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Tomas Cvrcek
Miroslav Zajicek

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ABSTRACT

The rise of education has featured prominently in the debate on the sources of modern long-term economic growth. Existing accounts stress the positive role of public education and the importance of political support for its provision. We argue that such an explanation for the spread of schooling is probably a poor fit for many nations' schooling histories and provide an example, using detailed data on schooling supply from the Habsburg Empire. We show that while economic development made schooling more affordable and widespread, the politics of demand for schools was not motivated by expectations of economic development but by the ongoing conflict between nationalities within the Empire. We find that public schools offered practically zero return education on the margin, yet they did enjoy significant political and financial support from local political elites, if they taught in the "right" language of instruction. Our results suggest that, for some countries at least, the main link, historically, went from economic development to public schooling, not the other way round.

Tomas Cvrcek
Department of Economics
Clemson University
213 Sirrine Hall
Clemson, SC 29634
and NBER
tcvrcek@clemson.edu

Miroslav Zajicek
Katedra institucionální ekonomie
Národohospodáská fakulta
Vysoká škola ekonomická v Praze
nám. W. Churchilla 4
130 67 Praha 3
miroslav.zajicek@vse.cz

1. Introduction

Modern economic growth has been correlated with concurrent increase in schooling and human capital accumulation. It has been investigated in numerous Barro-style cross-sectional regressions and proposals regarding the provision of schooling count among core policy recommendations issued to developing countries around the world (Sala-i-Martin, 1997). The strong correlation between human capital and growth appears not only in the cross-section but also across time. It has become an integral part of theoretical modeling of industrialization, long-term growth and the accompanying demographic transition (Galor, 2011).

There is less certainty about how the human capital is accumulated and what kind of human capital exactly matters for growth. Formal schooling has long been considered one of the most efficient channels (Easterlin, 1981). This line of argument, recently revisited by Lindert (2004), Go and Lindert (2010), Mariscal and Sokoloff (2000) and others, sees modern growth as a consequence of (among other things) the rise of national public systems of education which themselves were the product of increased political voice and, eventually, electoral support for tax-based schooling. On closer inspection, any of these causal links becomes more complicated (Mokyr, 2013). While Becker et al. (2009) claim that Prussia caught up with UK only thanks to her schools, Mitch (1999) argues that Britain's industrialization was orthogonal to her educational system. Sandberg (1979) cites Sweden as a case of "impoverished sophisticate" where human capital reportedly stood entirely out of proportion to the country's level of income. As for the link from political voice to education, the impulse for nation-wide education may come (and has come in many instances) not from savvy voters but from the ruling elites whose motives had more to do with political control than economic development (Van Horn Melton, 1988). Even democratic politics must contend with questions about who may or may not enroll,

who pays for the schools, what is to be taught and it is far from obvious that the answer has always been "more, better, broader" (Naidu, 2012; Palma & Reis, 2012; Troen, 1975).

We aim to introduce more nuance to the argument by investigating these details of public education decisions. Our research questions lie at the heart of the Easterlin-Lindert story. Using data from the Habsburg Empire, we ask: how well was its educational system responding to (and thereby aiding) economic development? How did the provision of schooling infrastructure interact with the Empire's economic development? How important was educational politics vis-à-vis economic factors? How did individuals respond to the public schooling provision and to the local economic development in making their decisions about investing in human capital? In contrast to the Easterlin-Lindert story of credit-constrained but newly enfranchised poor parents wisely voting themselves more public school provision to be financed by stingy elites to further the economic fortunes of their children and their country, we describe a system where the local elite foists a politically-motivated and economically irrelevant education on lukewarm masses while making them pay for it mostly out of their own pockets.[1] Our hypothesis is not new (Lindert, 2004: 100-103) but, as far as we are aware, ours is the first attempt to empirically test it using historical statistical evidence.

2. Explaining the rise of schooling

A frequent point of departure for the literature on the provision of schooling and economic growth is the high cross-sectional variation among nation states (Easterlin, 1981). Lindert (2004: 87-88) opens by noting that Britain, the leader in school enrollment in early 19th century, was overtaken by 1880 by France and Germany (Prussia). His explanation is that for a widely

[1] Easterlin (1981: 10-11), citing the example of Church-controlled Spanish educational system, is aware of the fact that not all kinds of formal schooling are equally useful, yet he still sees the rise of schooling primarily in the context of democratization of opportunity and of the political life, noting that absolute monarchies are usually suspicious of mass education's subversive potential.

available schooling system to develop, three ingredients had to come together: (i) local autonomy so that local decision-makers could appropriately respond to local economic developments, (ii) political voice, i.e. a mechanism whereby broad public support for tax-based schooling could be converted into actual policy, and (iii) low-cost provision which amounted to cheap, abundant teaching staff. The reason why schooling almost always ended up being publicly financed in spite of being among the most profitable private investments was that most of the population was credit-constrained and positive externalities were too weak to interest moneyed local elites in generating critical mass of schooling through philanthropic activity. The argument was further developed in Go and Lindert (2007, 2010) where it was tested on enrollment and schooling data from US censuses of 1840 and 1850. This county-level analysis used information on votes cast in presidential elections and property restrictions on eligibility to state legislatures as a measure of political voice and showed a positive effect of political voice on enrollment and on public spending per pupil. Studies in similar vein have appeared or are under way for Britain, Brazil, Russia, India and China (Mitch, 2012; Chaudhary et al., 2011; Musacchio et al., 2012).

One recurring problem that these studies encounter is that they have to work around a lack of suitable reliable data. An analysis of schooling provision would ideally require data that are both sufficiently broad in scope to encompass all the necessary economic, political and educational indicators and sufficiently detailed geographically so as to capture the local variation. As it stands, educational statistics (enrollments, attendance records, age-schooling profiles) are often unreliable or incomplete; economic statistics, such as GDP per capita or real wages, rarely exist on the sub-national level; and measures of political voice are hard to construct and interpret. As a result, both Chaudhary et al. (2011) and Musacchio et al. (2012) have to stay at the level of federal states or corresponding units, which is a considerably greater level of aggregation than Go and Lindert's (2010) US counties. Go and Lindert (2007, 2010), on

the other hand, have no economic variables on the local county level and given that the whole education-growth nexus is riddled with endogeneity anyway, they propose to sidestep the issue and estimate the demand (and supply) of education in reduced form.

There is a further issue with measures of political voice. Go & Lindert's (2010) choice of votes cast in presidential elections makes sense in the context of American political institutions but for most countries such measure is too restrictive, if it exists at all. Many European countries at the time of Industrial Revolution had scarcely any democratic institutions and the variation in suffrage, where it existed, was small across localities. This does not mean that various special interests and segments of population had no way to voice their concerns; it does mean, however, that their political voice was much less formalized and thus much harder to measure.

How exactly that political voice would shape educational policies is also far from obvious. The cited studies usually posit the issue in the form of a dichotomy between elites who were ambivalent about educating the masses and strongly opposed to having pay for it and the general population, which would demand more educational infrastructure, if only it had more political clout. Musacchio et al. (2012), for example, show that exogenous positive shocks to various states of the Brazilian federation had differential impact on local public spending on education depending on whether the state's institutions were more or less democratic. Similarly, Chaudhary et al. (2011) blame low enrollment rates in early 20th century BRICs on absence of mass political voice and correlate the provision of schooling with the characteristics of local elites who did have political voice. But in many cases, among which the Habsburg Empire is one, the original and continuing impetus for the spread of primary schooling came decidedly from the top of the political hierarchy. Palma and Reis (2012), using Portugal as their example, go so far a to argue that an authoritarian state may be, for various reasons, more effective in achieving literacy than a republican regime. In other cases, the dichotomy between centralization and

decentralization is false, as many educational systems settled for some hybrid arrangement. Such would be the case in Prussia (as well as the Habsburg Empire) where the oversight over content of education was relatively centralized and tightly controlled while the school financing was local. Under such circumstances, the local popular demand for more educational infrastructure will likely depend on what kind of education the state deems allowable. Ficker (1873) documents, for example, that for the whole first half of the 19th century, the Austrian government pushed for the spread of primary schooling but resisted the growth of secondary, particularly technical, schooling.

