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Distance Matters: Geographic Accessibility and Higher Education Participation Decisions

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Abstract

There is extensive evidence that substantial inequalities persist in relation to higher education participation and outcomes in many countries. One potential barrier to participation is geographic accessibility, which can lead to a wide range of direct and indirect costs. This chapter examines the theoretical and empirical economics literature on the role and importance of geographic accessibility for a range of decisions relating to higher education participation. In doing so, it reviews three main methodological approaches used to estimate the impact of distance, namely those that model individual student choices, those that consider aggregate student migration flows, as well as approaches based on stated preference techniques. In addition, the chapter presents an illustrative example of the importance of travel distance based on recent data from Ireland. In particular, it uses Sankey diagrams to illustrate the highly localised nature of school to higher education transitions and gravity models of student migrations to measure the elasticity of flows with respect to distance. The chapter's overall main conclusion is that distance matters for students, higher education institutions, and policymakers, and it finishes with a discussion of a range of proposed policy responses that aim to address various equity and efficiency concerns related to disparities in geographic accessibility to higher education.

1. Introduction

There is extensive evidence that substantial inequalities persist in relation to higher education participation and outcomes in many countries. One potential barrier to participation is geographic accessibility, often measured by travel distance, which can lead to a wide range of direct and indirect costs (Spiess and Wrohlich, 2010). These costs may impact not only on the decision to participate in higher education, but also on where and what to study. Importantly, they generally tend to be more salient for students from poorer backgrounds. As a result, distance deterrent effects can have important implications for inequalities in educational outcomes, earnings, and life chances (Gibbons and Vignoles, 2012; Britton et al., 2019, 2020). They can also result in an inefficient allocation of resources, if those facing higher costs have higher potential gains from education. Moreover, they may also lead to long-run spatial disparities in human capital and labour market outcomes (Faggian et al., 2007; Gibbons and Vignoles, 2012). Given all of this, there has been increasing attention on the role of spatial factors in influencing higher education opportunities and outcomes.

This chapter examines the theoretical and empirical economics literature on the role and importance of geographic accessibility for decisions relating to higher education participation. We begin by discussing the theoretical foundations of economic analyses of higher education participation decisions and the role distance plays. For example, the geography of student mobility is usually explained as an investment process in human capital theory, or as a short-term cost-benefit assessment using random utility theory (Sá et al., 2004). In addition, consumption motives have also been suggested as a potentially important factor (Kodde and Ritzen, 1984). Following this, we then consider the main methodological approaches that have been used to estimate the impact and importance of distance, and spatial factors more generally, on choices relating to higher education participation. In particular, we examine three main types of approaches, namely those that model individual students' choice behaviour, those that examine the determinants of aggregate student migration flows, as well as approaches based on stated preference techniques. In addition, the main findings from the empirical literature are described and discussed.

As well as providing a thorough review of the relevant theoretical and empirical literature, we also demonstrate the importance of travel distance using an illustrative example based on recent data from Ireland. In particular, we use Sankey diagrams to illustrate the highly localised nature of school to higher education transitions and estimate a series of gravity models of student migration flows to measure the elasticity with respect to travel distance. We conclude the chapter with a discussion of the main lessons from the literature, including the implications for students, higher education institutions (HEIs), and policymakers.

2. Theoretical Foundations

2.1 Human Capital Framework

Early theoretical work on human capital by Mincer (1958), Becker (1964), and Ben Porath (1967) presented a lifecycle dimension to education choice, with lifecycle earnings playing a key role in the decision to invest in education or not. Building on this, Turner (2004) described higher education choices as arising when individual i selects among a set of higher education options related to programme type/length s and programme quality j, in order to maximise lifetime utility. Importantly, within this framework, individuals are likely to differ with regard to the available choice set, as well as their expected returns from different HEI options. In relation to the former, such differences could include institutional admission criteria, as well as other factors such as travel distance to a HEI. Assuming full information around lifecycle earnings and the nature of the college experience, we adapt Turner's model to present a simple way to consider a student's decision that incorporates such distance effects. In particular, we assume that individual i chooses HEI j and length of enrolment s in order to maximise the lifetime value of earnings i.e.

$$max_{j,s} \sum_{t=s+1}^{T} \frac{Y_{ijs}}{(1+r)^t} - \sum_{t=1}^{s} \frac{F_j}{(1+r)^t} - \sum_{t=1}^{T} \frac{Y_{i0}}{(1+r)^t} + \sum_{t=1}^{s} \frac{A_i}{(1+r)^t} - \sum_{t=1}^{s} \frac{D_j}{(1+r)^t} \quad [1]$$

where Y_{ijs} denotes earnings for individual i attending HEI j for s years, F_j is the direct cost of participation at institution j (e.g. tuition fees), Y_{i0} is expected earnings with no higher education (including foregone earnings while in higher education), A is financial aid received while in higher education, and D_j represents direct and indirect costs related to travel distance to institution j. This model also assumes that individuals are able to borrow, without constraint, at rate r.

As outlined in Cullinan et al. (2013), this type of framework is consistent with a number of previous theoretical and empirical studies that have focussed on the factors impacting higher education choices. This includes studies considering the binary decision of whether or not to participate in higher education, as well as the related decision of where and what to study. For example, Willis and Rosen (1979), Flannery and O'Donoghue (2013), and Patnaik et al. (2020) all highlight the influence of expected gains in lifetime earnings on a young person's decision to attend college and/or the major they choose. However, the latter study does note that this effect is small relative to the role of other characteristics of the major for most students. Relative earnings are also considered in McVicar and Rice (2001), Flannery and O'Donoghue (2009), and Sievertsen (2016), who examine the relationship between local employment conditions and post-secondary education decisions for the UK, Ireland and Denmark respectively. The latter study shows that effects are strongest for children of parents without a higher education qualification.

Tuition fees provide a more direct cost to potential participants and so higher fees would be expected to have a negative impact on participation. Indeed, Heller (1997), Neill (2009), and Hübner (2012) all provide evidence that this is the case. However, in contrast, Denny (2014) suggests that the removal of higher education tuition fees in Ireland in 1996 was not sufficient to increase lower social class participation in a context where other direct costs remained high and employment represented an attractive option. Studies such as Dynarski and Scott-Clayton (2013) and Castleman and Long (2016) have shown that increased levels of financial aid impact positively on the education decisions of young people.

