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Published in:
Journal of Rural Studies

DOI:
10.1016/j.jrurstud.2021.09.016

Publication date:
2021

Document version:
Final published version

Journal of Rural Studies 87 (2021) 226–235

Contents lists available at ScienceDirect

Journal of Rural Studies

journal homepage: www.elsevier.com/locate/jrurstud

Do rural school closures lead to local population decline?

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ARTICLE INFO

Keywords:
School closure
Village
Population development
Difference-in-differences (DiD)
Interviews
Mixed methods
Social capital
Housing markets
Denmark

ABSTRACT

In Denmark, many rural schools have been closed since 2000. These school closures have often resulted in heated debates between local politicians and the local population. Locals have feared that closing their school would have adverse effects and lead to local population decline. Meanwhile, previous research has found mixed evidence on the population effect of rural school closures. The aim of this paper is to contribute to the existing literature by looking at the case of Denmark. The paper analyses the local population effects of the simultaneous closure of eight village schools in 2011 in the same peripheral municipality in Denmark. The case study offers a quasi-experimental setting, and the population effects are estimated through an ordinary and a flexible difference-in-differences (DiD) analysis. Overall, the results show clear evidence of a negative population effect of rural school closures. The ordinary DiD analysis shows a population decline of 7.6 percentage points during the 10-year post-closure period. The flexible DiD analysis points to long-term effects, as the population decline first becomes statistically significant from the sixth year following the closures and onwards. To qualify the results of the econometric tests, we report findings from interviews with local people carried out in 2015 in four of the eight rural communities. Among other things, findings from interviews point to lock-in effects in terms of social capital and housing markets, which helps to understand the dominance of long-term population effects from school closures.

1. Introduction

Heated debates on closures of public primary schools have for decades been going on in many countries around the world. Especially in many sparsely populated, rural areas schools have been closed *en masse*, as often as a result of cuts in public budgets (Kirshner et al., 2016, p. 202). This has also been the case in rural Denmark, where many schools have been closed. Hence, from 2000 to 2020, there has been a decline in the number of schools of 45% and 43% in the so-called rural and peripheral municipalities, respectively (Municipal Statistics Denmark, 2020). In the debates on possible school closures, policy makers often express their hopes of cost reductions and higher quality in education. On the other hand, local citizens fear that closing their local school will have adverse effects on the community and lead to population decline. This paper is concerned with the latter by asking the question: Do rural school closures lead to local population decline? Or put differently, what is the relationship between school closures and population change at the local level in rural settings?

Considerable research has been done on the importance of the local school and local school closures. Studies have found that school closures have reduced costs (Cohn, 1968; Duncombe and Yinger, 2007), while empirical studies on whether sending pupils to larger schools improves student achievement have produced mixed results (Beuchert et al., 2018; De Haan et al., 2016; Brummet, 2014; Engberg et al., 2012). Moreover, several studies have stressed the importance of the local school for the local community. Thus, small rural schools have been found to promote social cohesion and social capital (see e.g. Bagley and Hillyard, 2014; Autti and Hyry-Beihammer, 2014), be rich on parent involvement (Downes and Roberts, 2015; Hargreaves, 2009), and to contribute to the general "health of a community" (Kearns et al., 2009, p. 131; Witten et al., 2001, p. 309).

When it comes to the population effect of school closures, studies are

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https://doi.org/10.1016/j.jrurstud.2021.09.016
Received 7 June 2021; Received in revised form 16 August 2021; Accepted 14 September 2021
Available online 22 September 2021

few and have produced mixed results. An early US study by Johnson (1978) found no population effects of school closures. Later, this was also found by Amcoff (2012), Barakat (2015), and Kroismayr (2019) using data from Sweden, Germany, and Austria, respectively. Lourenço Marques et al. (2021), on the other hand, found mixed results when analysing the relationship between the lagged number of schools and fertility and net migration rates at the municipal level in Portugal. Elshof et al. (2015) found that closing the last school was related to increased out-migration of families with children. However, closing the last school was not found to influence the level of in-migration of families with children. Finally, in contrast to previous studies, Lehtonen (2021) found a clear negative population effect when analysing the community-level population effect of rural school closures that were carried out in Finland during 2011–2018.

The aim of this paper is to contribute to the existing literature by looking at the case of Denmark. Whereas previous studies have used mainly national or regional datasets, we use a more narrowly defined case study area, namely Tønder Municipality which is one of Denmark's 98 municipalities. We chose the Tønder Municipality case, because 8 of its 17 public schools were closed simultaneously in 2011. The 8 closed schools were independent schools located in different rural communities that are evenly spread across the municipality. The simultaneous closing of these 8 rural schools in Tønder Municipality represents a time-specific event, and the case study therefore offers a quasi-experimental setting. The simultaneous closing of so many public schools in one municipality is unique in the Danish context. Another advantage is that the chosen case holds a relatively long post-closure period which enables us to identify any long-term effects. Further, Tønder Municipality is a quite homogeneous municipality. It lies well away from any major regional centres and is large in terms of size but small in terms of population numbers. Such geography of peripheral location, low urbanization and sparse population seems especially interesting to study from the perspective of effects from local institutions, as few other intervening factors may affect such analysis.

We use a mixed methods approach to examine the school closures in Tønder Municipality. First, population effects are analysed quantitatively by conducting an ordinary and a flexible difference-in-differences (DiD) analysis including a 10-year pre-closure period and a 10-year post-closure period. Second, to qualify the findings of the quantitative analyses, population effects are analysed qualitatively based on in-depth interviews with four municipal politicians and officials as well as six residents in four of the eight affected communities. These 10 interviews were conducted in 2015, that is, about four years after the schools were closed.

The rest of the paper is organized as follows. Section 2 contains theoretical considerations and a review of the previous literature. In Section 3, we describe the case study area in more detail and provide information about the process leading up to the closing of the schools. In Section 4, we describe the empirical strategy and data. Section 5 presents the results of the quantitative analyses, while Section 6 contains the results from the interviews. The last section concludes.