All things considered, not all demand for education takes the form of public or political action, nor does a political activity necessarily reflect widespread individual demand among the local population. Our contribution is to attempt (i) to separate individual demand for more education, driven presumably by rising returns to education, from the public/political demand for more educational facilities and (ii) in analyzing the public demand for educational infrastructure, to separate the influence of economic development from that of political clout/voice.

We exploit the rich detail of schooling information in the Habsburg school census of 1865 and combine it with data on local economic development, such as industrial employment, local railroad access and use of steam power. The descriptive statistics from the school census for relevant variables are reported in Table 1. Not all provinces reported the full slate of variables. Those that did we call "core provinces" – they happen to be the ones, which have lived under the Habsburg scepter since at least the late Middle Ages (see Figure 1).[2] The unit of observation is a

[2] In contrast, Galicia, Bukowina and Dalmatia came under the Habsburg rule between the Partition of Poland (1772) and the Peace of Vienna (1815). We therefore call these the "new provinces". We also have no data on Hungary and the rest of the eastern half of the Empire (Transleithania).

school district – an average district encompassed an area of about 363 km^2 and was a home to an average of 3.036 children aged 6-12.[3]

[Figure 1 here]

[Table 1 here]

We also have data on all secondary schools within the empire, so as to account for that part of the returns to primary schooling that consisted in enabling a student to continue with his (but not her!) education. We link our education data with information on local ethnic composition to capture the political aspect of the problem: since education content was centrally determined and school provision and attendance were compulsory by law, the language of instruction was education's most prominent feature of local political import.[4] We use this factor to test the importance of political voice in schooling.

We merged this schooling dataset with information on the structure of employment, contained in the 1869 census. This gives us share of workers employed in services, agriculture, several different sectors of industry, as well as those who did not report any occupation.[5] We use it as our measure of economic development and as a measure of the human capital demand arising from the local labor market in individual school districts.

3. Education in the Habsburg Empire cca 1865

From the start, the spread of primary education through the Empire was shaped by government policy. The schooling law of 1774 was the foundational act of systematic primary

[3] Considering that these age cohorts usually represent about 13-14% of the total population, we infer that the average district had about 22 – 24.000 inhabitants.
[4] Other aspects, such as content and teaching methods, were determined centrally, not locally, and local religious variation had ceased to be a political matter, given that school curriculum allowed for separate religious instruction for Protestant children.
[5] The 1869 census unfortunately does not differentiate employment by gender, reporting only the total in each location and sector, so we supplement this information by using the 1880 census figures.

schooling. It introduced several basic features that survived until the next major reform of 1869, such as the 6-year compulsory schooling for both boys and girls aged 6 to 12, the stress on religion and the *trivium* in education, the distinction between two-grade country schools and 3- or 4-grade town schools, the compulsory certification of teachers and the strict control of the curriculum. An amendment of this law, promulgated in 1805 during the Napoleonic Wars, tightened government control over the schooling system and, in consequence of the Habsburgs' contempt for the ideas of the French Revolution, reinforced its conservative thrust. The system also betrayed a preference for (though not insistence on) instruction in German.[6] Cases where "Romanian children were taught in Polish to read from a German textbook" (Prausek, 1868: 6) opened the system to accusations of Germanization. The revolutions of 1848 produced a few changes in legislation, most notably an explicit statement in favor of instruction in one's mother tongue, freedom of teaching methods, an expansion of primary schools from two grades to three grades and an extension of teaching colleges from one year to two. But other attempts at liberal education were soon quashed through the Concordat of 1855, which put the Church yet again firmly in charge of the school supervision and teacher appointments. Even the language provisions were less than perfectly enforced, as we shall see, and the freedom of teaching method fell flat.[7]

Until the secularization reforms of 1868-69, the curriculum was saturated with religious instruction. Pacher (2008) quotes a "recommended" school timetable where catechism and biblical history took up six out of eighteen weekly lessons for the 9-12 year-olds and four out of

[6] The local primary schools, even those with a Slavic language of instruction, were called "German schools".

[7] The 1805 law recommended that teachers commit the teacher manual to memory so as to minimize deviations from it in the classroom. It explicitly stated that "the Bell-Lancaster method" of peer learning, then popular in England, "was banished from our class-rooms." Post-1848, teachers were no longer bound by these provisions but, for various reasons, only few teachers took up the opportunity to update their methods (Ficker, 1873: 40).

nine weekly lessons among the 6-8 year olds. The law stipulated that a school day should preferably begin and end with a lesson of religion (Helfert, 1860: 286). Writing, reading and counting were next in importance, apportioned equally across the remaining weekly lessons, with a few lessons spared for singing.

[Figure 2]

Figure 2 offers a rudimentary measure of the effectiveness of these schools. It plots the average enrollment recorded for the generation born in the 1830s against the literacy rates of that same cohort in the 1890 census. At first glance, the schools seem to have been adequately successful in teaching literacy: the scatter plot by and large lies along the 45° line and simple correlation between the two variables is 0.98 for men and 0.99 for women. But there are also some worrying signs. Consider the case of Carinthian women (denoted KT). While 47.4% of them enrolled in school during their school-age years, only 30% reported themselves capable of reading and writing in the 1890 census. Of course, historical literacy rates are susceptible to biases such as education creep, selective mortality and selective migration. The first two of these, however, bias literacy upwards (as illiterates die out faster than literates and surviving illiterates report themselves more educated than they really are), so in the Carinthian case, one would have to posit an enormous selective emigration of literate women (but not literate men who are much closer to the 45° line) to generate the more than 17-point shortfall in literacy relative to enrollment. Clearly, the more plausible explanation is that the enrolled girls did not attend very diligently, or if they did attend, they did not learn much, or even if they did learn, they later lost their literacy skills for lack of use. None of these hypotheses bodes well for the effectiveness of the educational system.

Schooling was compulsory for children aged 6 to 12. Figure 3 suggests that at least in some provinces the enrollment was successfully enforced. But it also shows a telling contrast with

enrollment rates reported during the same time period in those US states where school attendance was not yet compulsory.[8] The gradual arc of the American age-enrollment profile captures voluntary decisions, based presumably on one's weighing the pros and cons of each extra year of education. On the other hand, the sharp increase in enrollment at 6 and the sharp decline at 12 in some Habsburg provinces suggests enrollment conforming not so much to the schooling preferences of children or their parents but rather to the law's demands. Together with the Carinthian example of a shortfall in literacy, discussed earlier, this constitutes a particularly damning indictment: a schooling system that underperforms in terms of education, yet forces the population to devote time to it over and beyond its useful margin.

[Figure 3 here]

Apart from compelling pupils to attend, the law also required local communities to supply the resources for school provision. This consisted of construction and maintenance of the school building, paying teacher salary and providing teacher accommodation. In principle, wherever 100 school-age children lived within half-hour of walking distance, a school was to be built with ideally 80 but certainly no more than 100 pupils per classroom. Table 1, column (ii) shows that, with 12.04 classrooms per 1000 school-age children on average, this regulation was upheld in many districts but the high standard deviation around this average reveals that the legal benchmark was far from universal.

When a school was built, the area around it, usually corresponding to the parish, was considered "covered" (*eingeschult*) and the school-age children living there were obliged by law to enroll and attend the particular local school.[9] All core provinces were more than 80% covered, although there were districts in the Austrian Littoral where coverage sank below 30%. Less than

[8] The data for US states were kindly shared by Karen Clay and her co-authors in Clay et al. (2012).

