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<Title> **Class size: does it matter for student achievement?**

<Teaser> Smaller classes are often associated with increased student achievement, but the evidence is far from universal

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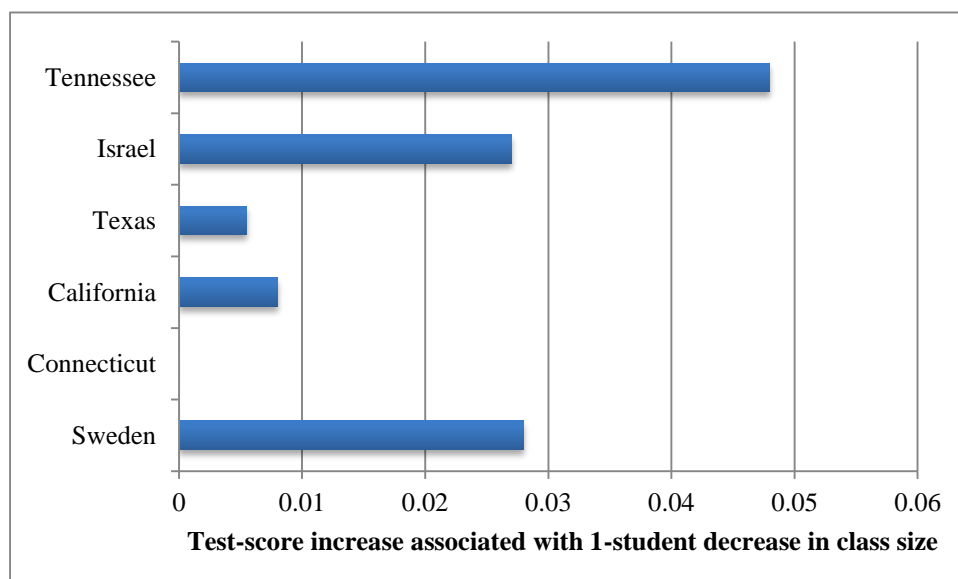
<Keywords> education; class size, student achievement

<A> Elevator Pitch

Numerous economic studies have considered the relationship between class size and student achievement, the majority of which have focused on elementary schools in the US and Europe. While the general finding is that smaller classes are associated with increased student achievement, a few high-quality studies find no relationship. Further, research on the costs and benefits of smaller classes concludes that other education policies, such as tutoring, early childhood programs, or improving teacher quality would be better investments.

Graphical Abstract

Average effect of a 'one-student' reduction in class size on test scores, by location



Sources: Tennessee – Chingos (2013) and Krueger (1999); Israel – Angrist and Lavy (1999); Texas – Rivkin, Hanushek, and Kain (2005); California – Jepsen and Rivkin (2009); Connecticut – Hoxby (2000); Sweden – Fredriksson, Öckert, and Oosterbeek (2013).

<A> Key findings

** Pros**

1. In general, smaller classes are associated with increased student achievement.
2. There are benefits of smaller class sizes when variation in class size, due to maximum class-size rules and random fluctuations in population, are taken into consideration.
3. Smaller classes are associated with higher achievement for students in different grades, in different countries and across continents.
4. Reducing class size is a clear education policy that is popular with students, parents, teachers, and policymakers and hence easy to argue for.

** Cons**

1. Several high-quality studies find no relationship between class size and achievement.
2. Reducing class size is a very expensive policy reform relative to other reforms, which may also provide better value.
3. Because most studies focus on elementary schools, much less is known about the relationship between class size and student achievement in secondary schools.
4. Reducing class size in many schools in developing countries is unlikely to improve achievement as these schools have more fundamental challenges, such as high teacher absenteeism.

<A> Author's main message

Reducing class size is a popular education policy measure with parents, teachers and policymakers. However, research shows that reducing class size leads to, at best, only modest improvements in student achievement. Also, students in early grades appear to gain more from smaller classes than do older students. Despite extensive research on class size, much about this relationship is still unknown. Policymakers should be aware that reducing class sizes can be costly, is no guarantee of improved achievement, and is only one of many possible reforms.

<A> Motivation

Class size is an extremely popular education reform among many stakeholders, including students, parents, teachers, school administrators, and educationalists. With such broad appeal, reducing

class size is also popular among policymakers. Intuitively, students in smaller classes should have better learning outcomes than students in larger classes – for example, the teacher can provide more individualized attention in smaller classes, and classroom discipline is easier with fewer students [1].