2. The population effect of rural school closures

Theoretically, the closure of a public school can be viewed in the context of Tiebout's hypothesis (Tiebout, 1956) that people choose to settle in the community that provides them with the most optimal bundle of taxes and public goods. In this understanding, people are expected to 'vote with their feet' in response to changes in public goods. In other words, a school closure may push people out of the community and no longer pull potential residents to the community, thus producing a population decline in the short or long run. Obviously, the local school is important to local families with children, but the local school may also be important to other resident groups. In the words of Woods (2005, p. 587): "The village school plays a multidimensional role in a rural community. It is not only an educational establishment, but also a focal point for community life". Thus, the village school can be used to hold meetings and carry out events and social activities that involve all resident groups across age, family type, and educational cleavages. In this way, the village school has a potential of generating local social capital and strong social ties between the different types of community members (Putnam, 2000; Granovetter, 1973).

Rural school closures can also be seen through the lenses of rural development theory. Thus, drawing on neo-classical endogenous and exogenous growth theory, a strand of literature has concluded that rural development is not only determined by external factors, but also by internal factors (e.g. Terluin and Post, 2000; Bryden and Munro, 2000; Terluin, 2003; Ceccato and Persson, 2003). This strand of literature would view the local school as an example of an internal factor that might be important for generating endogenous rural development. Moreover, in a community capital framework, the local school can be viewed as physical capital just like the local inhabitants can be viewed as human capital. In support of this view, a previous study from Denmark has shown that initial stocks of physical, economic, and human capital in rural parishes were positively related to future population growth if the rural parishes were located in predominantly rural municipalities (Sørensen, 2018). In this study, physical capital was measured by the distance to nine different types of physical infrastructure, one of which was the nearest public school.

2.1. Previous studies

Even though theory thus suggests that rural school closures will lead to local population decline, previous studies have found mixed evidence with regards to the local population effect of school closures. As mentioned, previous studies are few, and we will give a review in the following.

In an early US study, Johnson (1978, p. 357) examines four elementary school closures in the Seattle school district and finds "virtually no evidence of community deterioration associated with the closure decisions". Using the local 'school area' within Seattle school district as area unit, the study compares four case areas and three control areas in terms of trends in enrolment numbers and property turnover rates and values in a 4-year pre-closure period and a 4-year post-closure period. The comparison of trends in enrolment numbers could be made because the four case areas still had other elementary schools after the closure. The comparisons are based on non-inferential statistics.

Amcoff (2012) analyses the migration effect of rural school closures that took place in Sweden during 1990–2004. The analysis includes 236 rural school closures and migration data is recorded in catchment areas around each school.[1] Amcoff (2012) regresses in- and out-migration data against year dummies, a variable measuring the distance to the nearest bigger city, the population size of the area as of 1997, and a dummy variable for the 2-year post-closure period. The latter dummy variable turns out insignificant in all estimations, which means that the in- and outmigration levels did not change significantly in the two years following the closures. Amcoff (2012, p. 58) concludes that "the general conclusion of this study is that no statistically significant effects of the closing of rural schools can be established on the migration patterns in the schools' surroundings". Methodically, the paper focusses on a relatively short post-closure period (2-year period) and does not include control areas.

Using register data for 1996–2011 on in- and out-migration to and from 553 rural villages in North Netherlands, Elshof et al. (2015) find the absence of a primary school and the closure of the last primary school to be associated with higher out-migration of families with

[1] For each school two kinds of catchment areas are constructed: 1) one based on Voronoi polygons that can vary from a few km^2 and up to 12,000 km^2, and 2) a local buffer zone defined by a 500 m radius around each and every school (Amcoff, 2012, p. 51).

school-aged children. However, the absence of a school and closing the last school was *not* found to influence the level of in-migration of families with children. Accordingly, Elshof et al. (2015, p. 633) conclude that the "persistent image that primary school absence and closure in villages are a 'recipe for depopulation' is only partly true". The results rely on linear regressions that include villages with schools, villages without schools, and villages with their last primary school closed during the period of observation. Of a total of 28 cases where the last school was closed, 19 were implemented "within three years of the beginning or the end of the period of observation and therefore only moving behaviour before or after the closure of these villages was included in the sample" (Elshof et al., 2015, p. 627), that is, a specific school closure can enter the regressions with only pre-closure or post-closure data. Thus, Elshof et al. (2015) refrain from comparing the village-specific difference between pre-closure and post-closure data in the regressions.

For the province of Saxony in East Germany, Barakat (2015) analyses the in- and out-migration effect of 60 school closures in municipalities that had their last school closed during the period 1994–2007. By using a log-linear regression model where in- and out-migration are regressed against closure status and time and municipality dummies, Barakat (2015, p. 746) finds "no evidence that closing the last primary school increased out-migration" and finds evidence at the 10% significance level that closing the last primary school decreases predicted in-migration by about 10%. In these regressions, 3-year and 6-year post-closure periods are considered, while being compared to a 2-year pre-closure period and the base closure year, respectively. Based on his own statistical analysis and a review of previous studies, Barakat (2015, p. 735) concludes that "there is little evidence of an appreciable effect of primary school closures on local population decline".

Kroismayr (2019) studies the Austrian case and comes to a similar type of conclusion as Barakat (2015). This study analyses the pre-closure and post-closure population development in municipalities affected by school closures taking place between 2001 and 2008. The focus is put on municipalities that lost their last public school. To include such a municipality in the sample, a control municipality had to exist in the same region, the control municipality being a municipality that also had had a public school closed during the period but without losing the very last public school. The analysis yielded the following conclusion: "In conclusion, it seems that the municipalities which closed their last school were not as badly affected as the concept of the downward spiral would imply, as in our sample the municipalities with one remaining school suffered a much greater loss in the number of families and births. So there is some evidence that the existence of a school is of negligible importance" (Kroismayr, 2019, p. 289)[2]

Using a panel vector autoregressive (PVAR) model and data from the 278 municipalities of mainland Portugal between 1999 and 2016, Lourenço Marques et al. (2021) analyse the time lagged relationships between the number of primary schools, the fertility rate, and the net migration at the municipal level. The relationships between the three variables are estimated by using four time lags going one to four years back in time, while controlling for three variables (registered unemployment rate, employment by private firms, and average income of the employed). The results show little relation between fertility rates and lagged number of primary schools and only in the fourth time lag (number of primary schools four years back in time). Migration rates show a significant relation with the lagged number of primary schools for two of the four time lags. However, the results are mixed, as the relation is positive for the second time lag, but negative for the first time lag. Consequently, Lourenço Marques et al. (2021, p. 309) conclude that "the relationship between primary schools and population growth at the local scale has not been clearly established and is a challenging subject given the potential circular causality between them".