Empirical studies that have examined the role of geographical factors in higher education choices are discussed later in this chapter. However, from a theoretical perspective, there are a number of potential reasons why travel distance, or geographic accessibility more generally, might impact participation decisions. For example, from an economic point of view, the 'transaction cost argument' suggests that the greater the distance to a HEI, the higher the transaction costs of higher education, and the lower the associated probability of participation (Spiess and Wrohlich 2010). There may also be 'neighbourhood effects' whereby the presence of a local university can generate 'spillover effects' that influence the behaviour of young people living in the vicinity of a HEI, or 'information network effects' whereby a HEI's faculty or student body provide information about higher education that could influence decisions. Overall, the basic argument is that students who live further from a HEI may be less likely to participate in higher education (Cullinan et al. 2013).

In addition to these factors, there are also a range of other potential influences that are important when considering higher education choices. For example, factors such as gender, parental educational attainment, household income, and peer effects may drive heterogeneity in the costs and returns to education for different individuals and thus influence preferences and outcomes (Card, 2001; Winston and Zimmerman, 2004; Mendolia et al., 2018; Paloyo, 2020).

For example, an individual with higher parental educational attainment may show stronger preferences for education, because they may have first-hand experience of the gains from higher education (Suhonen and Karhunen, 2019). Furthermore, there may also be a positive role model effect. Osterbeek and Van Ophem (2000) and Black et al. (2005) find evidence that higher maternal education levels are associated with a stronger preference for higher education.

It is also important to note that the basic human capital framework of higher education participation implicitly assumes perfect capital markets, though this can be relaxed to acknowledge the role of differing credit constraints. For example, individuals who come from low income households may face difficulties in financing participation due to poor access to credit, meaning that participation in higher education may be more, or even too, costly (Teng Sun and Yannelis, 2016). Indeed, Cameron and Heckman (2001), Hilger (2016), and Manoli and Turner (2018) all present evidence of a negative association between higher education participation and lower household income. Given this, and in the context of this chapter, it is also important to note that some of the influencing factors described here are likely to interact. For example, household income and geographical factors may interact in how they impact higher education choices, with travel distance having differential impacts across the income distribution.

2.2 Random Utility Theory

While the human capital framework is a common theoretical lens through which to consider higher education choices, there are other theoretical frameworks within economics that are also useful in this context. For example, the characteristics model of demand outlined in Lancaster (1966) can help us understand higher education participation decisions. This theory argues that it is the attributes of a good that determine the utility that a person receives from the good and, as a result, utility can be expressed as a function of the good's attributes. Here, the good of interest could be a HEI, with the consumer's choice a function of the attributes of a set of HEIs, including cost, reputation, facilities, as well as travel distance.

Therefore, given the discrete choice nature of decisions relating to whether and where to go to higher education, random utility theory (McFadden, 1974) represents another useful theoretical framework. Also known as the random utility model (RUM), it is based on the principle that utility U_{ni} for individual *n* of alternative i is assumed to consist of an observable component V_{ni} and a random component ε_{ni}, which leads to the following representation of utility:

$$U_{ni} = V_{ni} + \varepsilon_{ni} \qquad [2]$$

where $V_{ni} = \beta x_{ni}$, with β representing a vector of parameters used to describe preferences for individual attributes x.

Due to the presence of the random component in the utility function, it is only possible to make probabilistic statements about the choice outcomes. An individual is assumed to choose Option 1 if, and only if, the utility from Option 1 is higher than the utility of any other option in a set of J alternatives. Thus, the probability *P* that utility is maximised by choosing Option 1 is given by:

$$\begin{aligned} P(Y_i = 1) &= P\left(U_{i1} > U_{ij}\right) \\ &= P\left(V_{i1} + \epsilon_{i1} > V_{ij} + \epsilon_{ij}\right) \\ &= P\left(V_{i1} - V_{ij} > \epsilon_{ij} + \epsilon_{i1}\right) \forall j \neq 1 \end{aligned} \qquad [3]$$

where Y_i is a random variable representing the choice outcome (Lancsar and Louviere, 2008). This implies that the probability of choosing Option 1 over any other option in a set of J alternatives increases as the difference in the estimated utility between the two alternatives increases. Therefore, the probabilities can be interpreted as the strength of preferences for the different alternatives. This theory provides a strong link to the empirical side of higher education choice with the empirical specification of the model depending on the assumptions made around the distribution of the random utility components. As a result, and as discussed further in the next section, discrete choice models such as conditional, multinomial, and mixed logits have been commonly used in extant empirical literature in the field.

It is also important to acknowledge other prevalent theories that attempt to explain variation in decisions around whether and where to go to higher education. For example, individuals may view education not only as an investment good, but also as a consumption good. In other words, individuals may choose whether and where to go to higher education because they enjoy certain course content or the student life a HEI may offer (Kodde & Ritzen, 1984; Jacob et al., 2018). Therefore, it is possible that individuals may be willing to trade off factors related to higher costs, such as longer distances, to enjoy higher consumption benefits in a HEI. The RUM approach described above provides a useful framework to consider such issues.

3. Empirical Evidence

The importance of geographic accessibility for decisions relating to higher education participation has been measured using a number of different methodological approaches. In general, the research can be divided into three main types of studies: (i) those that estimate individual-level participation choice models; (ii) those that model student migrations flows at an aggregate level; and (iii) those that employ stated preference techniques. In all three cases, the analysis is generally situated within a utility maximization framework. Here we present an overview of each of the three approaches, and the different insights they offer, along with a summary of the key findings from the empirical literature that employs them.

3.1 Choice Models of Participation

A popular approach to estimating the importance of travel distance for participation decisions has been to estimate models of the probability of progressing to higher education and/or choosing a specific HEI, type of HEI, or field of study. In general, this literature employs discrete choice models estimated using cross-sectional data on individuals (e.g. school leavers) and Sá et al. (2004), Sá et al. (2006), and Gibbons and Vignoles (2012) all provide useful summaries of early previous work using this approach. A range of explanatory variables are typically included in these choice models, including student-, school-, and HEI-level characteristics. They also include a variety of geographical/spatial variables, such as regional-level indicators, travel distance to nearest HEI, as well as measures of system-wide higher education accessibility. In terms of travel distance, both straight-line Euclidean distance (Sá et al., 2006) and road-network travel distance (Cullinan et al., 2013) have been included, with the latter generally preferable when modelling geographic accessibility (Cullinan et al., 2008). Some studies have adopted simple binary logit models of participation (DesJardins et al. 1999; Ono, 2001; Cullinan et al., 2013), while others, when modelling choices across multiple HEI alternatives, have applied conditional logit models (Long, 2004; Suhonen, 2014), multinomial logit frameworks (Sá et al., 2006; Spiess and Wrohlich, 2010), or more advanced high-dimensional methods (Gibbons and Vignoles, 2012).