At the same time, reducing class size is an expensive education policy. For example, a class-size reduction policy instituted in California in 1996 reduced class size from an average of 30 students per class to a maximum of 20 students per class, but as a result increased the number of teachers by approximately half [2]. To illustrate this calculation, consider a grade with 60 students; the legislation would increase the number of teachers from 2 to 3, which is an increase of 50%. Teacher salaries constitute the vast majority of schools' non-capital expenses, and in the first two years of California's class size reduction, over 25,000 additional teachers were hired.

Research indicates that the costs of reducing class size are more likely to exceed the benefits, and that other education policies such as tutoring, early childhood programs, or improving teacher quality would be better investments [1].

In addition, a simple comparison of achievement across classrooms of different sizes will not reflect the true relationship between class size and student achievement, for a number of reasons. For example, in the U.S., where the biggest source of funding is local property tax revenue, schools in wealthier areas are more likely to have smaller classes and higher achievement due to students' more advantaged backgrounds, rather than being a casual effect of smaller classes [1]. In contrast, if a school provides smaller classes for its most 'at-risk' students, the result would be higher achievement in the larger classes, again for reasons unrelated to class size.

Therefore, a rigorous analysis of the causal relationship between class size and student achievement is complicated, as the number of students in each classroom is not determined randomly. And while smaller classes are generally associated with higher student achievement, the evidence is not universal.

<A> Discussion of pros and cons

** Influential research**

As discussed above, it is quite challenging to isolate the effect of class size from other determinants of student achievement, as schools explicitly decide class sizes, and they often base class-size decisions, as well as the assignment of specific students to classes of different sizes, on prior student

achievement. Consequently, researchers view the class-size experiment conducted in Tennessee in the late 1980s as the highest-quality study on the topic. Over 11,000 students and their teachers were randomly assigned between small classes of 15 students and regular classes of 23 students [1]. If it is assumed that class-size effects are linear (in order to make comparisons between studies with difference changes in class size), then the 'per-pupil' effect of the Tennessee experiment was 0.048 standard deviations [1], [3]. In other words, each 'one-student' reduction in class size is associated with an increase in student achievement of 0.048 standard deviations.

However, the bulk of research on the relationship between class size and student achievement is based on techniques other than random experiments. Such studies, often called 'quasi-experimental' or 'non-experimental', attempt to isolate the effect of class size in several ways. One compelling way, first used in an analysis of Israeli schools, is to focus on small changes in student enrollment that correspond with changes in the number of teachers, thus leading to differences in class size [4]. This approach is often called the 'maximum class-size rule' (or Maimonides' Rule, after the 12th century scholar who proposed it).

As an example of this, in Israel the maximum number of students in a classroom is 40, which means that a school with 39 people in a grade has one teacher with a class size of 39, whereas a school with 42 people in a grade has two teachers with an average class size of 21. The underlying idea is that natural fluctuations in the area population generate potentially large, and presumably random, changes in average class size. However, researchers and policymakers using this type of analysis should carefully investigate the extent to which these fluctuations in class size appear to be random. The study for Israel is very carefully investigated and shows that smaller classes are associated with sizable improvements in achievement for 5th grade students, but with smaller effects for 4th grade students. In terms of a 'per-student' reduction, the effect is around 0.036 standard deviations for 5th grade and approximately 0.018 for 4th grade.

Another technique that has been frequently used is to study yearly fluctuations in class size, thereby attempting to isolate presumably-random changes in class size that occur as a result of student population variation (i.e. students moving into and out of school and classrooms). This approach typically involves using detailed data on a large number of students over multiple years, as a given grade or school may have very little fluctuation between one year and the next. This approach was first applied to data on students in late elementary grades in Texas [5]. In the 5th grade, a one-student reduction in class size is associated with an increase of 0.0055 standard deviations in mathematics and 0.0043 standard deviations in reading (in their most sophisticated analyses). In the 6th and 7th grades, the authors could not refute the proposition that class size is unrelated to student achievement. This approach has also been used to estimate the effect of class-size reduction in

California, with effects of 0.006 to 0.01 standard deviations for 3rd grade reading and mathematics, respectively [2].

A similar approach looked instead at variations in the population of school-age children, rather than the actual student population. Estimates from this approach are much smaller than those using more detailed student-level data. In Connecticut, for example, there is no evidence that reductions in class size are associated with gains in student achievement, using data from the 1980s and 1990s [6]. The results are similar when using the maximum class-size rule, referred to earlier.