Finally, Lehtonen (2021) analyses the community-level population effects of 518 school closures that were carried out in Finland during 2011–2018. Of these school closures, 66% were in rural areas. The analysis is based on a difference-in-differences (DiD) approach involving a mixed-effect model and a genetic matching technique whereby each community with a school closure (intervention group) was matched with a community without a school closure but with otherwise similar observable characteristics (control group). Population data were available in 1 km times 1 km population grids, and the paper uses 5-km and 10-km catchment areas for each school which include all the population grids that can be reached within 5 and 10 km from the school. The regression results show a clear negative population effect of the school closures in the 5-km and 10-km catchment areas surrounding the schools. If school closures would not have been carried out during 2011–2018, the population development in the 5-km catchment area would have been 2.8% more favourable. Lehtonen (2021) is the first study that finds a clear negative population effect of rural school closures. Lehtonen (2021) suggests that one reason why his results differ from those in other studies is that his analysis focuses on small catchment areas, that is, the local communities surrounding the school closures, whereas most other studies have used municipalities as area unit.

To sum up, previous studies generally report mixed results. Most studies, however, tend to find no population effect of school closures. Notwithstanding, the most recent paper (Lehtonen, 2021) finds a clear negative population effect of rural school closures. This departure from previous studies may be due to the use of the community level as area unit by Lehtonen (2021), which contrasts with most other studies that use the municipality level as area unit, such as Barakat (2015), Kroismayr (2019), and Lourenço Marques et al. (2021). Like Lehtonen (2021), our study also uses the community level as area unit, and therefore it is interesting if we can confirm the results of Lehtonen (2021). Next, therefore, we provide community-level evidence using our Tønder Municipality case, where eight schools were closed simultaneously in eight different rural communities in 2011. First, we turn to describe the Tønder Municipality case in more detail.

3. Tønder Municipality case

Tønder Municipality is one of the 98 municipalities in Denmark. It is situated in the very south of the peninsula Jutland and borders Germany. Although the fifth largest municipality in Denmark in what regards square kilometres (about 1300), it is sparsely populated with only 37,366 inhabitants in 2020. There has been a population decline of close to 12% since 2000 (Municipal Statistics Denmark, 2020). In the Danish rural district classification, Tønder Municipality is classified as a peripheral municipality.[3]

As mentioned, in 2011, almost half of the public schools in Tønder Municipality were closed simultaneously. According to interviews with government officials in Tønder Municipality, the consideration to close primary schools in Tønder Municipality goes back to the work of a so-called Master Plan for the School Area, which was initiated in December 2009. A key element of this plan was a so-called 70/80 model. This implied that a school should be closed if the number of pupils was below 70 for two consecutive years. Therefore, a number of pupils between 70 and 80 should be seen as critical. However, the decline in

[2] This result was not expected by Kroismayr (2019, p. 295): "The municipalities which still had one school and which were expected to show better results, did not fulfil these expectations".

[3] The rural district classification divides the 98 Danish municipalities into four municipality groups depending on the degree to which they contain rural areas: peripheral municipalities, rural municipalities, intermediate municipalities, and town municipalities (Kristensen et al., 2006). The classification has been used by various ministries in their surveys on the development in rural districts, e.g. Danish Ministry of the Interior and Health and Danish Ministry of Food, Agriculture and Fisheries, 2011.

childbirth rates in the municipality changed the minds of the politicians, and a more radical solution, a so-called *Helhedsløsning* (overall solution), was developed.

The *Helhedsløsning* involved the closing of the eight small independent schools located in the villages of Abild, Ballum, Bedsted, Døstrup, Jejsing, Nørre Løgum, Visby, and Vodder. All these are villages situated in the countryside in parishes with around 600 to 1500 inhabitants. The proposal for this was made public on November 2, 2010. Subsequently, a consultation procedure took place with a deadline for written responses from local residents on January 6, 2011. The proposal triggered many protests from locals, and many local associations and private citizens wrote comprehensive and generally very critical consultation responses which, however, did not exert an impact on the school closure solution which was formally approved on February 24, 2011. Consequently, the schools got closed after the school summer break in 2011. The decision and implementation of school closures therefore gradually emerged from 2010 onwards.

4. Methods and data

We will use mixed methods to study the Tønder Municipality case. We will combine quantitative and qualitative methods which we will describe in the following.

4.1. The quantitative study

The quantitative study contains econometric analyses that calculate the local population effect of the school closures during the 10-year post-closure period. The econometric analyses rely on the difference-in-differences (DiD) method. The DiD method uses samples containing a treatment group that is affected by an event and a control group that is not affected by the event. In the Tønder Municipality case, the treatment group consists of the eight parishes in Tønder Municipality where the school was closed: Abild, Ballum, Bedsted, Døstrup, Hostrup, Nørre Løgum, Visby, and Vodder. The control group consists of the nine parishes in Tønder Municipality where the school was not closed: Agerskov, Brede, Højst, Løgumkloster, Møgeltønder, Højer, Skærbæk, Toftlund, and Tønder. The 17 schools were spread out evenly across the geography of Tønder Municipality.