Early examples of studies that adopted this individual-level choice model approach include Ordovensky (1995), who found that distance to a HEI was an important determinant of where to enrol in the United States (US), and Kjellström & Regnér (1999) who found some evidence of a distance deterrent effect for participation in university programmes in Sweden. Similar evidence on negative distance effects have also been presented in numerous other studies using related approaches across a range of countries – see, for example, studies by DesJardins et al. (1999) for the US, Ono (2001) for Japan, Do (2004) for the US, Long (2004) for the US, Sá et al. (2006) for The Netherlands, Frenette (2006) for Canada, Faggian et al. (2006; 2007) for the UK, Griffith and Rothstein (2009) for the US, Spiess and Wrohlich (2010) for Germany, Gibbons and Vignoles (2012) for England, Suhonen (2014) for Finland, and Cullinan et al.

(2013) and Flannery and Cullinan (2014) for Ireland. Overall, the general consensus from these studies is that distance acts as a deterrent for a range of higher education participation decisions, though there are some anomalies.

In terms of this literature, a number of issues are worthy of special mention. For example, while some studies have found that travel distance can have a negative impact on the decision to proceed to higher education (Long, 2004; Alm and Winters, 2009; Cullinan et al., 2013), Gibbon and Vignoles (2012), in contrast, find that distance has little or no impact on the decision to participate in England, though they do find it has a strong influence on institutional choice. They caution that the estimation of 'causal' effects of home-university distance on participation decisions is beset by problems of spatial heterogeneity and residential sorting and, as a consequence, they warn that findings from previous studies may suffer from endogeneity bias.

It is also instructive to consider the various ways in which distance might impact participation decisions and, in their paper, Spiess and Wrohlich (2010) note that distance could matter for two main reasons, namely (i) transaction costs, and (ii) neighbourhood effects, which were defined in the previous section. Transaction costs may include direct financial costs, search costs, indirect financial costs, information costs, as well as emotional costs, while neighbourhood effects may include spillover and/or information network effects. The distinction between the two types of costs is important, since the specific source of any distance effects should determine the precise nature of any policy response. Using a discrete choice model of the demand for higher education in Germany, Spiess and Wrohlich (2010) show that distance effects are mainly driven by transaction costs, implying that individuals who live farther away are disadvantaged in terms of accessing university because of the variety of direct and indirect costs this imposes.

The interaction of distance effects and socioeconomic disadvantage is another important issue in this literature. For example, Frenette (2006) shows that while students living further away are less likely to attend university in Canada, it is students from lower-income families that are particularly disadvantaged by distance. This finding is consistent with Cullinan et al. (2013), who consider how distance effects helps explain differential higher education participation rates across social classes in Ireland. In particular, they find that students from higher social classes have a higher probability of participating in higher education than those from lower social classes across all distances, but that the difference grows larger as travel distance increases. This, they claim, is evidence that the impact of distance-related costs on participation is greater for students from poorer backgrounds, who typically have fewer resources and face greater credit constraints. In a follow-up study, Flannery and Cullinan (2014) showed that geographic accessibility and social class also play an important role in determining outcomes relating to HEI type, degree level and field of study.

3.2 Gravity Models of Student Migration

A second common approach in the empirical literature on geographic accessibility and higher education participation is the gravity model of student migration, which provides alternative insights on distance and other spatial effects by adopting a different perspective. While gravity models are most commonly used in the international trade literature to examine bilateral trade flows, they are also useful to model population migration patterns, including student migration. Indeed, a large number of previous studies have estimated gravity models of student migration flows – see Sá et al. (2004) for a thorough review of the early literature and Alm and Winters (2009) for a detailed assessment of gravity models of student flows from the US. They have also been used to model international student migration, though we don’t consider this topic in this chapter. For a good review of that literature, see Beine et al. (2016).

Gravity models of migration are generally used to predict the degree of interaction or movement of individuals between two places i.e. an origin and a destination. In the context of student migration decisions, previous studies have examined student flows from a geographical region, such as a county or state, to a specific location, such as a HEI (Alm and Winters, 2009). However, the origin may also be a specific location, such as a school (Cullinan and Duggan, 2016), while the destination may also be a region, such as a county or province (Sá et al., 2004). Regardless, gravity models assume that migration flows are proportional to the product of the sizes of the origin and the destination and inversely proportional to the (travel) distance between them. They are useful because they provide estimates of the distance deterrent effect on flows, but can also be used to consider the impact of a range of other potentially important factors. For example, 'push' factors such as school or region-of-origin characteristics and 'pull' factors such HEI or region-of-destination characteristics are usually included.

Similar to the choice modelling approach outlined above, studies using the gravity model approach also tend to employ cross-sectional observational data. Instead, however, they look to model the determinants of aggregate migration patterns, as opposed to individual-level behaviour, while both stock and flow data have been used. Notable examples of the gravity model approach from the literature include the aforementioned Sá et al. (2004) for The Netherlands and Alm and Winters (2009) for the US and the references therein, as well as Cooke & Boyle (2011) for the US, Faggian and Franklin (2014) for the US, Cullinan and Duggan (2016) for Ireland, and Lourenço and Sá (2019) for Portugal.

Again it is worth highlighting some notable issues and findings from this literature. For example, in their gravity model, Sá et al. (2004) take a rational choice perspective, with students considering and comparing universities and choosing the one which maximizes their utility. Geography enters their choice framework as a potential constraint in the decision making process. They find a strong distance deterrence effect for high school graduates and conclude that university accessibility is a fundamental aspect of higher education systems and that it impacts student flows over space. Their results also demonstrate trade-offs between the constraints imposed by distance and the attraction of universities and regions where universities are located. In a later study, Faggian & Franklin (2014) assume that prospective college students compare the utility of their current location (origin) with that of an alternative location (destination) and show how their individual level utility maximization framework is consistent with a gravity model analysis of migration data at an aggregate (e.g. states or regions) level.