[9] When a village or an area was not covered, the local priest nonetheless had to report to his superiors on the number of children in school age, which is how we came to know their numbers.

full coverage indicates that some communities did not meet the stipulations of the law. If a town or a parish failed to provide schooling, the district authorities had at their disposal some carrots in the form of subsidies and some sticks in the form of power to sequester a portion of the local budget and assign it to schooling. The upper echelon of both public and church administration expressed, however, a strong preference for using carrots and avoiding unnecessary conflict between district supervisors and individual communities (Helfert, 1860: 19). Communities were expected to enforce attendance. With overall enrollment reaching only 70.2% (Table 1), it is clear that in some school districts – especially in the "new" provinces – schooling was compulsory in name only.[10]

As regards the ethnic/language question, post-1848 official policy no longer endorsed education in German explicitly but issues of language of instruction and of public support for non-German schools remained a sore spot practically to the end of the monarchy. Non-German nationalities continuously complained about the residual Germanizing tendencies of the educational system, which was, after all, run by an overwhelmingly German civil and church administrations and designed by German policy makers. Our 1865 dataset includes 22 school districts with zero German students which nonetheless had at least one German or bilingual school. The broad outlines of the situation are summarized in Table 2, which also reports simple t-tests for mean differences. The German-majority districts did have almost everything better and by a significant margin: more classrooms and teachers per 1000 school-age children, more public spending per child and better coverage by school infrastructure. Only the curriculum extent, measured by the average number of grades per school, was comparable between German and non-German districts. The German districts fell behind, however, in provision of education in

[10] Austrian statistics make no conceptual distinction between enrollment and attendance. The figures reported in Table 1 come from statistics labeled "*Schulbesuch*" (school attendance) in the original document. But from the context of the operation of the schools, it is clear that they were enrollment numbers.

minority languages, i.e. in building schools for the local Slav minorities, while German minorities in non-German districts had almost certain access to instruction in their mother tongue.[11] The better school provision in German districts could be a result of their higher level of economic development but the economic variables at the bottom of Table 2 cast some doubt on that: some are better in German districts, some in non-German ones, some show no significant difference.

[Table 2 here]

The German element undoubtedly had the strongest political voice among all the nationalities, although in the Habsburg context it would be counterproductive to try to measure it using electoral statistics.[12] Table 2 suggests that the German political voice, however informal and unobservable directly, may have had measureable impact on the disbursement of public funds in matters of schooling and especially minority German schooling. Recall that the district authorities – the political elites in our case – were not in a strong position to prevent a school from being built by a determined community, but they could make it significantly easier and cheaper by providing a subsidy to a within-district minority who may not have been big enough to support a school on its own.

An important part of our empirical analysis is to see whether these plain differences in mean along ethnic lines survive when we control for other local factors. The main lesson from our brief outline of the Austrian educational system is that – unlike in the Easterlin-Lindert story, where political voice is an ally of economic development – in our case the two forces are, if not set against each other, then certainly not pushing in the same direction. If the pro-German advantages do not survive controlling for economic variables, then apparently political voice

[11] Note that these particular measures are calculated from a subsample of districts with more than 100 minority students, i.e. those where a minority school may be reasonably justified.
[12] As of 1865, the Empire had had experience with mere two nation-wide elections (1848 and 1861), the suffrage was highly constrained and too complicated to interpret easily, falling into four different electoral colleges of unequal importance; and in any case, it encompassed only a tiny fraction of the public.

mattered less than development. If, on the other hand, economic variables turn out not to matter in the presence of the ethnic variables, then it suggests that the school was not so much an engine of growth as a cultural battlefield.

4. Estimation

We separate our empirical analysis into three parts. First, on the individual level, economic development may potentially affect one's demand independently of the provision of schooling. That is, whether parents choose to enroll their child in a school, given some existing supply, depends on the expected returns to education. Second, on the district level, the provision of schooling may respond to economic development through two channels: by increasing the tax base which will make public financing of local schools easier and presumably through greater demand for such provision. Finally, to assess the importance of political voice relative to the economy, we look for differences in the treatment of German minorities in non-German districts and non-German minorities in German districts along the ethnic boundaries within the Empire.

4.1. Individual demand for education

We investigate how enrollment in a district responded to economic changes, conditional on the existing supply of schools. Ideally, one would like to know the expected returns to primary education for individual children and see how these varied with development. We do not have such detailed information and so we exploit the difference in post-primary school careers open to boys and to girls. For each district, we construct a dependent variable that measures enrollment of boys and girls separately. Since this variation took place within districts, we are able to include district-level fixed effects that will capture district-specific levels of law enforcement, supervision and other characteristics of the school supply. Since boys and girls face the same school supply and primary schooling was overwhelmingly coeducational in terms of

extent and content, any differences between boys' and girls' enrollment will be due to differences in their expected returns to education: the post-primary-school prospects.[13]

Girls did not continue with their education beyond primary school; secondary schools were for boys only. We use the sum of all secondary schools' entering class slots within 50km of a district to measure the prospects of secondary education for boys; for girls, this value is set to zero. Girls and boys also benefited differentially from economic modernization in their employment prospects after graduation. While industrialization generated new employment opportunities for men and women alike, some sectors were more feminized than others. We measure the impact of economic development on private demand for education by constructing what we call literacy content of local labor market: from the 1869 population census, we take sectoral shares of employment within 50km of each school district, estimate proportions of women in each sector and evaluate each occupation in terms of its literacy usage, using Mitch's (1992: 213-4) classification for mid-19th century jobs.[14] The result is an index between 0 and 1 where 1 means that all local jobs required literacy and 0 means that literacy was not in any way useful in the local labor market. Figure 4 displays the values for men and women in each district.

[Figure 4 here]

School attendance was compulsory by law and even though its enforcement was far from perfect, the actual observed enrollments were presumably at least partially affected by the existing threats of fines and other penalties. However, in all the districts in our dataset, actual enrollments included children who were not under legal compulsion. First, there were children who lived in villages currently not covered by school provision (*nicht eingeschulte Ortschaften*) and it is clear from the data that in many places these did actually enroll in whichever school was

[13] We also include a boys fixed effect to capture potential other, non-economic, gender biases.
[14] See Appendix 1 for more detail on the construction of this variable.

closest.[15] Second, while compulsory education extended to age 12, all but three districts report positive enrollment among children over 12. For these two groups, the enrollment was voluntary, so as to avoid the problem of a censored dependent variable. We therefore use, as our dependent variable Y_{is}, enrollment per covered school-age child. The presence of the two groups of voluntary enrollees explains why in many districts this measure would exceed 1.

Our specification is:

Eq. (1) $$Y_{is} = \beta_1 + \beta_2 EC_{is} + \beta_3 LC_{is} + \beta_4 1(Boys)_{is} + \delta_i D_i + \varepsilon_i$$

where EC_{is} stands for secondary school entering classes within 50 km of the school district, LC_{is} is the literacy content of local labor market, $1(Boys)_{is}$ is a gender fixed effect and D_i is a vector of school district fixed effects. Subscript *i* indexes school districts, subscript *s* genders.

[Table 3 here]

Table 3 presents the results of the least-squares estimation. For comparison, we also present a model with no fixed effects in column (i) and with diocese (but not district) fixed effects in column (ii). Our baseline specification is in column (iii). Overall, the coefficients on literacy content do not indicate a very large impact on enrollment. Using the standard deviation from Table 1, increasing literacy content by 0.04 will increase enrollment by 2.5 percentage point. Even the secondary school prospects have a weak impact.[16] To see how robust these results are, we re-estimated the same specification on various subsamples, as presented in columns (iv) – (vii). Perhaps the biggest worry, given our definition of the dependent variable, would be that

[15] Coverage (*Einschulung*) meant that each child was assigned to a particular school. Teachers were required to turn away pupils who were assigned to a different school but the law was silent on children who were not assigned to any school.

[16] Interestingly, given that the schooling law was ambiguous enough to allow for a certain age overlap between primary and secondary schools, the negative sign of this coefficient suggests that an increase in available secondary school slots produced no more than a relocation of some pupils from primary schools to a secondary school. This corresponds also with the size of the coefficient – one standard deviation increase in secondary school spots decreases enrollment rate by about 1 percentage point – i.e. very little; and secondary school enrollment usually hovered around 1-2 percent of an age cohort (see Figure 3).

districts with already full coverage would inevitably show considerably less variation in enrollment because voluntary enrollment can only happen there along the age margin, but not the coverage margin. The last two columns of Table 3 give some credence to this. The difference in the literacy content coefficients is a factor of three and a half. Still, even the large coefficient in column (vii) would imply an increase in enrollment of 4.2 percentage points as a result of extra 0.04 increase in literacy content in the local labor market. In short, the effects in any of the subsamples are effectively zero, and a fairly precisely estimated zero at that. If on average 95.2 out of every 100 covered school age children went to school, it was not the lure of labor market payoff to literacy that was doing the heavy lifting.

4.2. Determinants of school supply

The individual demand for education therefore does not seem to have responded very strongly to economic development. Either the education offered in school was not a strong complement to modern industry, or schools – and the enforcement that went with them – were built "ahead of demand", thereby placing a more or less binding constraint on who enrolled. Since we do not have any direct measure of the strength of enforcement, which would be captured by the district fixed effects anyway, and we know that an established teacher in a school was the "first instance" of enforcement of compulsory attendance, this question ultimately speaks to the determinants of the supply of schools: were the developed communities building more schools because they proved useful to economic development in a way not captured by Table 3? Or was the industrialization merely making compliance with the schooling law easier?