We will perform two types of DiD analysis: 1) an *ordinary DiD analysis* of the population effects of school closures by comparing population growth figures during the 10-year periods prior to and after the school closures, and 2) a *flexible DiD analysis* that identifies the effects of school closures for each of the single years in the post-closure period compared to each of the single years in the pre-closure period. The flexible DiD analysis allows us to check for compliance with the assumption of comparability between the case and control group in the pre-closure period, and it allows us to determine the dynamics of possible effects from school closures in the post-closure period. As extensively discussed by Mora and Reggio (2012), it is important to check for pre-treatment parallel trends as well as allowing for dynamic effects after treatment.

Given that the proposal to close the eight schools was made public on November 2, 2010, we use 2010 as the first year, where school closures may have had a population effect. Even if implementation took place in 2011, the debate on school closures may already have led to anticipation effects in 2010.

The *ordinary DiD analysis* consists of a linear regression where the explanatory variable (Y_i) is the population growth in % in both the pre-closure period (January 1, 2000 to January 1, 2010) and the post-closure period (January 1, 2010 to January 1, 2020). Parish population figures per 1 January were found in the publicly available database of Statistics Denmark.[4] The regression is defined as follows:

$$Y_i = a + \beta_1 TR_i + \beta_2 P_t + \beta_3 (TR_i)(P_t) + \varepsilon_i \tag{1}$$

where Y_i is the population growth in percent in parish i either from January 1, 2000 to January 1, 2010 or from January 1, 2010 to January 1, 2020, P_t is a dummy variable taking value 1 for period January 1, 2010 to January 1, 2020 and zero otherwise, TR_i is a dummy variable for school closure in parish i, and ε_i is an error term with standard properties.

The coefficient β_3 in Equation (1) captures the *difference between the two following differences:* 1) the difference between the population growth in the treatment group and the population growth in the control group *in the period before the school closures*, and 2) the difference between the population growth in the treatment group and the population growth in the control group *in the period after the school closures*. If the coefficient β_3 is negative and statistically significant, it means that there has been a population decline in the parishes with public school closures (treatment group) in the post-closure period relative to the parishes not having their public school closed (control group), relative to the pre-closure period.

The *flexible DiD analysis* is similar to the ordinary DiD analysis, only allowing for a full set of cross-section and time variables. Therefore, in the flexible DiD analysis, we regress the natural log of the number of inhabitants per 1 January in a given year and in a given parish against parish dummies, time dummies, and the interaction terms between the treatment dummy and the time dummies:

$$Y_{i,t} = a + \beta_{1,i} C_i + \beta_{2,t} T_t + \beta_{3,t} (TR_i)(T_t) + \varepsilon_{i,t} \tag{2}$$

where $Y_{i,t}$ is the natural log of the number of inhabitants in parish i in year t, C_i are parish fixed effects for parish i, T_t are time fixed effects for time t, TR_i is a dummy variable for school closure in parish i, t span 2000 to 2020 per 1 January, and $\varepsilon_{i,t}$ is an error term with standard properties. There are several differences among parishes and over time not included in Equation (1) that may possibly confound the effects of school closures. Including parish fixed effects (C_i) and time fixed effects (T_t) in Equation (2) controls for such unobservables. We will use the log number of inhabitants per January 1, 2010 as the time reference because, as mentioned, the proposal to close the eight school was put forward in November 2010. From an analytical point of view, the most interesting term in Equation (2) is the term $\beta_{3,t}$ (TR_t) (T_t). The results for this interaction term will reveal two interesting things when using January 1, 2010 as time reference. The coefficient $\beta_{3,t}$ for $t < 2010$ will first tell us for each year (per 1 January) whether the case parishes and the control parishes are comparable in the pre-closure period, i.e., if pre-trends are prevalent and pose a problem. Second, the coefficient $\beta_{3,t}$ for $t \geq 2010$ will tell us *for each year* (per 1 January) whether a statistically significant population decline can be observed in the parishes with school closures in the post-closure period. This makes it possible to identify when – i.e., after how many years following the closures – a population decline sets in, if ever.

4.2. The qualitative study

In the qualitative study, in-depth interviews with local dwellers, politicians and municipal officials have been undertaken in 2015. The purpose was to investigate the whole process of school closures and the consequences as perceived by the local residents. During May–June 2015, after a start-up meeting with representatives from the municipality, one of the authors made 10 interviews with a duration of between 1/2 and 1 h. A semi-structured interview guide was used. Six of these interviews were with residents in four of the eight communities where the municipal school was closed in 2011. The last interviews were with four representatives from the municipality: Coordinator and secretary of the project, chairman of the municipal rural district committee, and two members of the municipal council, see Table 1.

[4] The data was found on this page: www.statbank.dk/SOGN10 (accessed 14 November 2019).

Table 1
Overview of interview persons.

Interview persons (pseudonyms)	Village name/Title	Date of interview	Length of interview (minutes)
Residents in village with school closure			
Lasse	Ballum	June 4, 2015	41
Rita	Ballum	June 19, 2015	30
Anna	Bedsted	June 5, 2015	71
Peter	Bedsted	June 11, 2015	44
John	Døstrup	June 4, 2015	32
Lars	Vodder	June 15, 2015	48
Municipal civil servants and local politicians			
Lisa	Chief consultant	May 4, 2015	53
Jesper	Chairman of the municipal rural district committee	May 4, 2015	56
Niels	Municipal council member	May 4, 2015	55
Hans	Municipal council member	May 5, 2015	42

5. Results

In this section, we will first present the results from the quantitative study and then the findings from the interviews. As mentioned, our aim is to use the findings from the interviews to quality the results from the quantitative study.

5.1. Quantitative analysis of population effects

Initially, Table 2 shows the population growth in the eight treated parishes (parishes that had their school closed), in the nine control parishes (parishes that did not have their school closed), and in Tønder Municipality for two 10-year periods prior to and after the school closures.

As can be seen in Table 2, Tønder Municipality experienced population decline in both the pre-closure and post-closure period. The population decline in Tønder Municipality was smaller in the post-closure period than in the pre-closure period (−5.9% vs. −6.3%). At the parish level, seven out of the eight parishes that had their school closed witnessed a larger population decline in the post-closure period than in the pre-closure period, whereas this was only the case for three out of the nine parishes that did not have their school closed. Overall, therefore, Table 2 suggests a negative population effect of the school closures. Meanwhile, it is not possible to draw a firm conclusion on the effect of the school closures based on the descriptive statistics in Table 2. We therefore turn to inferential statistics and the results of the two difference-in-differences (DiD) analyses.