In a study from the US, Alm and Winters (2009) consider *intrastate* migration for the state of Georgia. They note that the vast majority of previous US studies had considered *interstate* migration (e.g. McHugh and Morgan (1984)), but point out that in such a large country, this represents only a small percentage of overall student migration. They find that student intrastate migration is strongly discouraged by greater distance, but that effects differ by HEI type. In particular, they find that demand for more prestigious institutions is less elastic with respect to distance. This finding is consistent with results from Cullinan and Duggan (2016). They estimate a school-level gravity model of student migration flows to HEIs in Ireland and conclude that distance is less of an impediment for HEIs with higher levels of institutional quality and those with greater degrees of specialisation.

Finally, a number of recent studies have used gravity models to consider specific policy-relevant issues relating to higher education participation. For example, Raab et al. (2018) show that the strength of collaboration between HEIs and secondary schools may play a role in reducing the negative effect of geographic distance on student migrations, while Lourenço and Sá (2019) use gravity models to examine what matters in terms of spatial competition for students. The latter study finds that distance is a highly significant determinant of student flows in Portugal, and since higher education applicants are not evenly distributed, the effect of distance causes a shortage of demand in HEIs located outside the biggest cities. This, they state, implies an important role for policy in terms of addressing regional imbalances.

3.3 Stated Preference Approaches

While revealed preference and gravity model approaches are common methodologies for examining the role that spatial factors play in higher education decisions, there are often challenges in accessing appropriate data on potentially relevant variables of interest. In addition, in many countries, the 'price' of higher education, as measured by tuition fees, is uniform across HEIs and programmes, meaning there is often little or no variation in price from which any welfare estimates, such as willingness to pay (WTP), can be measured or analysed. Given this, stated preference techniques, such as discrete choice experiments (DCEs), have been used to elicit student preferences and WTP for HEI attributes. When considering geographic accessibility, such approaches can help us better understand how prospective students trade off certain characteristics of HEIs, such as reputation, versus longer travel distances. In addition, they can also be used to examine heterogeneity in these kinds of trade-offs. Such analyses are useful to both HEI managers and policymakers from a marketing, service provision, and policy perspective, as they provide information on how much different students value specific HEI attributes. Furthermore, in the broader policy landscape, there is continued debate surrounding the optimal financing structure for higher education, specifically with regard to the relative burdens faced by the state and/or students themselves. Exploring the scale and variation of students' WTP for various attributes, including geographical factors, and how these preferences may vary by socioeconomic background, for example, is therefore important.

In terms of its specifics, a DCE is an economic approach used to model preferences that builds upon the previously mentioned characteristics model of demand in Lancaster (1966). This model suggests that any good or service can be described by its characteristics (or attributes) and the extent to which an individual values a good or service depends on the nature and levels of these characteristics. When conducting a DCE, the selection of appropriate attributes (e.g. travel time from home to a HEI) and levels (e.g. 1 hour, 2 hours, 3 hours) is crucial for the validity of results. International best practice suggests this should be based on a robust experimental design, and should involve a review of the relevant extant literature in the area, as well as focus groups and pilot studies with smaller samples to help identify the attributes of the good or service in question that are of most relevance.

From a practical perspective, the experiment itself involves presenting individuals with choices of scenarios described in terms of characteristics and associated levels, otherwise known as ‘choice cards’, and for each choice respondents are asked to select their preferred scenario. Analysis of DCE choice data, typically using discrete choice empirical models such as conditional logit, latent class, or mixed logit models, then allows for an examination of whether or not the attributes are important, the relative importance of attributes, as well as the extent to which individuals are willing to trade off attributes. The inclusion of a price proxy (i.e. different levels of hypothetical tuition fees) as an attribute also allows for a monetary value of each attribute to be estimated, which is its marginal WTP. Furthermore, a DCE also allows for the estimation of the compensating surplus of different bundles of HEI attributes.

While the application of DCEs is well established in other areas of economics, their use in the education economics and education policy literatures is relatively new, particularly when examining the relative importance of HEI attributes to students. In one of the first applications in this space, Holdsworth and Nind (2006) conducted a ‘labelled DCE’ to examine the preferences of high school seniors for university education in New Zealand. The quality and flexibility of the degree and/or course options, as well as the likelihood that employers will recruit from the university, were found to be attributes that students preferred. The overall cost of attending the university was also found to be important. Burge et al. (2014) also used a DCE to examine the relative importance of tuition fees on the choice between universities in England.

They established that several factors influence university choice other than tuition fees, including employment prospects, living expenses, location, and quality of the course offered. More recently, studies by Walsh et al. (2018; 2019) reported on a DCE of upper secondary students in Ireland that examined the trade-off between geographic accessibility and a range of other HEI attributes, including the availability of work placements and the level of tuition fees.

To help illustrate the benefits of this approach for examining the importance of geographic accessibility for higher education choices, we now discuss the Walsh et al. (2018; 2019) papers in more detail. Both used data from an in-person survey-based DCE of 1,105 Leaving Certificate students from 34 schools across Ireland. In addition, data on respondent plans for higher education, factors that might influence higher education decisions, as well as socio-demographic characteristics were also collected. Table 1 reports the five attributes and their respective levels used to elicit preferences for HEI characteristics. In particular, these included: travel time from home to the HEI; type of HEI; course reputation; availability of work placements; and a cost attribute. Given these attributes and levels, each DCE respondent was asked to complete 12 'choice cards' and in each case, asked to choose their preferred alternative. A sample choice card from the DCE is presented in Figure 1. Each choice card contained three HEI alternatives along with an opt-out alternative, with the latter helping to derive welfare estimates consistent with demand theory.

[Insert Table 1 and Figure 1 about here]

In terms of findings relevant to this chapter, Walsh et al. (2018) show that not only are young people are willing to pay for particular HEI attributes, but there is significant heterogeneity in WTP across both attributes and socioeconomic groups. In particular, they find that course reputation is the most important determinant of institution choice for students in all socioeconomic groups, which suggests that the quality of the courses on offer at a HEI is key to determining a student's choice of institution. However, in terms of geographic accessibility, they also find that students have strong preferences for shorter travel times from home, with implications for spatial equity of access. In addition, they also show that those in the lower socioeconomic groups have the greatest disutility from longer travel times. This confirms findings from previous studies using different methodological approaches that distance is more of an impediment for students who are less well off. In a follow-up analysis, Walsh et al. (2019) present a further examination of heterogeneity in preferences by region, socioeconomic status, and academic ability. Using a WTP space model, they find significant preference heterogeneity for students across regions. For example, students from Dublin (a largely urban area) having the highest disutility associated with distance, likely reflecting the relative high availability of HEIs in the area.