We choose three school characteristics to capture the extent and quality of school provision. These are all defined on the level of a school district. Our main measure of curriculum quality is

the average number of grades per school.[17] The extent and density of school infrastructure is measured by the number of (non-priest) teachers per 1000 school-age children.[18] We also include annual expenditure on teaching staff per school-age child in a district, measured in gulden of Austrian currency.[19]

To analyze the intersection between economy and politics, we estimate, in Table 4, a system of simultaneous equations where we allow the local industrial employment share to depend on local stock of human capital, proxied by the supply of teachers and quality of primary schools. The system is specified as follows:

Eq. (2a) $T_i = \alpha_1 + \beta_1 IND_i + \theta_1 1_i(G) + \boldsymbol{\lambda}_1 \boldsymbol{X_i} + DFE + \varepsilon_{i1}$

Eq. (2b) $GR_i = \alpha_2 + \beta_2 IND_i + \theta_2 1_i(G) + \boldsymbol{\lambda}_2 \boldsymbol{X_i} + DFE + \varepsilon_{i2}$

Eq. (2c) $P_i = \alpha_3 + \beta_3 IND_i + \theta_3 1_i(G) + \boldsymbol{\lambda}_3 X_i + DFE + \varepsilon_{i3}$

Eq. (2d) $IND_i = \alpha_4 + \gamma_4 T_i + \delta_4 GR_i + \zeta_4 P_i + \theta_4 1_i(G) + \boldsymbol{\lambda}_4 \boldsymbol{X_i} + DFE + \varepsilon_{i4}$

where T_i is the number of teachers per 1000 school-age children, GR_i is the average grades per school, P_i is the spending on teaching staff per school-age child, IND_i is the share of employment in industry, $1_i(G)$ is an indicator for a district with a German majority and $\boldsymbol{X_i}$ is a

[17] Two-grade schools followed the curriculum followed in Section 3. Communities could, in agreement with church and civil authorities, extend it by introducing third and fourth grades where subjects like Geography, Nature and Drawing were also included. Passing fourth grade was a prerequisite for further secondary education.

[18] We could also include classrooms per 1000 school-age children among the endogenous variables in this system of equations but it is highly correlated with the teacher measure.

[19] Our measure of expenditure is equal to the total income received by the teacher. In case the pay from public budget was insufficient, the community and the teacher could agree that the teacher levy an additional fee from attending pupils, called *Schulgeld*. We do not have information on spending on maintenance of infrastructure, but teacher salaries make up the bulk of public spending on education (Go & Lindert, 2010).

vector of exogenous variables which ensure that the order conditions of identification be satisfied.[20] *DFE* stand for diocese fixed effects.

The results are presented in Table 4 and they suggest a link from industrial development to school supply but not necessarily the other way round. Share of industrial employment positively impacts with all three measures of school provision; in equations 2b and 2c, the impact is sizeable. One standard-deviation increase in industrial share (13.9 percentage points – or 0.139) would add 0.4 grades[21] in each school in the district and increase the spending on teaching staff by 0.68 gulden per school-age child. On the other hand, the coefficients on the school variables in column 2d are all imprecisely estimated and do not even operate in the same direction. The positive effects of grades per school and spending on teachers are in fact more than outweighed by the negative impact of teacher supply, when all three measures are increased by one standard deviation. These conclusions are reinforced, when, in Panel B, we re-estimate the system without Vienna, a clear outlier along most dimensions (see Table 1, column (iv)).

[Table 4 here]

The coefficients on the German dummy variable suggest that economic factors are unable to account fully for differences in school provision between nationalities but the results are somewhat ambiguous. German districts seem to enjoy significantly higher teacher supply per

[20] The vector $\boldsymbol{X_i}$ must include enough exogenous shifters for the system to be identified. These are: a measure of population dispersion in Eq. (2a), number of spots in local secondary schools in Eq. (2b), distance to provincial capital in Eq. (2c) and total population living in urban centers with more than 5000 inhabitants in Eq. (2d). These are determined exogenously (outside the model) but have a direct bearing on the dependent variables. For example, population dispersion will increase the demand for teachers because districts with many small villages will have to build more smaller schools compared to a more concentrated district, even if they both have comparable populations of school-age children.

[21] Given that grades are indivisible, perhaps a better way of expressing the result is that all schools in a district would be raised from two-grade schools to three-grade schools – a big change –, if industrial share increased by 35 percentage points.

child than non-German district but they also seem to have a slightly lower quality of schools (coefficient in column 2d is -0.22, statistically significant but small), with no difference in spending on teachers (column 2c). But German districts happen to be more industrial (after controlling for other factors), so on the basis of Table 4 alone one could argue that the advantages of German districts, reported in Table 2 as unconditional means, were really a result of different economic conditions, which correlate with German population.

Overall, the evidence in Table 4 indicates a strong interaction between the local economy and the local school supply. The extent of industrial development is positively and non-trivially correlated with investment in school quality as well as school quantity. The differences between schools in German and non-German districts do not quite go away after controlling for the economic environment, although they are diminished along some dimensions.

4.3. Treatment of ethnic minorities: a spatial discontinuity regression

To isolate the impact of (the pro-German) political voice of the elites vs that of the local masses as cleanly as possible, we go below the level of school districts and compare the treatment of German minorities in non-German districts against the treatment of non-German minorities in German districts. As mentioned before, district or higher authorities had scarcely any official means to prevent a school from being established; in fact, they were expected to enforce a law, which required full school coverage and full attendance. They could, however, be more or less cooperative in providing a subsidy to small communities who expressed a desire to build a school but claimed to lack sufficient means to sustain it. Such could reasonably be the case of local ethnic minorities. If political voice mattered in this way, then we would expect –

since public administration was overwhelmingly German[22] – that German minorities would be more successful in securing such aid than non-German ones.

To explore this idea, we exploit the fact that the 1865 school census reported the language of instruction for each school in each district, together with the number of students of each mother tongue. Even when some minorities were too small to have their own schools, the record noted if a local school was bilingual, providing at least a parallel class in the minority language. To control for as much variation in other characteristics of these districts, we look for German and non-German districts straddling long-standing ethnic boundaries within the Empire. We are confident that these are exogenous to schooling provision, as they were a result of mediaeval settlement patterns, and in the opinion of 19th century demographers they scarcely moved (Rauchberg, 1905; Ficker, 1864; Czoernig, 1855). The boundaries were also quite sharp, so much so that there were pairs of districts, no more than 15 miles apart, on either side of an ethnic boundary that reported no minority students at all. However, we were able to locate 34 pairs of German and non-German districts such that they both contained a linguistic minority that either had a school operating in its own language or was big enough that it should have had one (i.e. it numbered over 100 students of a given mother tongue). Of these 34 matches, 27 are German-Czech in Bohemia, Moravia and Silesia, 5 are German-Slovene in Styria, Carinthia and Carniola and 2 are German-Italian in South Tyrol.

The 34 matches consist of 68 districts, each appearing in exactly one match, and each district contributes two observations: one for the local majority schools and one for local minority schools.[23]

[22] Until 1880, German was the sole language of administration both internally and externally and clerks of German mother tongue disproportionately outnumbered other nationalities (Jaszi, 1929: 273-279)

[23] Schools that offered both local languages of instruction are counted as minority schools.

Eq. (4) $$Y_i = \beta_1 1_i(G) + \beta_2 1_i(Min) + \beta_3 1_i(GMin) + \beta_4 IND_i + \beta_5 1_i(U) + \sum_j \delta_j D_{ji} + \varepsilon_i$$

Our regression specification includes dummy variables for a German majority district, $1_i(G)$, for minority status, $1_i(Min)$, for a German minority school, $1_i(GMin)$, as well as 34 match fixed effects, D_j. The variable $1_i(U)$ is a dummy for urban school districts. Since the districts are immediate neighbors (average distance between their administrative centers being 11 miles), any local specifics are likely to operate in both matched districts and will be captured by the match fixed effect. We also include the local share of industrial employment, IND_i, to control for within-match variation in economic development. Given this set-up there are several ways in which the importance of political voice can play out: (i) if $\beta_2 = \beta_3 = 0$, then we find no conclusive evidence of minorities of either kind receiving any systematically different treatment, so it will be difficult to argue that district authorities were playing favorites; (ii) if $\beta_2 \neq \beta_3 = 0$, then minorities of any kind are treated differently and the advantage of political voice rests with district majorities rather than with Germans; (iii) if $\beta_3 \neq 0$, then the German minority is clearly getting a different treatment (for better or worse) and so political voice matters.