The result of the *ordinary DiD analysis* is reported in Table 3. The coefficient β_3 in Equation (1) is negative and statistically significant at the 5% level. This indicates that the school closures have had a negative

Table 3
Effect of school closures on population growth in %, 2010–2020 (per 1 January).

	Coefficient	t	p (2-tailed)
Constant	−6.57	−3.93	0.0004
School closure (TR_i)	1.32	0.55	0.590
Post-closure period (P_t)	1.78	0.76	0.453
DiD ((TR_i) (P_t))	−7.60	−2.22	0.034

Notes: OLS regression. Number of observations = 34. Adjusted R^2 = 0.13. Dependent variable: Population growth from January 1, 2000 to January 1, 2010 (pre-closure period) and population growth from January 1, 2010 to January 1, 2020 (post-closure period). Included parishes with public school closure: Abild, Ballum, Bedsted, Døstrup, Hostrup, Nørre Løgum, Visby, Vodder. Included parishes having a public school throughout the entire period from January 1, 2000 to January 1, 2020: Agerskov, Brede, Højst, Løgumkloster, Møgeltønder, Højer, Skærbæk, Toftlund, Tønder.

Table 2
Inhabitants and population growth in 17 parishes and Tønder Municipality.

Parishes	Number of inhabitants as of January 1, 2010	Population growth (%) before the school closures (January 1, 2000–January 1, 2010)	Population growth (%) after the school closures (January 1, 2010–January 1, 2020)
Treated parishes			
Abild	1214	−5.6	−9.4
Ballum	604	−12.7	−17.7
Bedsted	888	−6.6	−13.0
Døstrup	746	−12.6	−5.2
Hostrup (Jejsing)	1161	3.8	−12.2
Nørre Løgum	1466	3.3	−4.0
Visby	621	−7.5	−9.0
Vodder	792	−4.1	−17.9
Control parishes			
Agerskov	2286	−3.8	−7.4
Brede	2017	−7.2	−7.2
Højst	1028	−3.3	−4.2
Løgumkloster	3355	−4.9	−4.6
Møgeltønder	1229	−7.3	−9.0
Højer	1445	−19.1	−7.8
Skærbæk	3483	−3.0	0.6
Toftlund	3783	−5.0	−2.0
Tønder	8038	−5.4	−1.6
Tønder Municipality	39,710	−6.3	−5.9

Note: The treated parishes had their school closed. The control parishes did not have their school closed. The plan to close the schools was published in November 2010.
Source: Own calculations based on data from Statistics Denmark (www.statbank.dk/SOGN10) and Municipal Statistics Denmark, 2020 (www.kommunalenoegletal.dk).

population effect in the affected communities. The total population decline in the eight parishes in the 10-year post-closure period amounts to 7.6 percentage points compared to the control group and compared to the 10-year pre-closure period.

The coefficients for the dummy variables *school closure period* and *post-closure period* are positive and statistically insignificant, see Table 3. In a regression (not shown) where the DiD term is left out, the coefficients for these two dummy variables were both found to be negative and still statistically insignificant. This implies that introducing the DiD term significantly strengthens the explanatory power of the model. This is confirmed by a likelihood ratio test that rejects the null hypothesis that the regression model *without* the DiD term (the reduced model) is nested in the regression model *with* the DiD term (the full model) ($\chi^2 = 5.17$, $p = 0.02$).

In sum, the result of the *ordinary DiD analysis* is that the school closures have had a negative effect on the local population development throughout the 10-year post-closure period. This begs the question: When did the negative population consequences emerge? This is particularly important given that most previous contributions to the literature have considered relatively short periods. The *flexible DiD analysis* specified in Equation (2) offers an answer to the question. The main results are shown in Fig. 1 with respect to the coefficient $\beta_{3,t}$ in Equation (2).

Fig. 1 conveys two important insights from our analysis. First, the negative population effect materializes gradually over time, cf. the increasingly larger negative values of the $\beta_{3,t}$-coefficient after January 1, 2010. In fact, it is first from January 1, 2017, that is, from the sixth year following the closures and onwards, that the population decline becomes statistically significant at the 5% significance level, see also the full results in Table 1A in the appendix.

The delayed materialization of negative population consequences suggests inertia in the reaction towards the school closures. Residents in the affected areas may need time to evaluate the new situation and to possibly react to it, e.g. by moving away. This might include selling their homes which can be difficult because of a limited number of buyers and because financial institutions are cautious in providing mortgages in peripheral areas. Also, the social capital of local communities may take time to erode. As we will report later, such lock-in effects are supported by the evidence from the qualitative study.

The second important insight from Fig. 1 relates to the school closure intervention being exogenous in order to fulfil the model assumptions. In practice, performing a DiD analysis requires that the case parishes and the control parishes are comparable at the outset of the school closure intervention. The decision to close the eight small schools in Tønder Municipality was not an exogenous event, but a conscious decision on part of the municipality council. The treated parishes had schools with low numbers of pupils in 2010, and the control parishes had schools with higher numbers of pupils in 2010. In other words, the parishes that were selected to have their public school closed were not randomly selected among the 17 parishes with a school. Therefore, the case and control parishes may not be directly comparable. However, it is appropriate to perform the DiD analysis anyway if the case and control parishes display empirical similarity in the pre-closure period (Angrist and Pischke, 2009, Chapter 5; Mora and Reggio, 2012). When looking at Fig. 1, there is no statistically significant difference between the case and control parishes in the pre-closure period before 2010. The absence of significantly different pre-trends indicates that the DiD analysis can be interpreted without concerns of biases from such pre-trends. The readily available population data from Statistics Denmark contains yearly parish population data that goes back to 1985, and the conclusion about the similarity of pre-trends holds when considering a 25-year pre-closure period, see Fig. 2.