4. An Illustrative Example

This section presents results from a simple gravity model of student migration flows to HEIs in Ireland. HEIs in Ireland include universities, technological universities (TUs), institutes of technology (ITs), and colleges of education (CEs), as well as a small number of other independent (mainly private) colleges. In 2018/19 enrolments totalled 228,503, with the majority of those (81%) at undergraduate level (HEA, 2020). Of those enrolled, 55% were in the university sector, 40% were in TUs/ITs, with the remaining 5% in other colleges (HEA, 2020)[1]. From a spatial perspective, universities and CEs in Ireland tend to be located in larger urban centres, whereas TUs/ITs are more geographically dispersed (see Figure 2). They also tend to be smaller in size, on average. There is extensive research on student mobility and enrolment patterns in Ireland[2]. In general, these studies have found that proximity to a HEI

[1] For more details of the Irish higher education sector, see Flannery and Cullinan (2017).
[2] See, for example, Cullinan et al. (2013), Flannery and Cullinan (2014), Walsh et al. (2015), Cullinan and Duggan (2016), Cullinan and Halpin (2017), and Walsh et al. (2017).

strongly influences where a student enrols and that these 'localised' patterns of progression have important implications for both students and HEIs.

[Insert Figure 2 about here]

In terms of progression to higher education, a competitive entry system based mainly on grades achieved in the terminal Leaving Certificate examinations at the end of secondary school largely determines admission to all HEIs. In total there are around 750 secondary schools and these are spread across 26 administrative counties. Financial aid and assistance from the State is available to help alleviate potential inequalities in accessing higher education related to income or geographic factors. For example, students who meet certain criteria based on parental income levels and geographic distance from their chosen HEI can apply for a student maintenance grant. In terms of the geographic component of this grant, students who satisfy an income-related means test receive either a full or partial maintenance grant, depending on whether they live greater or less than 45kms from the HEI they wish to attend.

In this section, we analyse publically-available 'feeder-school' data on secondary school to HEI transitions (Irish Times, 2019) to consider the importance of geographic accessibility for choice of HEI. In particular, we examine data for 2019 on the total number of students from every secondary school in Ireland who accepted a place at each HEI. Initially, to get a sense of the spatial dimension of the 41,336 transitions we analyse, Figure 3 presents a Sankey diagram[3] of student flows by county and province[4]. It highlights that the majority of students in each province, apart from the three Ulster counties, tend to proceed to HEIs within their own province (Connacht: 62.6%; Leinster: 83.3%; Munster: 84.9%; Ulster (part of): 27.7%).

[3] Sankey diagrams are a type of flow diagram in which the width of the arrows is represented proportional to the flow quantity and can be used, for example, to illustrate the specific location choices of HEI by students at a county level (Cullinan and Halpin, 2017).

[4] There are 4 provinces in Ireland: Connacht (counties Galway, Leitrim, Mayo, Roscommon, and Sligo), Leinster (counties Carlow, Dublin, Kildare, Kilkenny, Laois, Longford, Louth, Meath, Offaly, Westmeath, Wexford, and Wicklow), Munster (counties Clare, Cork, Kerry, Limerick, Tipperary, and Waterford), and Ulster (counties, Cavan, Donegal, and Monaghan).

Overall it suggests that proximity to a specific HEI is a major factor in a student choosing to study there.

[Insert Figure 3 about here]

As discussed, gravity models of migration can also be used to model the degree of interaction or movement of individuals between two places, e.g. to model the flow of students from a school region or county (origin) to a HEI (destination), as is the case here. They can also be used to consider the impact of a range of push and pull factors. For example, region-level push factors in the context of student flows to HEIs could include the total population of school leavers and socioeconomic status of the region. HEI-level pull factors, on the other hand, could include variables relating to HEI size, type, centrality, academic quality, and resources.

In this illustration, we adapt the models and approaches of Sá et al. (2004), Alm and Winters (2009), and Cullinan and Duggan (2016). We start with a simple representation of our region-HEI gravity model of student migration flows, such that:

$$S_{ij} = A_{ij} P_i^{\alpha} P_j^{\beta} d_{ij}^{\gamma} \quad [4]$$

where S_{ij} represents student migration flows from county i to HEI j, P_i is the total population of Leaving Certificate graduates in county i, P_j is the total number of first year students admitted to HEI j, and d_{ij} is the road network-based travel distance from the population-weighted centroid of county i to HEI j. The parameters associated with these variables, which are to be estimated, are α, β, and γ. To incorporate the aforementioned push and pull factors, the model also includes a multiplicative shift term, such that:

$$A_{ij} = \prod_k (z_{kij}^{\delta_k}) \quad [5]$$

where z_{kij} represent these k factors and δ_k the associated parameters. In our analysis we consider a range of push and pull factors and these are defined in Table 2, which contains variable definitions and sample descriptive statistics for all our variables.

[Insert Table 2 about here]

Our primary independent variable of interest is travel distance, though we also consider the importance of other spatial factors. For example, and again following Alm and Winters (2009), we include a centrality index as one of our *z* pull variables. This variable is constructed as:

$$z_{1j} = \sum_m (\frac{P_m}{d_{mj}}) \qquad [6]$$

where z_{1j} is the value of the index for HEI j, P_m is the first year student intake at HEI *m*, and d_{mj} is the distance from HEI *m* to HEI *j*, again measured as the road-network travel distance. Thus, the centrality index z_1 is a population-weighted average of the inverse distance between institution *j* and the other *M* – 1 HEIs and helps to account for the competing location of each HEI (Alm & Winters, 2009). The larger the index, the more centrally located the HEI, and the more spatial competition it faces.

In terms of estimation, we present results from a set of negative binomial models of student flows where we include the natural logarithm of travel distance as an independent variable. This means that its estimated parameter coefficient can be usefully interpreted as the elasticity of migration flows with respect to distance. We estimate models using two different subsets of data, as well as two different sets of explanatory variables. First, for the full sample of HEIs, we estimate models including county-specific variables relating to the Leaving Certificate student population and average income. We then re-estimate this model including instead a set of county (origin) fixed effects. As discussed in Sá et al. (2004), this can help control for unobserved heterogeneity in origin areas that is imperfectly captured by the push factors, though it implies that the push variables disappear from the model. Second we also estimte both models using a subset of our data relating to university and IT/TU flows only. This allows us to add a set of HEI pull factor variables that are not available for the other HEI types.