** Further evidence in the U.S.**

A class-size reduction program was also conducted in Florida. This was undertaken across all grades (as opposed to the Californian study, which focused on kindergarten through 3rd grade) and had both district-level and school-level components. The results show little, if any, improvement in achievement resulting from the reductions in class size [7].

In Minnesota, researchers used changes in the school-age population (as opposed to the actual school population) to study the relationship between elementary school class size and student achievement. However, over half the schools have missing data on either the school-age population or the class size. Among the schools with non-missing data, a 'one-student' reduction in class size is associated with smaller achievement gains than those found in the most influential studies of class size.

Several studies utilize state-level databases with detailed information on class size and student achievement, as well as student demographic information and information on teachers. These data typically cover entire school districts, or even states, such as New York, North Carolina, and San Diego. The data are available for multiple years. With these data, researchers studied the determinants of student achievement in general, often with a focus on teacher characteristics. Almost all of the studies include class size as one of the factors under study, even if it is not the focus of the analysis. The majority of the studies find a negative relationship between class size and student achievement. In other words, the research typically concludes that smaller classes are associated with higher student achievement.

** Studies in Europe**

In Europe, the most influential studies use the maximum class-size rule. In Sweden, a 'one-student' reduction in class size in grades four to six is associated with an increase in test scores, at ages 13 and 16, of 0.023 to 0.033 standard deviations respectively [8]. Similarly, in France, numerous

researchers have applied this technique and identified a smaller, positive relationship between smaller classes and student achievement, both in elementary and secondary grades [9]. Two studies in Denmark, using different data sets and statistical techniques, demonstrate small benefits of reduced class sizes.

However, the findings from Europe are far from universal. A study of 11 countries, predominantly in Europe, shows substantial cross-country variation in the relationship between class size and student achievement, with most countries having a small or no benefit of smaller class sizes [10]. In Norway, two studies using the maximum class-size rule obtain different results. One study finds a positive effect of smaller class sizes on student achievement in the early years of secondary school, whereas another study, using similar methods (on a larger dataset), essentially finds no effect. Using a variant of the maximum class size based on the government's school funding formula, researchers were not able to discern a clear relationship between class size and student achievement for 4th, 6th and 8th grade students in the Netherlands.

** Studies outside the U.S. and Europe**

Class-size research is rare outside the U.S. and Europe. In Japan, smaller classes are associated with higher achievement in 4th and 6th grades, but there is no evidence of a positive relationship for 9th grade. As of July 2015, there are, to the author's best knowledge, no studies on class size in Canada, Australia or New Zealand in the main economics database, 'Econlit'.

In developing countries, few high-quality studies of class size exist. One of these high-quality investigations is for Bolivia, which finds a positive relationship between student achievement and smaller classes [11].

In general, the problem of isolating the effect of smaller classes from other factors is more challenging in developing countries than in developed countries. Basic services, such as having a teacher (or even a substitute teacher) are often missing in schools in many locations. If the teacher is not present, then the size of the class is irrelevant. In Kenya, for example, a reduction in class size from 82 to 44 is not associated with improved achievement, but the use of a locally-hired contract teacher (ie, a teacher who is hired on a short-term, temporary basis) is associated with improved achievement. The likely explanation for this is that absenteeism is much lower among contract teachers.

Therefore, in many developing countries, more fundamental issues, such as adequate staffing and facilities, need to be addressed before focusing attention on class size.

** Do certain types of students benefit more than others?**

The 'take-away' message from the existing research is that smaller classes are associated with improved student achievement more often than not, though some high-quality studies find no relationship. But what does past research tell us about whether some students benefit more than others from smaller classes?

As with the overall pattern of results, smaller classes do not clearly benefit (or harm) specific groups of students. The studies finding no relationship between class size and achievement generally report analyses for different types of student groups, and none of them finds any particular group of students who benefit more from smaller classes.

The closest thing to consensus on class-size effects is that when smaller classes are beneficial, they tend to be more beneficial for younger students than for older students. This finding is demonstrated, for example, by the research in Texas and Japan.

Some evidence suggests that disadvantaged students receive larger benefits, as shown in the class-size experiment in Tennessee and the maximum class-size rule in Israel [3], [4]. However, this pattern of results is not echoed elsewhere in the literature. In Europe, the effects do not appear to differ much by student demographics. In Japan, the benefits of smaller class sizes appear to be larger for wealthy students and for class sizes under 20 students.