The simultaneous equations framework employed in previous section rested on the unstated assumption that economic development, measured by IND_i, could be endogenous to the school supply. The stock of schooling infrastructure, available in 1865, is likely highly correlated with past stock of schooling infrastructure (since school buildings, teaching staff and even public budget items have certain inertia), which in turn affects local literacy levels and, by extension, economic development. Consistency alone requires that the potential endogeneity we assumed in Eqs. 2a-2d be accounted for in the spatial discontinuity regression also, which is why we instrument for IND_i. Relying on an old empirical regularity, observed already by Austrian contemporaries, that economic development follows a West-East gradient, we instrument IND_i with longitude (Good, 1984: 11).

The results are presented in Table 5. The instrument, though not perfect, seems to perform reasonably well: the first-stage F-statistic is equal to 13.4. With 34 fixed effects and 8 other variables in a regression counting 136 observations, statistical significance is inevitably going to suffer. Yet in spite of that, some clear patterns emerge. Across the different specifications, we see β_1 either positive or a statistical zero, indicating that German-majority districts had at least some advantage, already seen in Tables 2 and 4. But it went deeper than that: $\beta_2 < 0$ and is statistically significant in all four regressions, while $\beta_3 > 0$ in all and significant in three of them. The bottom of Table 5 shows a series of t-tests for $\beta_2 + \beta_3 = 0$, to see whether the German minorities had enough clout to outweigh the otherwise negative effect of minority status. As it turned out, $\beta_2 + \beta_3 > 0$ unambiguously in three specifications, i.e. the German minorities were actually doing better in terms of the supply of teachers, classrooms and public funds per school-age child than the local majorities (in some aspects, they were even slightly better off than German schools in German districts, $\beta_2 + \beta_3 > \beta_1$). Overall, these results add up to a fairly consistent evidence of significant advantage for the Germans – it means that when it came to a stand-off between the German elites and local Slav majorities, the elites were able to impress their preferences on the ethnic mix of local schooling.

[Table 5 here]

Within the narrow confines of matched district pairs, the impact of economic development is only imprecisely estimated because there is usually relatively little variation in industrial employment (in contrast to the sharp ethnic boundary which district pairs straddle). The coefficients are mostly positive (with the exception of column (iv)) but not practically meaningful. Perhaps only for grades per school (column (i)) and spending per school-age child (column (ii)) can it be said to have a noteworthy impact: an increase in IND_i by the standard

deviation of 0.143 in the subsample would add 0.21 florins to per-child spending and add 0.25 grades to every school in a district.

5. Conclusions

The evidence reveals two important features of the Habsburg educational system. First, we find stronger support for the claim that economic development enabled a more extensive supply of educational facilities, perhaps through broadening of the tax base, than for the notion that economic development generated a strong individual demand for public education, such as through raising returns to primary education. Not that the Habsburg schools failed in imparting literacy across the board – the correlations in Figure 2 are too strong for such a claim. But the curriculum also included a lot of extra material that did not generate useful human capital. Apparently, the Viennese government designed a flawed product, decreed that it be oversupplied and burdened local communities with paying for it. We have no estimate of how much deadweight loss this policy generated but we cannot find any positive effect of this policy on economic development.

Second – and closely related, the reason why economic considerations were sidelined is to be found in the politics of schooling. Political voice seems to have played a role. Accounts of Austrian political history show unequivocally that education, its extent, availability and language of instruction were highly politicized matters. We find evidence that this nationalist politics impacted educational choices made on the ground, even at the local level.

Overall, this adds up to a different picture to that painted regarding the modern rise of public education. While all the elements of the usual story – the industrialization, the public provision of schools, the political voice of important pressure groups – are present in the Austrian case, they combine in a way very different from how, for example, Go and Lindert (2007, 2010) have described the rise of American public schooling. Rather than education and human capital

accumulation being among the drivers of economic growth, we see how economic development provides the resources for the Habsburg Empire's own version of "culture wars" whereby the school district elites – far from withholding public resources from education – actively subsidize that kind of schooling which corresponds to their ethnic preferences. For those who lacked political voice – in our case, the non-German nationalities – the road ahead did not pass first through enfranchisement to public education and eventually to economic development but exactly the other way: economic growth allowed them to catch up (at least in some respects) in matters educational which – a generation later (and outside the scope of our paper) – led to their political self-assertion. And while this order of causation does not in anyway refute the more traditional account, at least as it applies to the United States, for example, it highlights that the interplay of education, politics and development can be much more varied.

Appendix 1 – Measuring literacy content of local labor market

The variable "Literacy content of local labor market", used in Table 3, is a combination of three pieces of information. The first piece is the structure of employment of local labor market. We draw on the data published in the 1869 Cisleithanian census (K.k. Statistische Zentral-Commission, 1871). It contains employment totals for each of 813 *Gerichts-bezirks*, the smallest administrative units then in existence, split into 50 occupations (see Table A1 below for detail). Separate categories for men without an occupation, women without an occupation and children under the age of 14 were also included so as to fully account for the whole population in each *Gerichts-bezirk*.

Unfortunately, the occupations in the 1869 census were not disaggregated by gender. Therefore, the second piece of information comes from the 1880 census, which provided gender-specific employment figures for broadly similar occupational categories.[24] These were available for each province and they varied from zero share of women (among army officers) to zero share of men (among nuns and midwives).

The third and final piece of information came from Mitch (1992: 213-214). It is a classification of occupations by use of literacy for mid-19th century England. We make the assumption that the classification is applicable to the Habsburg Empire without major changes, especially since most of the assignments are probably quite uncontroversial. One potentially significant deviation from Mitch (1992) consists in reassigning farmers from the likely category to the ambiguous category but it is a change that does not affect the results in Table 3 and only leads to an increase in the literacy content measure across the board.

[24] Several gender compositions for some industrial sectors had to be supplied from the 1890 census.

These three factors are combined to produce the literacy content variable. For each school district, we take the employment data in *Gerichts-bezirks* that are within 50 km of the school district, calculate the shares of employment separately for men and women and weigh them by the assigned literacy weight L (noted in Table A1).

Table A1 – Assignment of occupations to various literacy categories
Literacy required (L = 1) Priests and nuns, public sector clerks, army officers, teachers, students, writers, artists, lawyers, doctors, surgeons, midwives, pharmacists, sanitation workers, clerks in the private sector*, entrepreneurs and business owners*, employees in finance
Literacy likely to be useful (L = 0.7) Employees in the trading sector, rentiers and renters of real property
Occupations with possible (or ambiguous) use of literacy (L= 0.3) Farmers, sharecroppers, laborers*, domestic service
Occupations unlikely to use literacy (L = 0) Agricultural laborers and farm servants, fishermen, industrial laborers*, those without occupation
Note: The assignments are based on Mitch (1992: 213-214). The * denotes those occupations which in the original document are further disaggregated into various sectors (e.g. 8 separate industrial sectors).

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Table 1 - Descriptive statistics				
	(i)	(ii)	(iii)	(iv)
	All provinces	Core provinces	New provinces	Vienna
Number of school districts	730	546	184	1
Number of school-age children	3036 [2514]	2882 [2394]	3491 [2797]	37958
Average number of grades		2.17 [0.48]		3.91
Non-priest teachers per 1000 school-age children	11.62 [7.82]	12.71 [6.73]	8.37 [9.72]	15.39
Classrooms per 1000 school-age children		12.04 [6.2]		12.17
Teaching staff expenditure per school-age child		2.16 [0.9]		5.22
Percent school-age children covered by school provision (school coverage)		95.7 [9.69]		100.0
Percent school-age children enrolled	70.2 [29.53]	84.1 [17.31]	29.1 [17.49]	86.1
Enrollment per 100 covered school-age children		95.2 [16.92]		96.0
# steam engines in school district	4.0 [12.01]	5.0 [13.62]	0.7 [2.92]	156.0
Share of industrial employment (%) (from 1869 census)	19.2 [13.8]	22.7 [13.9]	8.9 [6.3]	65.0
Distance to railroad (km)	44.8 [75.44]	20.9 [22.15]	115.6 [120.27]	0.0
Secondary school slots within 50 km	191.2 [188.4]	220.1 [201.9]	105.2 [100.8]	920.9
Literacy content of labor market (boys)	0.241 [0.041]	0.247 [0.043]	0.224 [0.029]	0.358
Literacy content of labor market (girls)	0.092 [0.037]	0.105 [0.032]	0.053 [0.024]	0.186
Note: Core provinces are Lower Austria, Upper Austria, Salzburg, Styria, Carinthia, Carniola, the Austrian Littoral, Tyrol and Vorarlberg, Bohemia, Moravia and Silesia. New provinces are Galicia, Bukowina and Dalmatia.				