Results from these estimations are presented in Table 3. Across all models, the elasticity of flows with respect to distance is negative and is both practically and statistically significant. According to the point estimates, a 10% increase in travel distance is associated with a 12.4% to 15.3% decrease in student flows. These elasticities are similar to previous estimates for Ireland (Cullinan and Duggan, 2016), as well as international estimates (McHugh and Morgan, 1984; Sá et al., 2004; Alm and Winters, 2011; Lourenço and Sá, 2019). In terms of push factors, student flows are positively associated with the number of Leaving Certificate students (though not statistically significant) and negatively related to average income. For pull factors, the size of the student intake, HEI type, and centrality are all associated with migration flows. In the sub-sample analyses, student flows are positively associated with the number of PhD graduates and negatively related to the student-staff ratio.

[Insert Table 3 about here]

In an extension to this analysis, we also considered separate models of student migration flows by HEI type and the distance elasticities estimates are presented in Table 4. It shows that there is considerable variation in the distance deterrent effect by HEI type, implying that students are more willing to travel further to attend particular types of HEIs. For example, the estimated distance elasticity is -1.14 (95% CI: -0.82 to -1.45) for universities and -1.76 (95% CI: -1.47 to -2.05) for ITs/TUs. CEs and other private colleges have estmated distance elasticities that are closer to the university estimates.

[Insert Table 4 about here]

5. Conclusion

This chapter reviews the theoretical and empirical literature on the role and importance of geographic accessibility for decisions relating to higher education participation. It also presents an illustrative example of the importance of distance effects in Ireland using Sankey diagrams and gravity models. The main overall conclusion to be drawn is that distance matters for students, HEIs, and policymakers.

Starting with students, the basic argument is that the closer learning opportunities are, the better the access to higher education (Spiess and Wrohlich, 2010). However, while there is extensive evidence that travel distance impacts whether students enrol in higher education for many countries (Long, 2004; Frenette, 2006; Alm and Winters, 2009; Cullinan et al., 2013), similar results have not been found in other studies (Gibbons and Vignoles, 2012). On the other hand, there does appear to be a general consensus that geographic accessibility plays a very important role in determining what specific institution a student attends, with numerous studies providing strong supporting evidence for this. This includes studies using both revealed preference discrete choice modelling approaches and gravity models of aggregate student migration flows.

So why is this important? First of all, it implies that in countries where there are large disparities in geographic accessibility to HEIs, some students may be disadvantaged as a result. If travel distance reduces the likelihood of participation in higher education, or results in students enrolling at lower quality local institutions, this means such students may be penalised in terms of future labour market outcomes, including earnings, on the basis of where they live. In addition, there is considerable evidence that it tends to be students from poorer backgrounds that are most impacted by distance effects. Thus, this implies that distance could be playing a role in driving the inequalities we observe in relation to higher education participation and outcomes in many countries. As well as these equity considerations, it is also important to acknowledge that there may also be efficiency issues related to travel distance, if those facing the highest costs also have higher potential returns from education (Gibbons and Vignoles, 2012).

Distance effects are also important for HEIs in terms of their current and future demand. This is because gravity model estimates of distance elasticities clearly demonstrate strong localised patterns of school to higher education transitions in many countries. Furthermore, as Alm and Winters (2009) note, knowledge of these distance elasticities can help HEI managers predict how institution-specific demand will change as the population around them changes and can also be used to help promote greater enrolment through the creation of new campuses. Relatedly, Cullinan and Duggan (2016) discuss how HEIs with high distance elasticities that are situated in areas with low (or declining) projected population growth could see a decrease in student numbers in the future, with potential implications for their long-term viability. This is unlikely to be a problem for all HEIs, however, since the evidence suggests that students are more likely to travel longer distances to attend higher quality HEIs and HEIs with greater levels of specialization.

In this regard, stated preference studies can be useful to suggest what HEIs can do to mitigate the distance deterrent effect. As discussed, evidence from DCEs shows that students are willing to trade off extra travel time for certain desirable HEI attributes. In a context of increasing competition amongst HEIs for students, knowledge of the attributes that students have strong preferences for can help HEIs innovate and become more attractive to potential applicants. The evidence from Ireland suggests, for example, that students are more willing to travel to attend a HEI that provides work placements (Walsh et al., 2018).

In addition to their relevance for students and HEIs, there are also likely to be important consequences from distance effects in terms of the spatial distribution of human capital. According to Gibbons and Vignoles (2012), inequalities in geographic accessibility can have implications for the sorting of students across institutions, since the type and quality of higher education in which students enrol will be determined, in part, by the type and quality of local HEIs. Furthermore, since where students study will partly determine the skill composition of the local population, this can mean that the local mix of HEIs may be a key determinant of the local human capital stock in cities, labor markets and regions.

Overall it seems clear that the spatial distribution of HEIs and, as a result, the geographic accessibility of the higher education system, has important implications for the demand for higher education through the existence of often substantial distance deterrence effects. As a result, a number of studies have discussed a variety of existing and potential policy responses to address the various efficiency and equity considerations. Of course, there are a range of other non-spatial barriers to participation that also need to be addressed. But in the context of addressing distance-related effects and their impacts, suggested policies include, but are not limited to, increased financial aid with staggered distance payments, scholarships to attend 'regional' universities (i.e. those outside large population centres), as well as policies that aim to reduce the costs of mobility.

In relation to the latter, Spiess and Wrohlich (2010) recommend that policymakers should think about measures to reduce the transaction costs of students who have to study far away from home. Such measures could include free travel permits for students, reduced accommodation costs, and subsidized relocation costs. Other suggested policies relate more directly to HEIs. For example, there have been proposals for the establishment of new HEIs in poorly-served regions, increasing the geographical dispersion of top-ranked institutions, greater HEI specialisation, as well as stricter limits on intakes in urban universities. In addition, increasing distance-learning and online programmes have also been proposed as a means of tackling distance effects. Obviously any particular policy response should be context-specific and take into account the unique local circumstances, including existing policies and supports. For example, in Germany it appears that distance effects are driven mainly by transaction costs, rather than by neighbourhood effects, though this might not necessarily be the case everywhere. In other words, the broader external validity of country-specific findings and results should be questioned in a policymaking context.