5.2. *Qualitative study of population effects: interviews with the local people*

To qualify the results of the above quantitative analyses, we now report the findings from the analysis of interviews with six local people carried out in 2015 in four of the eight communities.

Most frequent negative consequences that were mentioned by the local interview persons were depopulation, difficulties in attracting and retaining families with school-aged children, eroding social connections, decline in house prices, problems with borrowing money for potential buyers of property, less people volunteering and a decline in the number of members in local associations. This arguably points to an erosion of social capital in the community in line with e.g. Witten et al. (2001) and Autti and Hyry-Beihammer (2014). John from Døstrup gave this typical answer to the question on how the locals have experienced the consequences of the school closure:

> “We can see that it has been difficult to maintain families with children in the village (…) They say: Where is the school? It’s situated in Skærbæk. Well, okay, then that’s the place we go to. I want to

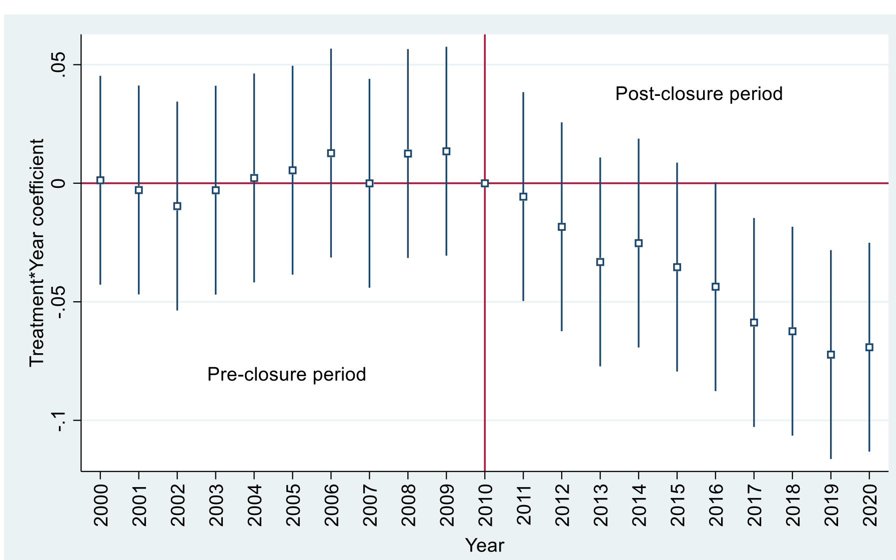

Fig. 1. Development in the number of inhabitants (natural log) per 1 January in parishes with school closures, 2000–2020: Flexible DiD coefficients with 95% confidence intervals, *Note*: Time of reference is January 1, 2010 (vertical line).

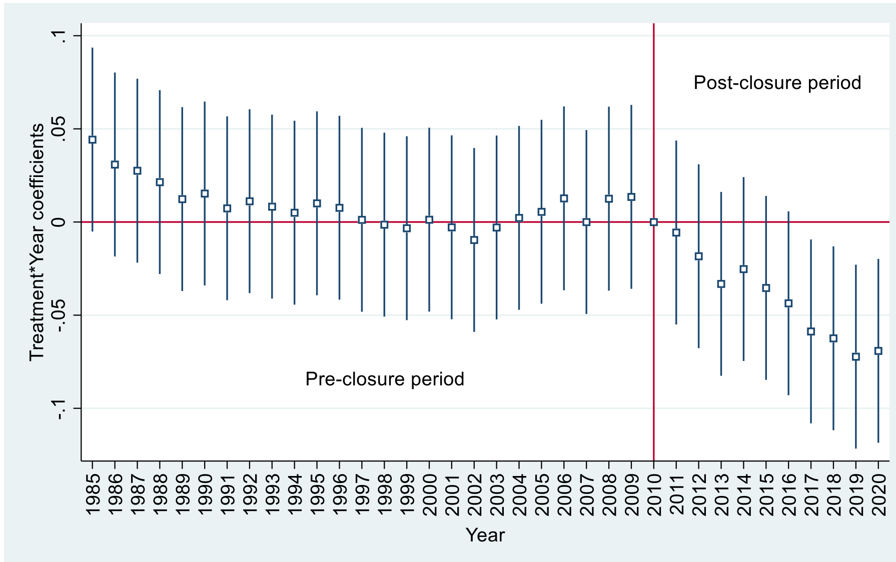

Fig. 2. Development in the number of inhabitants (natural log) per 1 January in parishes with school closures, 1985–2020: Flexible DiD coefficients with 95% confidence intervals. *Note*: Time of reference is January 1, 2010 (vertical line).

see my kid bicycling home together with his friends and then afterwards take his bike and go down to the swimming hall."

In similar terms, Lars from Vodder talked about local families moving out of the village:

"**Interviewer:** Are there families with children who have actually moved from Vodder? [due to the school closure]

Lars: Yes, for sure. Well, and I can add to this – and that's maybe the thing that worries me most of all – that we're talking about families where one of the parents, or both of parents, are local people. People, where one would think that – it would be natural for them to stay despite all inconveniences there are by staying. However, they don't stay.

Interviewer: They're not 'local patriots', as they were previously, maybe?

Lars: And that's a bit worrying. And I cannot see where we end …

In a village like Ballum, locals are in risk of being trapped in a vicious circle with steady depopulation, declining house prices and potential newcomers who do not dare to buy a house – or cannot borrow the money from a financial institution due to high investment risk. Thus, in such a village there is a fear of getting stuck with an unsellable house. In practice, this would imply the adoption of a modern version of the so-called Stavnsbånd ("Bond to Native Soil") that existed in the 18th century in Denmark by which, to maintain sufficient agricultural production and secure military enlistment, men in the countryside aged 14–36 by law were bonded to (not allowed to leave) the estate where they were born, unless the estate owners gave their permission (Busck and Poulsen, 2002). Rita said that she knew people who would move from Ballum if they were able to:

"**Interviewer:** You say that you know some people who have considered it [moving away]? More people, or?..

