression variables used

Variable	Meaning
deltaincome	percent change in DA average aftertax household income, 2006-2016
deltapop0to14	absolute change in child (0-14) population, 2006-2016
POP0TO142006	child (0-14) population, 2006
log(AVGAFTERTAXINCHH2006)	natural log of 2006 average after-tax household income
PERCLOWINC0TO52006	percent of children 0-5 under family low-income threshold, 2006

Two separate probit regressions were performed using *glm* in R, using a limited set of socioeconomic characteristics from the 2006 and 2016 census, to determine whether school closure was more likely to happen in DAs with certain socioeconomic characteristics. The variables used in the probit regressions for this paper are shown in Table 1; regression results for both Catholic and Public schools are compared in Table 2.

Discussion

As can be seen in Table 2, there is a significant negative relationship between 2006 household after-tax income and likelihood of public or Catholic primary school closure in Hamilton. This may be simply due to most school closures taking place in the older lower city where lower income housing is prevalent;

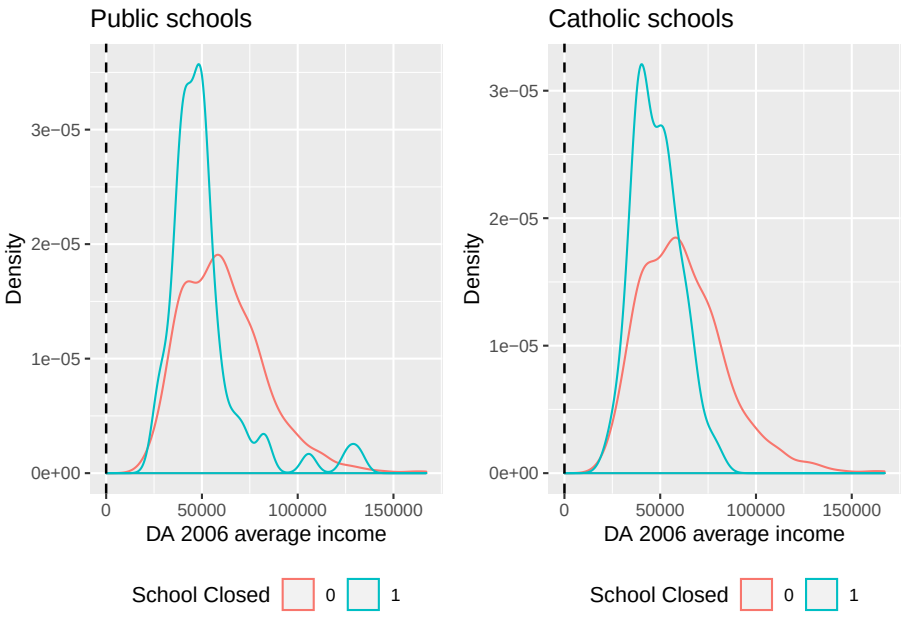

Figure 3: Income characterists of closed and non-closed DAs

Table 2: Regression results: Likelihood of school closure

Variable	Public		Catholic	
	β	p-val	β	p-val
(Intercept)	9.260	< 0.001	9.136	< 0.001
deltaincome	-0.966	0.017	-0.193	0.541
deltapop0to14	-0.003	0.269	-0.001	0.414
POP0TO142006	-0.002	0.164	-0.001	0.275
log(AVGAFTERTAXINCHH2006)	-0.857	< 0.001	-0.923	< 0.001
PERCLOWINC0TO52006	-0.001	0.755	0.003	0.258

Note:
AIC (Public) = 417.67
AIC (Catholic) = 542.74

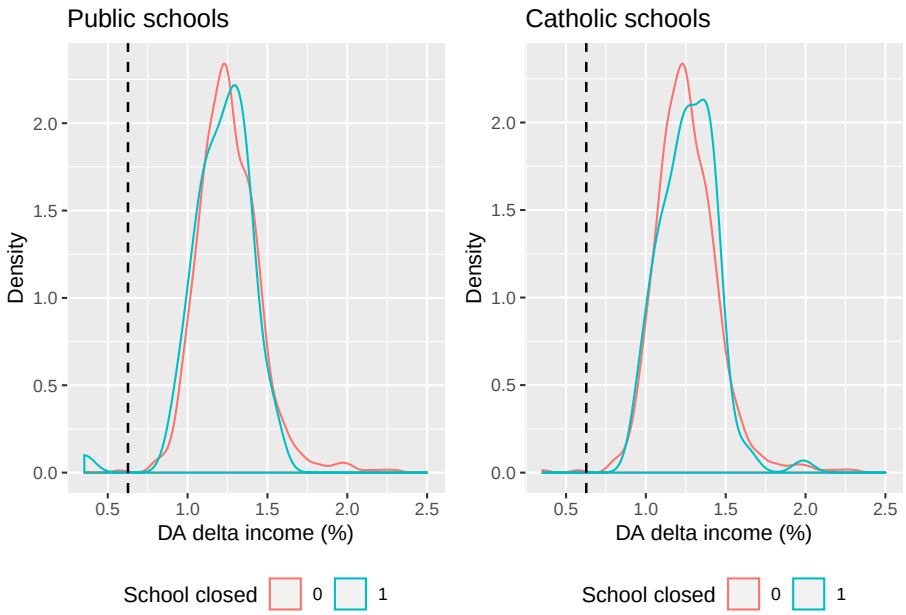

Figure 4: Delta income characterists of closed and non-closed DAs

newer areas of the city, which have more expensive houses and thus would require a higher after-tax income for residents, have seen net new construction of schools, with only a few school closures taking place south of the Lincoln Alexander Parkway.

The difference in Catholic and public regressions, for the variable of delta income, is an interesting result; Figures 1 and 2 show a locational difference in lower-city Catholic and public closures, with closed Catholic schools more likely to be located south of King Street, with closed public schools more likely to occur in the north end of the city. The significance of delta income for the public, and not Catholic, board may thus be an artifact of the gentrification that took place in the North End over the study period.

Since the public board combined lower-city school closures with rebuilding of several lower-city schools, a road to further understanding would be to conduct a regression of school age on the socioeconomic variables used in this paper, to illustrate whether longer walking distances to schools caused by HWDSB closures may have been offset by an improvement in the capital stock of lower-city schools. Another interesting study would involve seeing whether school age correlates positively with per-student education costs, to determine if the economic efficiency of education is affected by building age; this would require finding per-student education costs for each school.

References

Honey, K., 2002. Supervisor sees surplus for hamilton schools. The Hamilton Spectator 30 Oct 2002.

Prokaska, L., 2012. Spectator's view: School closures painful but necessary. The Hamilton Spectator 9 May 2012.