Finally, despite the fact that there has been considerable research in this area to date, some notable gaps remain. One critical issue is the need for studies that provide better identification of distance effects using more ‘credible’ methods and better research design (Angrist and Pischke, 2010). As discussed in Gibbons and Vignoles (2012), there are likely to be problems related to spatial heterogeneity and residential sorting that may result in endogeneity bias in standard cross-sectional analyses of student choices and/or migration flows. This has important implications for policy since, as Gibbon and Vignoles (2012) note, if geographic proximity is not an important driver of participation, this implies very little scope for policy to widen participation through increased geographic accessibility. As discussed above, while numerous studies have found evidence of an effect of distance on progression, and made associated policy recommendations, Gibbon and Vignoles (2012), using alternative methods, find no such evidence in their study. This could, of course, be due to differences across study contexts e.g. country or cultural differences. Nonetheless, studies that exploit variation from natural experiments and provide more credible estimates of the causal effects of distance would be a welcome addition to this literature. In addition, it seems likely that travel distance could also affect student retention, as well as degree completion and performance (Alm and Winters, 2010), and this would also appear to be an important related topic for future research.

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Tables

Table 1: Sample DCE Attributes and Levels

Attributes	Levels	Description
Travel time from home	1 hour, 2 hours, 3 hours	Time it would take to travel from a student's family home (as opposed to your college residence) to the HEI
Type of HEI	University, Institute of Technology	Refers to the type of HEI that a student would attend[1]
Course reputation	Excellent, Good, Fair	Indicates the reputation of the courses on offer at the HEI in providing the knowledge and skills required for future employment and/or study
Work placement	Yes, No	Describes whether or not work placement opportunities are available as part of degree programmes at the HEI
Student fee (per year)	€1500, €3000, €4500, €6000	Each of the HEI options will come at a cost to the student, referred to as a student fee. This is an annual out-of-pocket expense for student

Source: Walsh et al. (2018).

Table 2: Variable Definitions and Sample Descriptive Statistics

Variable	Definition	Mean (SD) or %
Student Flows	Number of county-HEI student migration flows	56.78 (194.44)
Distance	Travel distance from county centroid to HEI	152.72 (77.65)
LC Students	Number of Leaving Certificate students in county (000s)	2.04 (2.44)
Income	Household median gross income (€000s)	41.72 (5.67)
HEI Size	First year student intake (000s)	1.48 (1.29)
HEI Type	= University (base)	28.6%
	= IT/TU	46.4%
	= CE	10.7%
	= Other college	14.3%
Centrality	Centrality index (000s)	2.34 (2.85)
PhD Graduates	Number of doctorate graduates per 10 academic staff	0.92(1.16)
Student Staff Ratio	Student FTE/academic staff ratio	19.00 (4.49)

Source: Author calculations, Irish Times (2019), and HEA (2018).

Table 3: Gravity Models of Student Migration Flows

	Dependent Variable: ***County-HEI Student Flows***			
	(1)	**(2)**	**(3)**	**(4)**
Ln Distance	-1.244***	-1.437***	-1.337***	-1.528***
	(0.157)	(0.170)	(0.164)	(0.181)
LC Students	0.125		0.130	
	(0.096)		(0.084)	
Income	-0.024		-0.030*	
	(0.017)		(0.017)	
HEI Size	0.628***	0.579***	0.577***	0.549***
	(0.044)	(0.032)	(0.032)	(0.025)
IT/TU	-0.348**	-0.353***	-0.242	-0.148
	(0.135)	(0.098)	(0.207)	(0.156)
CE	-0.069	-0.244*		
	(0.194)	(0.142)		
Other college	-1.169***	-1.307***		
	(0.186)	(0.192)		
Centrality	-0.143***	-0.146***	-0.220***	-0.221***
	(0.019)	(0.018)	(0.021)	(0.022)
PhD Graduates			0.162***	0.197***
			(0.051)	(0.047)
Student Staff Ratio			-0.029**	-0.031***
			(0.012)	(0.010)
Constant	9.333***	8.592***	10.568***	9.504***
	(1.074)	(0.775)	(1.096)	(0.887)
County Fixed Effects	N	Y	N	Y
Ln α (overdispersion parameter)	-0.143	-0.451***	-0.225*	-0.521***
	(0.125)	(0.129)	(0.131)	(0.144)
Observations	728	728	546	546

Notes: The table presents parameter estimates for a set of negative binomial models. Robust standard errors, clustered by county, are in parentheses. *** denotes statistically significant at 1%, ** denotes statistically significant at 5%, and * denotes statistically significant at 10%.

Source: Analysis of data from Irish Times (2019) and HEA (2018).

Table 4: Distance Elasticity Estimates by HEI Type

	Dependent Variable: *County-HEI Student Flows*			
	University	**IT/TU**	**CE**	**Other**
Ln Distance	-1.139***	-1.760***	-1.094***	-1.279***
	(0.161)	(0.149)	(0.094)	(0.272)
Observations	208	338	78	104

Notes: The table presents estimates of the student flow elasticity with respect to distance for each of four types of HEI. All are estimated using a negative binomial model including county fixed effects and pull factors relating to HEI size and centrality. Robust standard errors, clustered by county, are in parentheses. *** denotes statistically significant at 1%, ** denotes statistically significant at 5%, and * denotes statistically significant at 10%.

Source: Analysis of data from Irish Times (2019) and HEA (2018).

Figures

Figure 1: Sample Choice Card

	OPTION A	**OPTION B**	**OPTION C**	**OPTION D**
Type	University	Institute of Technology	University	Prefer not to attend any of the higher education institutions presented here
Travel time <u>from home</u>	1 hour	3 hours	2 hours	
Course reputation	Good course reputation	Excellent course reputation	Fair course reputation	
Work placement	No work placement	Work placement	No work placement	
Student fee (per year)	€4,500	€1,500	€4,500	
Please tick the one option you **prefer**.	☐	☐	☐	☐

Source: Walsh et al. (2018).