** Cost-Benefit analysis**

It is important to measure the potential benefits of smaller classes against the costs. Assuming there is no change in enrollment, a reduction in class size corresponds with an increase in the number of classrooms. Thus, the two primary costs of reducing class sizes are the cost of additional teachers and the cost of creating additional classroom space. On this basis, studies from the U.S. suggest that each 'one-student' reduction in class size has a cost of \$200 to \$250 per pupil [1]. However, it is important to consider that there may also be additional costs involved, such as electricity and other costs of operation.

Another approach in estimating costs is a simple 'back-of-the-envelope' calculation, with the assumption that all costs are variable. In other words, a 10% reduction in class size would produce a 10% increase in per-student costs. Under this simplistic approach, the estimated cost of a 'one-student' reduction in class size is even higher, ie, in excess of \$400 per student [1].

A comprehensive cost-benefit analysis of smaller classes should include all the benefits of smaller classes, including short- as well as longer-run improvements in achievement. The benefits would also include other benefits, such as increased earnings, decreased unemployment, improved health, etc.

The U.S. studies that compare costs and benefits usually find that the total benefits of smaller class sizes – ie, not just the benefits associated with improved achievement – do not exceed the costs. Even in the study with the largest effects of smaller classes (ie, the experiment in Tennessee), the benefits are roughly equal to the costs [1], [3]. In other programs, where the perceived benefits are noticeably smaller, the benefits are even lower relative to the costs.

The cost-benefit ratio seems even less favorable in Europe, where the predicted effects of smaller classes are less consistent than in U.S. studies. That being said, however, the study of Sweden argues that the benefits of smaller classes exceed the costs [8]. This study follows students from school until they are middle-aged. It can therefore directly estimate the increase in wages associated with reduced class sizes. These direct estimates show larger wage increases than the indirect effects used elsewhere in the literature, including when they are used in Sweden (when the actual wage data is not used). Although other studies do not explicitly model the cost-benefit analysis, the smaller benefits of class size suggest that the benefits do not significantly outweigh the costs. However, the study from Sweden shows that predicting the effects of smaller classes on future wages will produce ‘estimated’ wage gains that are smaller than the ‘actual’ wage gains. Though it is unclear whether researchers would find a similar relationship in other countries.

** The ‘opportunity cost’ of reducing class size**

So far, the discussion of costs and benefits has been in terms of monetary costs. An *economic* cost-benefit analysis, however, would compare the benefits and costs of class size to those of an alternative use of the money [1]. The comparison with the ‘next-best’ alternative use of money is known in economics as the ‘opportunity cost’. With this in mind, given that the benefits of reducing class size do not exceed the costs in nearly all studies, a rational conclusion would be that smaller class sizes do not exceed the benefits of the next-best alternative – ie, that the ‘opportunity cost’ is not significant. For most of the studies reviewed in this contribution, the costs of reducing class size generally exceed the benefits, with the exception of the study of Sweden [8]. Studies looking at the costs and benefits of smaller classes, however, have concluded that other education policies (ie, the ‘opportunity cost’ of reducing class size), such as tutoring, early childhood programs, or improving teacher quality, would be better investments [1]. For example, the study of class size and teacher characteristics in Texas concluded that improving teacher quality, such as replacing the most ineffective teachers, would have significantly large returns – much larger than any conceivable class-

size reduction program [5]. However, in many countries, including the U.S., the ability to replace low-quality teachers is complicated by the tenure system; teachers with tenure are quite difficult, if not impossible, to remove from their positions. Alternatively, reassigning ineffective, tenured teachers to non-classroom duties is very expensive.

<A> Limitations and gaps

The Tennessee experiment is considered the 'gold standard' for class size research, in large part because it is the only sizable class-size experiment that has been conducted since the early 20th century. However, even random experiments, such as the one conducted in Tennessee, have limitations. Fewer than half the students randomly assigned to small or regular classes in kindergarten are in the data four years later [1], [3]. Only schools with at least three classrooms per grade are included in the study, which results in an overrepresentation of urban schools and schools with sizable non-white student populations, which is likely to bias results.

Another potential concern is that teachers assigned to smaller classes may exert extra effort to increase the likelihood of being assigned to smaller classes in the future [1], [6]. However, there is evidence that, even among the regular classes, those with slightly smaller class sizes have better student outcomes than those with larger class sizes [1], [3].