Rita: Yes, however the fact is that they cannot sell their houses out here (…) We know at least two couples with children – in case they move, their children would leave the kindergarten. And then, it's so difficult to be allowed to buy houses here in Ballum, to put it that way. I mean, the mortgage providers will not lend you money, not even small amounts (…) Of course, they're not so expensive the houses out here. But those who want to get away from here, they are not able to sell their houses, because no-one will lend other people money to buy their houses.

Interviewer: Okay, so they may risk becoming bonded to this place so to speak?

Rita: Yes! And those who, maybe, would like to come out here to live, they have difficulties in doing that."

In all communities, there had been a social fragmentation, especially among the children. Before the closure, the children used to spend the whole day together in the village. From 2011 and onwards, they have been spread to several schools in neighbouring towns where they spend their daytime. In this way, the children in a village like Ballum or Døstrup have become more strangers to each other and exhibiting less local identity and belonging. As it was formulated by Lasse from Ballum:

"Today, the children from Ballum are divided in four schools. That means that many of them are strangers to each other, and if it continues like this, some of the children do not even know each other in a year or two, even though they live in Ballum."

Also, associational activities are fewer, which – as admitted by many of the interview persons – not only is due to school closures but general depopulation in the municipality. However, the closures have worsened the trend in their opinion. The social cohesion has also eroded because of the loss of the most important meeting-place, subsequently leading to loss of local social capital. As Lasse from Ballum expressed it, the dynamics that arise when people "cross each other's ways" are no longer created:

"When children don't have much to do with each other, then probably their parents do not meet often either. And when they don't meet, then this dynamic is not created, that dynamic which we find in the associational life …"

Apart from this, Lasse also laments the loss of what he terms "soft values":

"[Another consequence] has to do with these softer values. You know, in daytime you could hear the school bell sound. And you could hear the children playing up there … And then, sometimes they would walk through the village and such things. It's quiet now, suddenly … That's also something that changes a village: Children's laughter."

Finally, it became difficult to keep local associations alive, partly because of the loss of school as a 'natural' meeting-place and the 'loss' of their kids. About the long-term consequences, Lars from Vodder told the following in a somewhat gloomy tone:

"I find it hard to see the end of depopulation, and I find it hard to see the end of the consequences of the school closure. Because it's the parents who live here now … those who form the community, they have all gone to Vodder School (…) I think, we will see the full effect of this not until the next generation, that next generation who have not gone to Vodder school. They will not have that network which we built up at school. It's really hard to see where this will end."

6. Conclusion and discussion

This paper focused on the population effect of rural school closures by asking the following question: Do rural school closures lead to local population decline?

In our study, we used a case study involving eight school closures in different rural communities that were carried out simultaneously in 2011 in Tønder Municipality in Denmark. In an ordinary DiD analysis, a statistically significant population decline of 7.6 percentage points was found in the eight communities affected by school closures throughout the 10-year post-closure period. Stated differently, we found that the population development in the affected communities would have been 7.6 percentage points more favourable if the schools had not been closed. Moreover, the flexible DiD analysis showed that the population decline first got statistically significant from the sixth year following the closures and onwards.

In sum, we found clear evidence of a negative population effect of rural school closures. This is in line with the results of Lehtonen (2021) who came to the same conclusion in his community-level study of the Finnish case. Most previous studies have found either mixed results (Elshof et al., 2015; Lourenço Marques et al., 2021) or no population effect of rural school closures (Johnson, 1978; Amcoff, 2012; Barakat, 2015; Kroismayr, 2019), and the question is why our result differs from these other studies. Obviously, other studies have examined other geographies which could have caused some of the difference in results. However, as noted by Lehtonen (2021), the municipality level, which is used as area unit by Barakat (2015), Kroismayr (2019), and Lourenço Marques et al. (2021), may not be able to fully capture the population effect at the local level. Overall, it seems relevant to focus on the local level, since the discussion about possible adverse effects of rural school closures is mostly centred around what happens in the local area surrounding the school. Moreover, some of the difference in results may be due to the relatively long time horizon that we use in our analysis. Although Barakat (2015) does report descriptive statistics covering a 10-year pre- and post-closure period, previous studies mostly operate with quite short time horizons, such as 2-year or 4-year post-closure periods. In our case, if we had used a post-closure period shorter than 6 years, we would not have found any significant population effect.

To supplement our quantitative analyses of the population effect, we reported the findings of interviews with local people carried out in 2015 in four of the eight communities. The interviews were able to shed further light on the school closures and on what mechanisms that lie behind the population decline that followed. Overall, negative consequences as perceived by the interview persons included increased depopulation, declining house prices, eroding social capital, and problems with attracting and retaining families with children.

One of the most negative consequences of the school closures was social fragmentation, especially among the children. In communities like Ballum and Døstrup, after the local village school was closed in 2011, the children were sent to different schools in neighbouring towns where they spent most of their daytime. Hereby, the children in these villages had become almost like strangers to each other. Obviously, such social fragmentation leads to less local identity and belonging and a gradual loss of social capital in the local community.

Moreover, the interview persons reported of families with children who had moved away from the village as a direct result of the school closure. One interview person pointed out that several people who wanted to move out of the village had been unable to do so because they could not sell their houses. The problem was not only about not being able to find an interested buyer, but also about mortgage institutions being unwilling to provide mortgages. In fact, an unwillingness on part of mortgage institutions in Denmark to provide mortgages to potential buyers of low-priced and uneasily resalable properties in rural areas has been widely talked about and documented by the Danish news media (e.g. Mikkelsen, 2014; Hansen, 2019), and the issue has also been addressed in a ministerial committee report from 2015 (Danish Ministry of Industry, Business and Financial Affairs, 2015).

The eroding social capital and the problem of not being able to sell one's house – and thus being tied to the local area through the housing market – are factors that contribute to the understanding of the six-year lag in significant population effects that we found in the quantitative analysis. Investments in social and housing capital may prevent residents of local communities affected by school closures from a short-run reaction. Thus, a lock-in effect to the local community may have occurred. In the longer run, this lock-in effect may be alleviated through depreciation of social and housing capital and school closures are thus gradually taking an effect on the population development of local communities.