Figure 2: Irish HEIs by Location and Type

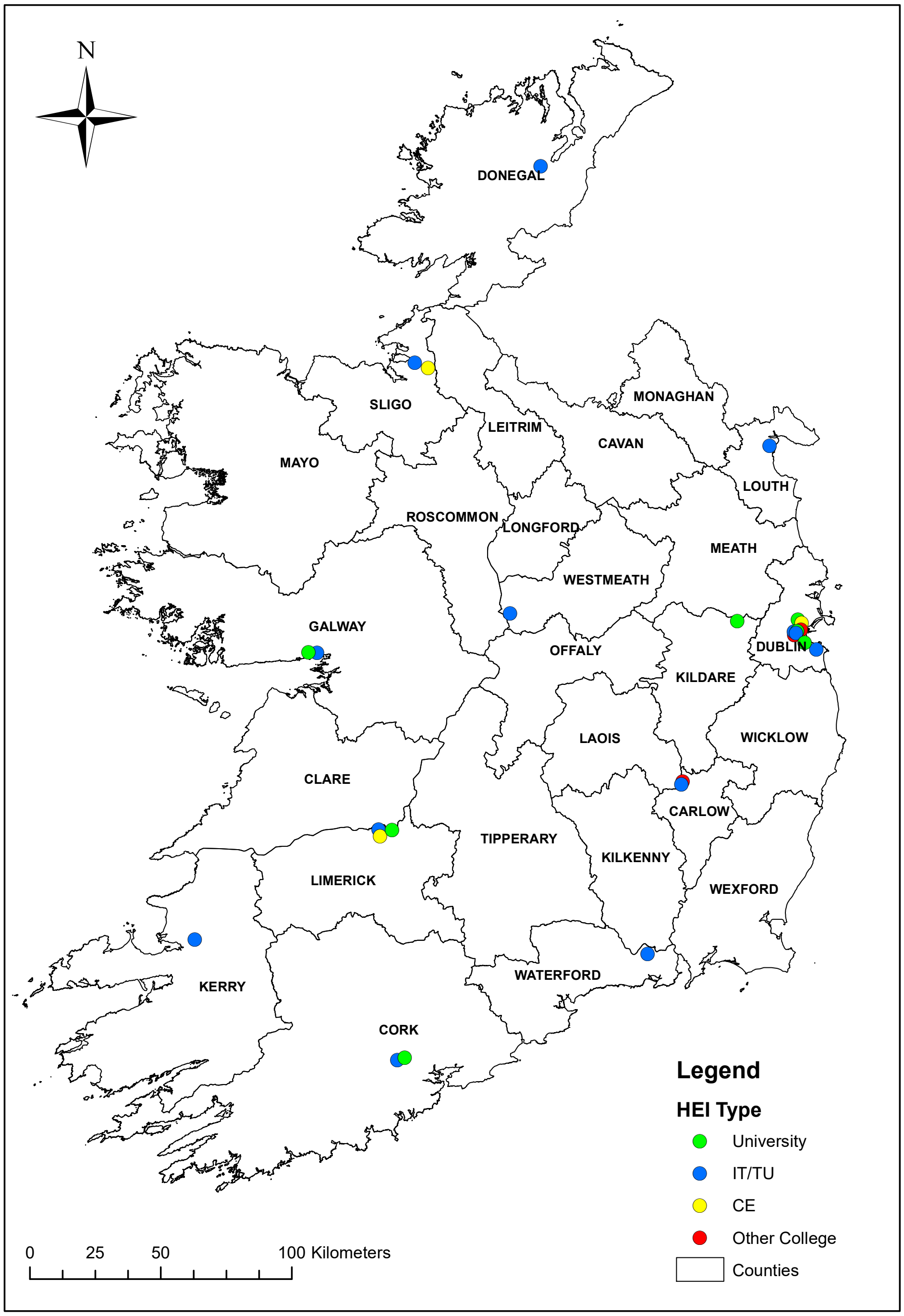
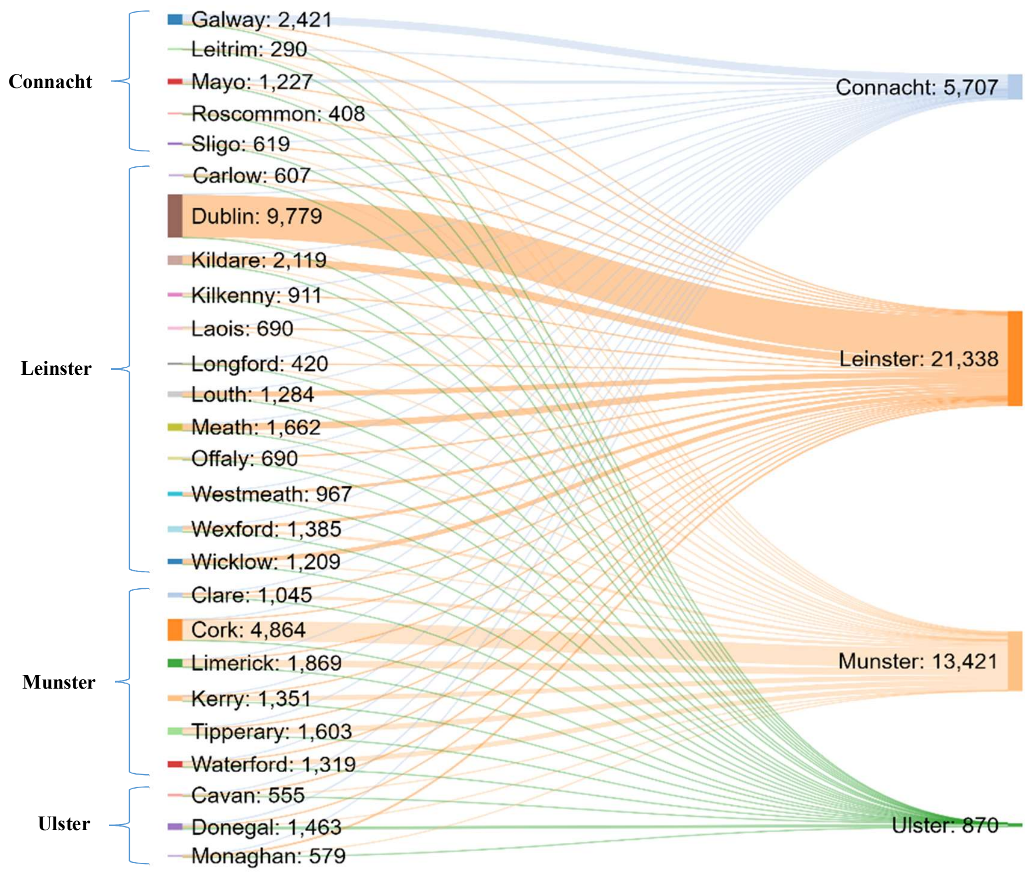


Figure 3: Sankey Diagram of Higher Education Migration Flows by County and Province



Source: Analysis of data from Irish Times (2019).