Studies using other techniques, such as the maximum class-size rule, also have their limitations. The studies in Sweden and Bolivia are limited to smaller schools, so it is not clear whether class size has similar effects in larger schools in these countries [8], [12]. One study of Japan is based on one year of data (2002) and another study of Japan is limited to the city of Yokohama. Again, there are concerns about whether the class-size effects are similar in other years and in other parts of Japan.

Another major limitation is the issue of 'external validity'. In other words, it is not clear to what extent the results from one study in one location or time period can inform the likely benefits of smaller classes in a different location or time period, or in a school of a different size or in a different country. To illustrate the point, consider two of the highest-quality studies, ie, the Tennessee experiment and the Israeli study using the maximum class-size rule. In Tennessee, the class-size experiment compared students in 'regular' classes of 23 with students in 'small' classes of 15. In Israel, the maximum class size rule is 40 students. Therefore, one of the smallest possible class sizes in Israel – ie, 21 students (say in a grade with 42 students) – would be considered a 'regular' class size in Tennessee (or elsewhere, such as Denmark). The few high-quality studies that exist only study a small set of possible changes in class size. Consequently, research provides little if any

insight on the effectiveness of class size across the possible, or even probable, distribution of class sizes. Researchers simply cannot identify the optimal class size.

A fundamental gap in the literature is the lack of high-quality studies in secondary schools [1]. Given the above concerns regarding external validity, the studies from primary schools are of little use when evaluating the relationship between class size and student achievement in secondary schools, particularly in the later grades of secondary school (i.e. grades 10 to 12). One challenge in studying class size in secondary school is that, in most locations, students in secondary schools have different teachers for different subjects. For outcomes such as subject-matter test scores, the class size in that subject is the most relevant, but the relevant class-size measure for overall outcomes, such as graduation or grade-point-average, is less clear.

An additional gap in the research is the absence of studies in many locations. Clearly, more high-quality research is needed in places where little, if any, such research is currently available, such as in Germany or Australia. Figure 1 illustrates the set of countries where economists have studied the relationship between class size and student achievement. The figure includes all single-country studies of class size contained in the main economics database, 'EconLit', through July 2015. Multi-country studies, i.e. where a single study includes data from several countries, are not included.

Insert Figure 1

Identifying the relationship between class size and achievement can be challenging in some settings. For example, many schools in Ireland, particularly in urban areas, have very little variation in class size due to school policies. Consequently, the techniques used elsewhere, such as the maximum class-size rule, are unlikely to work in Ireland, as there may not be enough classrooms with different sizes to compare achievement.

<A> Summary and policy advice

In summary, smaller classes are generally associated with higher student achievement, but the evidence is far from universal. The few studies that find no effect of smaller classes use data from similar (if not identical) locations to studies that find positive effects of smaller classes. The studies, by and large, use the same statistical techniques. Thus, advocates of smaller classes cannot simply dismiss the studies finding no effect as being somehow inferior or being confined to particular locations. Instead, the conclusion for policymakers and researchers is that reducing class sizes is no guarantee of improved achievement, even though the majority of past research finds such a positive relationship.

Even in situations where smaller class sizes are associated with improved student achievement, resources may be better spent on other reforms, such as teacher 'quality' (as opposed to teacher 'quantity').

In general, the effectiveness of education reforms is difficult – and in some cases virtually impossible – to estimate, especially as these reforms usually overlap. For example, in the late 1990s California instituted several educational reforms, such as expanded school accountability, in addition to reducing class sizes.

Policymakers must also keep in mind that policies designed to change class size are likely to have unintended consequences. The class-size reduction program in California led to a dramatic increase in the number of teaching positions in the state. Many teachers in low-performing schools in poor neighborhoods left for newly-created positions in higher-quality schools in more affluent areas, leaving the low-performing schools to hire new teachers with less experience (and, presumably, less ability) [2].

Also, in response to strong financial incentives to keep class sizes as small as possible, many schools in California combined students from different grades into the same classroom. These multi-grade classrooms tended to have lower achievement than otherwise similar classrooms with students from only one grade.

What should policymakers do regarding class size? Many stakeholders in education, including teachers and parents, strongly believe that smaller classes are better for students. However, policymakers should be aware that reducing class size is an expensive reform that will not automatically increase student achievement, although it will likely please teachers, parents, and students. They should consider class size as one of many possible reforms. A more holistic approach would be to consider the potential costs and benefits of many possible reforms, with the understanding that these costs and benefits are imprecise at best and completely unknown at worst.