In Denmark, many rural schools have been closed since 2000. The results of this study suggest that this is not conducive for the population development in the affected rural communities. Although it has been a trend to close rural schools in Denmark, some municipalities have deliberately refrained from doing so. From a municipality point of view, keeping the local school can be viewed as an investment that may grant the rural community the possibility of turning around the development in the future.

In terms of study limitations, unfortunately, we were not able to include parish-level net migration data in the analysis, because Statistics Denmark only provides such data from 2015 onwards.[5] Net migration is a more direct outcome measure than overall population growth, as population growth besides net migration also includes number of deaths and births. Likewise, it was not possible to retrieve or purchase relevant housing market data at parish level that covered the period back to 2000. Relevant data could be the development in the number of homes for sale or the development in the number of vacant homes from 2000 to 2020. With such data, some of the qualitative evidence regarding the delayed population effect via the housing market could be tested – again using the difference-in-differences approach. Unfortunately, relevant Danish housing data at parish level is only available back in time from 2010 onwards. Future community-level studies on the same topic are therefore urged to include such data.

Author statement

Jens Fyhn Lykke Sørensen: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Project administration. Gunnar Lind Haase Svendsen: Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing. Peter Sandholt Jensen: Methodology, Writing – review & editing. Torben Dall Schmidt: Writing – review & editing.

[5] Statistics Denmark provides this data on this page: www.statbank.dk/KMSTA003 (accessed 6 June 2020).

Declaration of competing interest

No conflict of interest.

Acknowledgements

Funding for the practical implementation of parts of the research described in this article was obtained from the Danish Ministry of Industry, Business and Financial Affairs in 2015.

Appendix

Table 1A
Development in the number of inhabitants (natural log) per 1 January 2000–2020: Results of the flexible DiD regression

Variables	Coefficients	Standard error	t	$p > \|t\|$	95% CI lower	95% CI upper
Intercept	7.3256	0.0079	927.25	0.000	7.3101	7.3412
Year (per 1 January)						
2000	0.0693	0.0154	4.51	0.000	0.0391	0.0995
2001	0.0685	0.0154	4.46	0.000	0.0383	0.0987
2002	0.0668	0.0154	4.35	0.000	0.0366	0.0970
2003	0.0599	0.0154	3.90	0.000	0.0297	0.0901
2004	0.0482	0.0154	3.14	0.002	0.0180	0.0785
2005	0.0375	0.0154	2.44	0.015	0.0073	0.0677
2006	0.0259	0.0154	1.69	0.092	−0.0043	0.0562
2007	0.0195	0.0154	1.27	0.204	−0.0107	0.0497
2008	0.0162	0.0154	1.05	0.293	−0.0140	0.0464
2009	0.0094	0.0154	0.61	0.542	−0.0208	0.0396
2010 (Reference)	0					
2011	−0.0016	0.0154	−0.10	0.918	−0.0318	0.0286
2012	−0.0136	0.0154	−0.89	0.375	−0.0438	0.0166
2013	−0.0153	0.0154	−0.99	0.321	−0.0455	0.0150
2014	−0.0340	0.0154	−2.21	0.028	−0.0642	−0.0038
2015	−0.0370	0.0154	−2.41	0.017	−0.0672	−0.0067
2016	−0.0393	0.0154	−2.56	0.011	−0.0695	−0.0091
2017	−0.0375	0.0154	−2.44	0.015	−0.0677	−0.0073
2018	−0.0417	0.0154	−2.72	0.007	−0.0719	−0.0115
2019	−0.0436	0.0154	−2.84	0.005	−0.0738	−0.0134
2020	−0.0495	0.0154	−3.23	0.001	−0.0798	−0.0193
*Treatment*Year*						
Treatment*2000	0.0013	0.0224	0.06	0.954	−0.0428	0.0453
Treatment*2001	−0.0028	0.0224	−0.13	0.899	−0.0469	0.0412
Treatment*2002	−0.0096	0.0224	−0.43	0.668	−0.0537	0.0344
Treatment*2003	−0.0029	0.0224	−0.13	0.896	−0.0470	0.0411
Treatment*2004	0.0022	0.0224	0.10	0.921	−0.0418	0.0463
Treatment*2005	0.0055	0.0224	0.25	0.806	−0.0386	0.0495
Treatment*2006	0.0127	0.0224	0.57	0.570	−0.0313	0.0568
Treatment*2007	−0.0000	0.0224	−0.00	1.000	−0.0441	0.0440
Treatment*2008	0.0125	0.0224	0.56	0.576	−0.0315	0.0566
Treatment*2009	0.0135	0.0224	0.60	0.547	−0.0306	0.0575
Treatment*2010 (Reference)	0					
Treatment*2011	−0.0056	0.0224	−0.25	0.802	−0.0497	0.0384
Treatment*2012	−0.0184	0.0224	−0.82	0.413	−0.0624	0.0257
Treatment*2013	−0.0332	0.0224	−1.48	0.139	−0.0772	0.0109
Treatment*2014	−0.0252	0.0224	−1.13	0.261	−0.0693	0.0188
Treatment*2015	−0.0354	0.0224	−1.58	0.115	−0.0794	0.0087
Treatment*2016	−0.0436	0.0224	−1.95	0.052	−0.0877	0.0004
Treatment*2017	−0.0587	0.0224	−2.62	0.009	−0.1028	−0.0147
Treatment*2018	−0.0624	0.0224	−2.79	0.006	−0.1065	−0.0184
Treatment*2019	−0.0723	0.0224	−3.23	0.001	−0.1163	−0.0282
Treatment*2020	−0.0692	0.0224	−3.09	0.002	−0.1132	−0.0251
Model						
Adjusted R^2	0.7128					
Observations	357					

Note: OLS regression. The dependent variable is the natural log of the number of inhabitants per 1 January in the given year in the included parishes. The regression is run with parish fixed effects (17 parishes).

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