Table 2 - Comparison of education variables in core provinces				
	Means		t-test	p-value
	German (N=274)	Non-German (N=272)		
Average grades per school	2.17	2.17	-0.04	0.96
Classrooms per 1000 school-age children	13.97	10.09	-7.69	0.00
Teachers per 1000 school-age children	15.06	10.34	-8.73	0.00
Spending on staff per child (in fl per year)	2.28	2.05	-3.09	0.00
School coverage	96.98	94.38	-3.16	0.00
*School with minority language of instruction is present	70.40	87.10	2.46	0.02
*Parallel class with minority language of instruction is present	85.20	95.30	2.09	0.04
Percentage of school-age children enrolled	90.10	78.04	-8.68	0.00
Number of steam engines	4.82	5.26	0.38	0.70
Share of industrial employment (%)	24.9	20.4	-3.78	0.00
1(railroad access)	37.50	30.30	1.78	0.08
Distance to railroad	22.12	19.69	-1.28	0.20
Note: *based on 139 districts with at least 100 German students and 100 non-German students.				

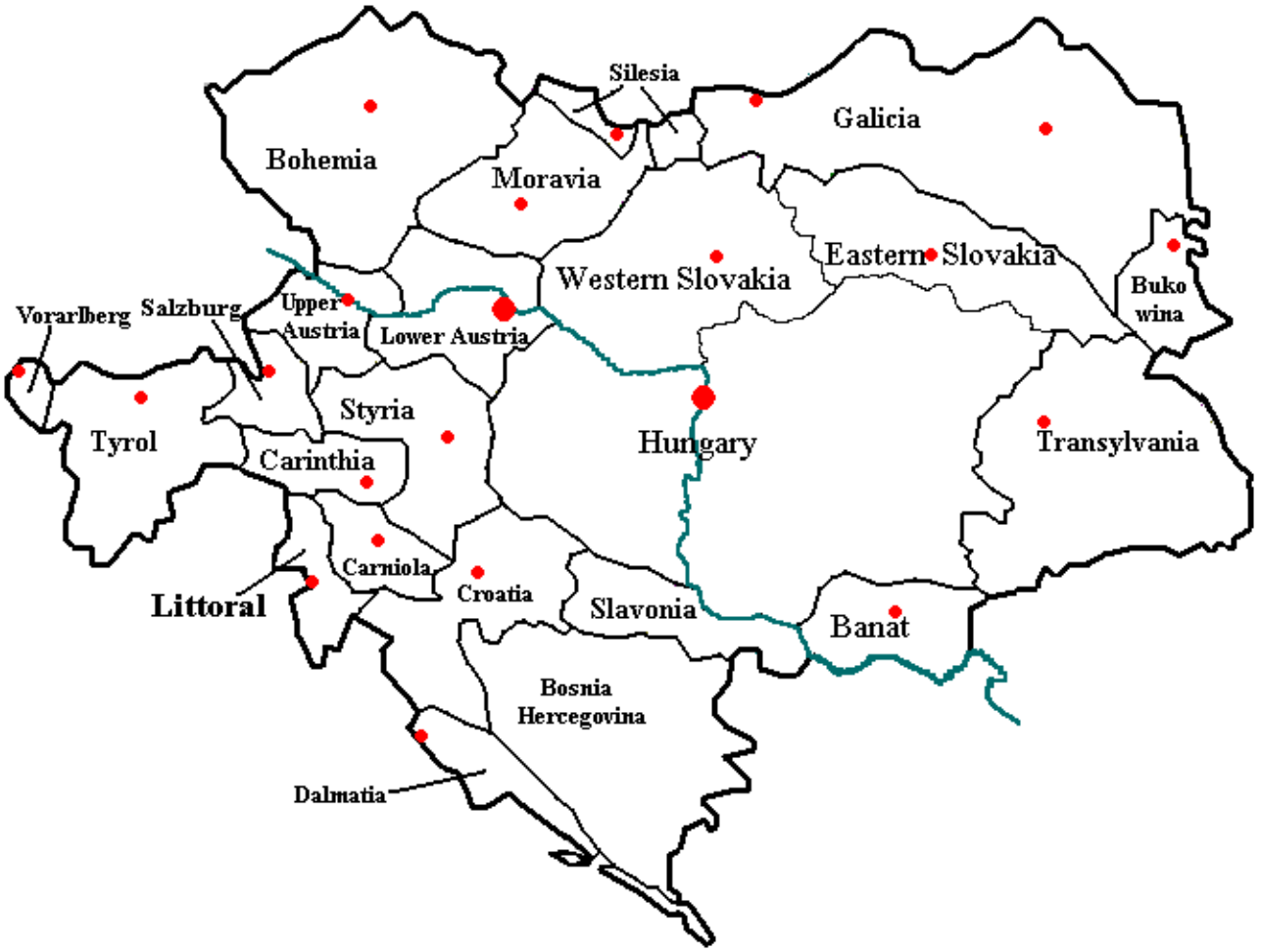
Table 3 - Individual demand for school enrollment (OLS)							
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
Dependent variable: Enrolled pupils per 100 covered school-age children							
Sample:	Full sample	Full sample	Full sample	German districts	Non-German districts	Full-coverage districts	Districts with less than full coverage
Secondary school slots	-0.011 [0.004]	-0.010 [0.003]	-0.011 [0.002]	-0.003 [0.002]	-0.023 [0.004]	-0.006 [0.002]	-0.016 [0.004]
Literacy content of labor market	126.201 [15.718]	59.030 [13.648]	61.084 [10.871]	15.566 [9.942]	63.560 [18.317]	30.018 [15.432]	105.143 [15.827]
1(Boys)	-11.391 [2.212]	-2.097 [1.850]	-2.271 [1.495]	0.075 [1.227]	2.127 [2.820]	-0.403 [2.359]	-5.463 [1.992]
Constant	79.700 [1.811]	86.776 [1.515]	86.559 [1.182]	97.617 [1.216]	80.707 [1.734]	92.658 [1.596]	79.194 [1.781]
N	1092	1092	1092	548	544	506	586
Adjusted R^2	0.067	0.609	0.856	0.841	0.856	0.826	0.874
Fixed effects	None	Diocese	District	District	District	District	District
Note: “Secondary school slots” measures the number of entry-level spots in secondary schools within 50km of each school district. “Literacy content of local labor market “ is a weighted index capturing the demand for literacy in the labor market within 50km of a school district. It is based on data on employment composition in the 1869 census (see Appendix 1 for more detail). Diocese fixed effects in column (ii) are 22 dummy variables for individual bishoprics. The estimation sample is limited to school districts in core provinces. Standard errors in brackets. See text for further details.							