Many parts of the world have little or no information on the effectiveness, or not, of smaller classes. For developing countries, schools often have fundamental challenges, such as teacher absenteeism, that will reduce if not eliminate any benefits of smaller classes. In these places, policymakers would be better served to solve the more pressing issues before turning their attention to class size.

If policymakers wish to understand the relationship between class size and student achievement in their area, then the easiest, quickest, and least costly way to determine that is to begin by studying the data that is available to them. High-quality data increase, but do not ensure, the likelihood that

researchers can identify the past relationship between class size and achievement. The possibility of conducting a class size experiment, as in Tennessee, is extremely challenging and expensive, and it still may not provide conclusive evidence on the effects of smaller classes, even after years of study.

The relationship between class size and achievement is not clear. Research suggests that policymakers should be aware that reducing class sizes is no guarantee of improved achievement and is only one of many possible reforms.

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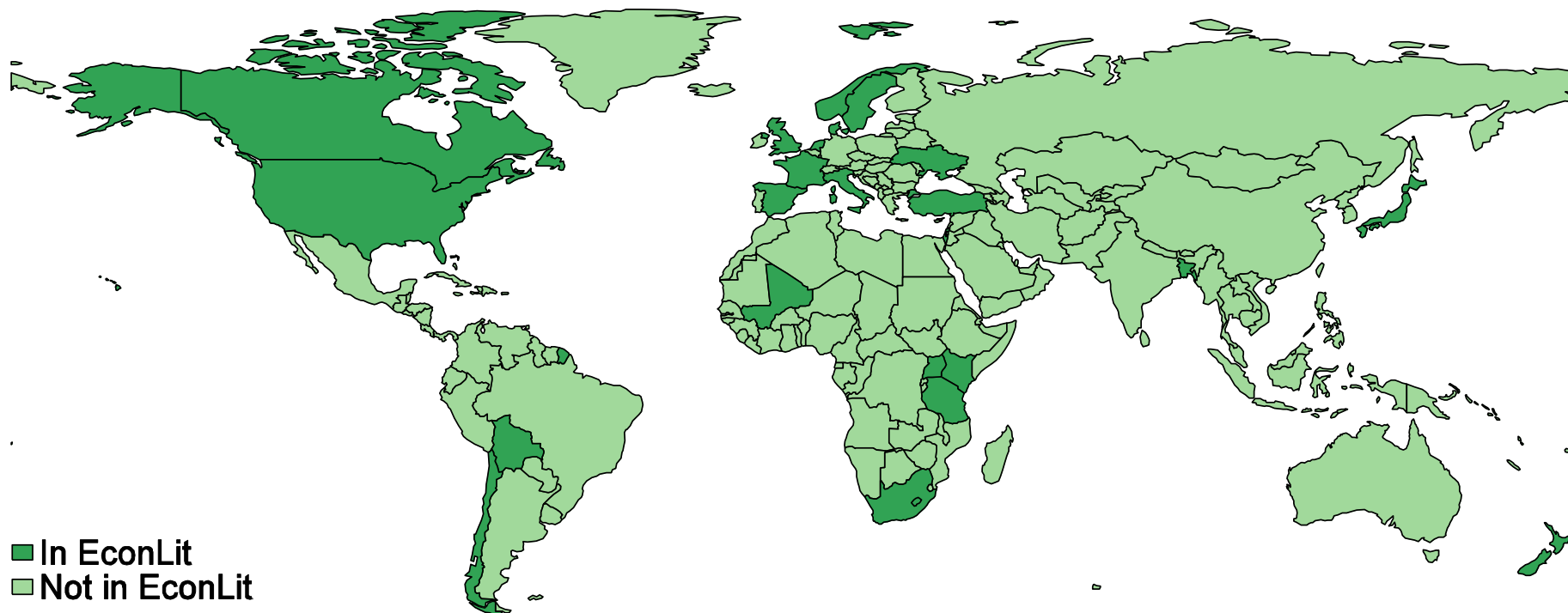
<A> Acknowledgments

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<A> Competing interests

The IZA World of Labor project is committed to the IZA Guiding Principles of Research Integrity. The author declares to have observed these principles.

Figure 1: Geographical Coverage of Class Size Studies in EconLit Database through July 2015



Sources: author's own search of EconLit database (searching for "class size") in July 2015.