Table 4 - Interdependence of school supply and economic development				
	Eq. 2a	Eq. 2b	Eq. 2c	Eq. 2d
	Teachers per 1000 school-age children	Grades per school	Staff expenditure per school-age child	Share of industrial employment
Panel A. Full sample - Core provinces (N = 546)				
Teachers per 1000 school-age children				-0.063
				[0.047]
Average number of grades				0.082
				[0.303]
Staff expenditure per school-age child				0.130
				[0.193]
Share of industrial employment	0.215	2.857	4.875	
	[4.588]	[0.610]	[1.190]	
1(German)	2.745	-0.220	-0.106	0.221
	[0.565]	[0.076]	[0.152]	[0.91]
1(Urban)	0.867	0.026	0.262	0.023
	[0.463]	[0.059]	[0.124]	[0.034]
Population dispersion	0.003			
	[0.005]			
Secondary school spots		0.096		
		[0.042]		
Distance to provincial capital			-0.001	
			[0.001]	
Urban population				0.000
				[0.001]
Constant	8.329	1.557	0.757	0.350
	[1.345]	[0.223]	[0.366]	[0.676]
Panel B. Core provinces, excluding Vienna (N = 545)				
Teachers per 1000 school-age children				-0.071
				[0.045]
Average number of grades				0.125
				[0.281]
Staff expenditure per school-age child				0.108
				[0.172]
Share of industrial employment	2.340	3.245	5.126	
	[4.591]	[0.639]	[1.186]	
1(German)	2.567	-0.255	-0.125	0.249
	[0.568]	[0.081]	[0.154]	[0.093]
1(Urban)	0.726	0.012	0.240	0.027
	[0.458]	[0.065]	[0.124]	[0.034]
Population dispersion	0.005			
	[0.005]			
Secondary school spots		0.074		
		[0.048]		
Distance to provincial capital			-0.001	
			[0.001]	
Urban population				0.000
				[0.002]
Constant	7.878	1.451	0.710	0.363
	[1.351]	[0.236]	[0.368]	[0.655]

Note: “Secondary school slots” measures the number of entry-level spots in secondary schools within 50km of each school district. “Population dispersion” is calculated as number of villages per 1000 school-age children in a district. “Urban population” is the total population in a district, living in towns of more than 5000 inhabitants. Standard errors are in brackets.

Table 5 - Regression results for spatial discontinuity regression (IV-2SLS)				
	(i)	(ii)	(iii)	(iv)
Dependent variable	Grades per school	Spending on teaching staff per school-age child	Classrooms per 1000 school-age children	Teachers per 1000 school-age children
sub-sample mean	2.191	2.559	10.852	16.684
sub-sample s.d.	0.731	1.32	4.607	7.062
1(majority German district)	0.026	0.502	1.695	3.294
	[0.152]	[0.262]	[0.888]	[1.289]
1(minority school)	-0.136	-0.444	-1.234	-2.276
	[0.141]	[0.243]	[0.823]	[1.194]
1(minority German school)	0.086	1.295	3.136	5.268
	[0.199]	[0.344]	[1.164]	[1.689]
Share of industrial employment	1.811	1.556	5.089	-1.773
	[2.044]	[3.535]	[11.974]	[17.372]
Urban dummy	0.483	0.128	-1.387	-1.982
	[0.209]	[0.361]	[1.222]	[1.773]
Constant	1.198	1.457	5.443	12.748
	[0.925]	[1.600]	[5.418]	[7.860]
t-tests:				
$\beta_2+\beta_3=0$	0.13	12.26	5.34	6.27
(p-val)	0.72	0.00	0.02	0.01
First-stage F:	13.42	13.42	13.42	13.42
Note: Standard errors are in brackets.				

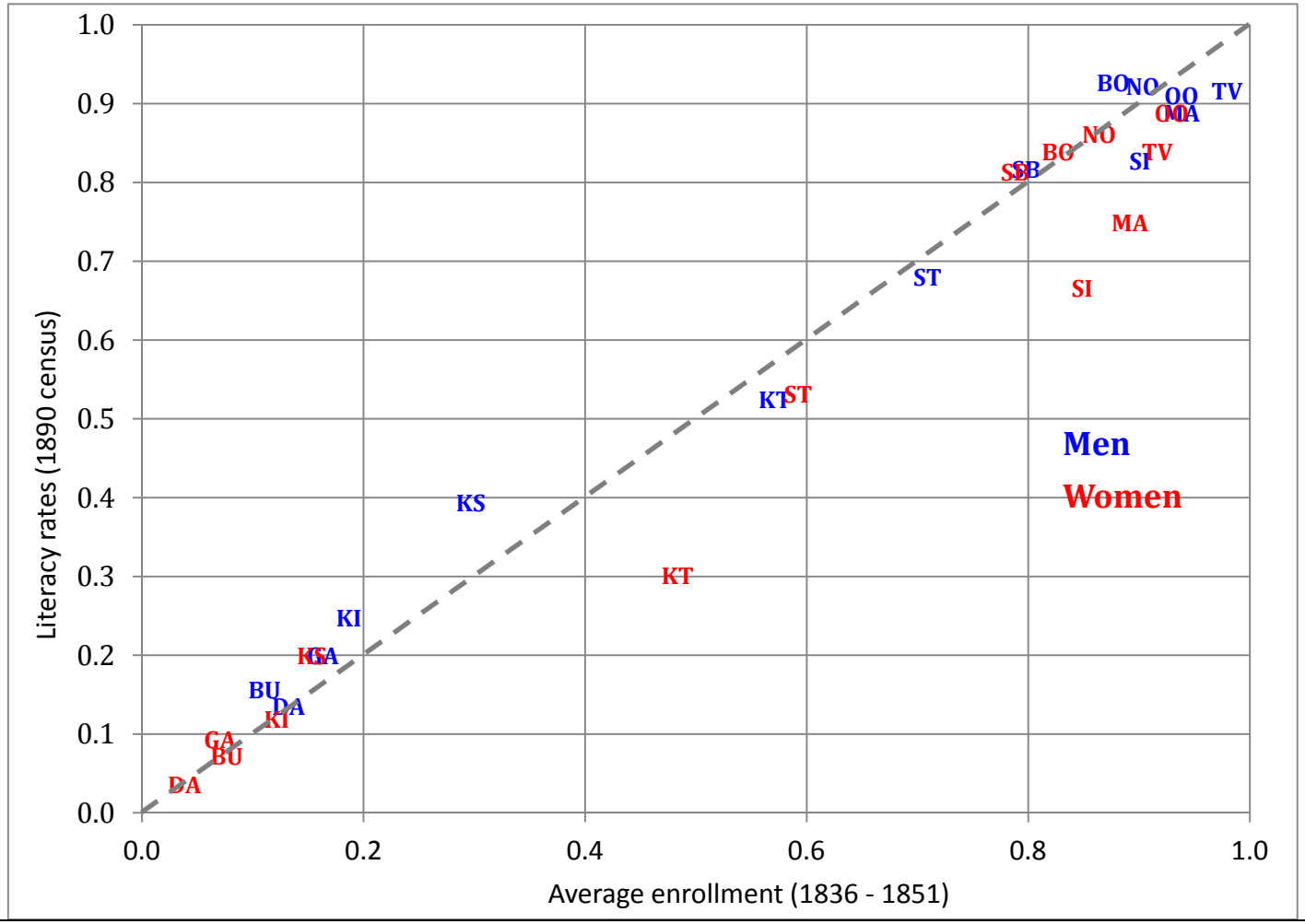
Figure 1 – Map of the Habsburg Empire in its 1914 borders



Province	Capital
Lower Austria	Vienna
Upper Austria	Linz
Salzburg	Salzburg
Tyrol	Innsbruck
Vorarlberg	Bregenz
Styria	Graz
Carinthia	Klagenfurt
Carniola	Ljubljana
Littoral	Trieste
Bohemia	Prague
Moravia	Brno
Silesia	Opava
Galicia	Lwow
Bukowina	Czernowitz
Dalmatia	Zadar
Hungary	Budapest
Transylvania	Cluj
Western Slovakia	Nitra
Eastern Slovakia	Košice
Croatia	Zagreb
Slavonia	Osijek
Banat	Timisoara
Bosnia-Hercegovina	Sarajevo

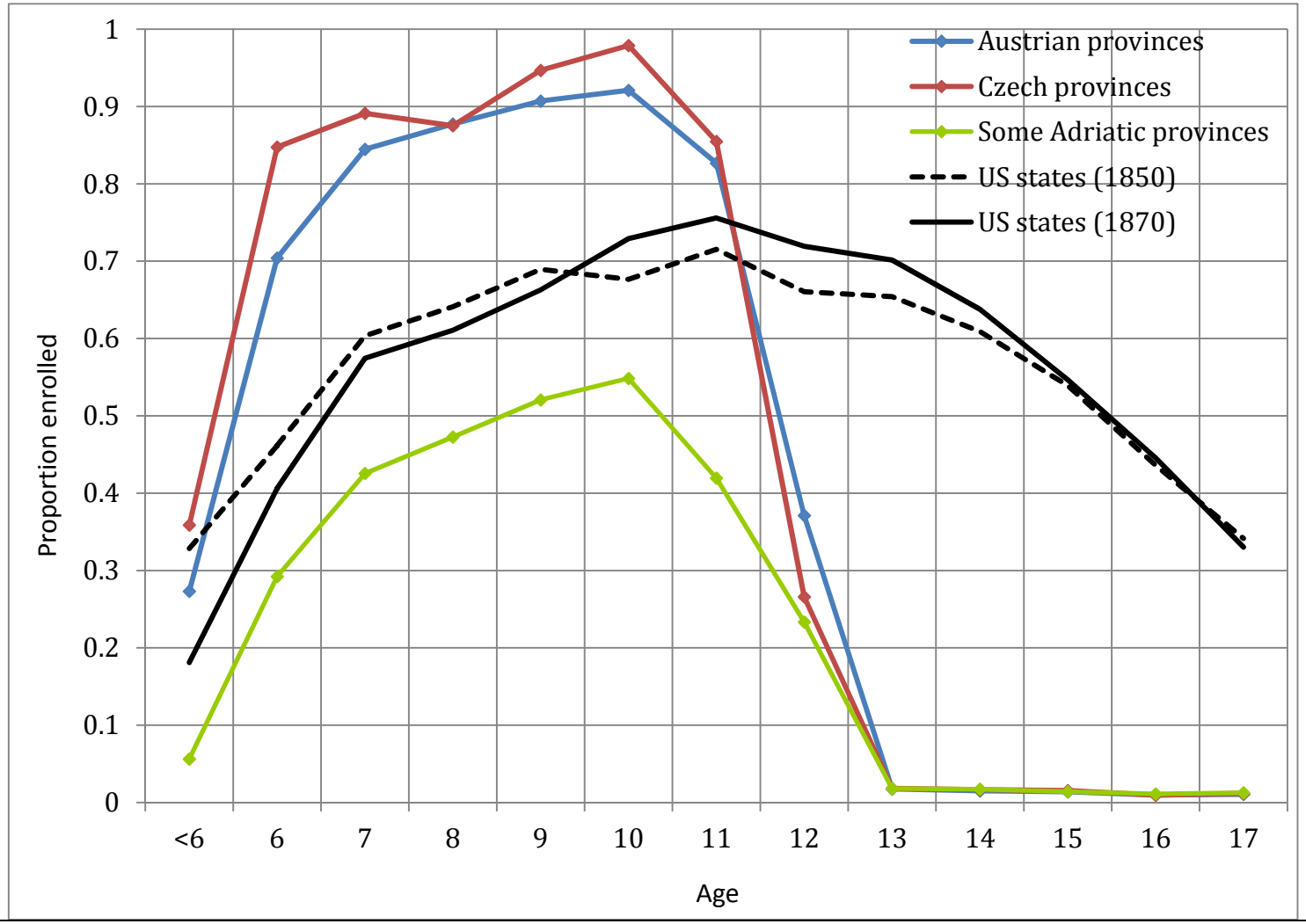
Note: Not all provinces were in existence at all times. Bosnia-Hercegovina was an Austrian protectorate between 1878 – 1908, after which it was annexed. Source: Wikimedia commons.

Figure 2 – Enrollment and literacy of the 1830-1839 birth cohort



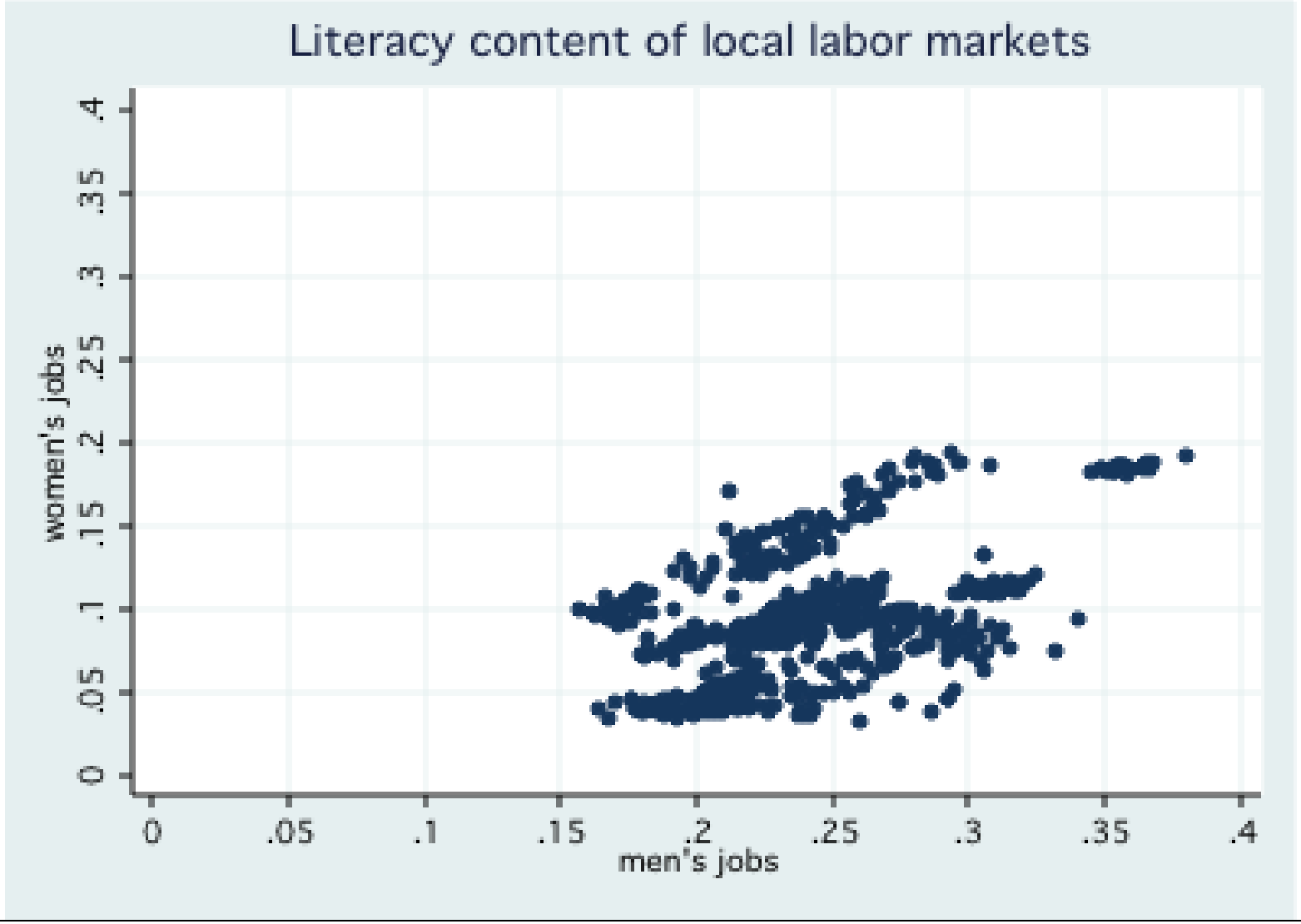
Note: Average enrollment is calculated as the average enrollment across years 1836-1851 when the 1830 - 1839 birth cohort was in school age (6-11.9 years old). Two-letter abbreviations denote individual provinces: BO – Bohemia, BU – Bukowina, DA – Dalmatia, GA – Galicia, KI – Carniola (Krain), KS – Austrian Littoral (Küstenland), KT – Carinthia (Kärnten), MA – Moravia, NO – Lower Austria (Nieder-Österreich), OO – Upper Austria (Ober-Österreich),SB – Salzburg, SI – Silesia, ST – Styria, TV – Tyrol & Vorarlberg

Figure 3 – Age-enrollment profile in Austria (1865) and US (1850-70)



Note: US data come from Clay et al (2012). Austrian provinces = Lower Austria, Upper Austria, Salzburg, Styria, Carinthia, Tyrol & Vorarlberg. Czech provinces = Bohemia, Moravia, Silesia. Some Adriatic provinces = Austrian Littoral and Carniola. The post-age-12 enrollment for the Habsburg empire includes enrollment in secondary schools, namely Gymnasia and Realschulen.

Figure 4



Note: For construction of literacy content, see Appendix 1.