25 Quantification, Evidence and Positivism

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Setting the Scene

Quantitative geographers do not often concern themselves with philosophy, and although externally we are often labelled (incorrectly in many cases) as positivists, such a label has little or zero impact on the way in which we prosecute research. We do not, for example, concern ourselves with whether our intended research strategy breaches some tenet of positivist philosophy. Indeed, most of us would have scant knowledge of what such tenets are. As Barnes (2001) observes, for many of us, our first experience with positivism occurs when it is directed at us as a form of criticism. We do not continually scrutinize our particular *modus operandi* with some philosophical checklist in hand. Our lack of engagement with the philosophical debates that seem to take up so much of the energy of our colleagues is more than compensated for by our concern with statistical, mathematical and, above all, *geographical* theory. To a large extent, our guiding principle is the question, 'Does what I'm doing provide useful evidence towards the better understanding of spatial processes?' The continuous debates about which particular philosophical approach or 'ism' is best leave most quantitative geographers shaking their heads and wondering what is happening to the rest of their discipline. The wonderful quotation attributed to the late Richard Feynman that 'philosophy of science is about as useful to scientists as ornithology is to birds' is rather apt here (*inter alia* Kitcher, 1998: 32).

However, in the recent decade, the exponents of various philosophical trends that have been co-opted into human geography appear to be increasingly antagonistic towards the use of quantitative methods, for reasons that often seem to be more emotive than substantive. It is especially worrying that some of our colleagues appear unwilling to engage at all with our work, despite its relevance to almost every substantive issue studied by geographers. Instead, they dismiss the whole field because it does not fit in with their particular philosophical credo. It therefore seems that some discussion and defence of the approaches taken by quantitative geographers is appropriate in order to generate a more balanced view of their contributions to the discipline. Consequently, in what follows I attempt to articulate what defines a quantitative geographer, given that it is not that we have all joined some philosophical 'club' with strict membership guidelines about how to and how not to prosecute research. I also try to explain why we have trouble with many of the current 'isms' that abound in human geography. In addition, I discuss some of the issues surrounding the relative demise of

the quantitative approach within geography during the 1980s and 1990s, as well as its recent resurgence. All I ask is the impossible: that the reader approach this with an open and unprejudiced mind.

So What Do Quantitative Geographers Do?

As I state with colleagues elsewhere:

> A major goal of geographical research, whether it be quantitative or qualitative, empirical or theoretical, humanistic or positivist, is to generate knowledge about the processes influencing the spatial patterns, both human and physical, that we observe on the earth's surface. (Fotheringham et al., 2000: 8)

Towards this goal, the work of quantitative geographers can be grouped into four areas.

1. The reduction of large data sets to a smaller amount of more meaningful information. This is important in analysing the increasingly large spatial data sets obtained from a variety of sources such as satellite imagery, census counts, private companies and local governments. Summary statistics and a wider body of data reduction techniques are often needed to make sense of these very large, multidimensional data sets.
2. The exploration of spatial data sets. Exploratory data analysis consists of a set of techniques to explore data (and also model outputs) in order to suggest hypotheses or to examine the presence of unusual values in the data set. Often, exploratory data analysis involves the visual display of spatial data generally linked to a map.
3. Examining the role of randomness in generating observed spatial patterns of data and testing hypotheses about such patterns. In so doing, we can infer processes in a population from a sample and also provide quantitative information on the likelihood that our inferences are incorrect. For instance, suppose we want to investigate the spatial distribution of some disease in order to examine if there might be an environmental link to that disease. We have to decide first on some method of measuring the spatial clustering of the disease with respect to the at-risk population and then we have to determine the probability that such clusters could have arisen by chance. Third, if the clusters are very unlikely to have arisen by chance, we must look at the relationship between the locations of the clusters and various environmental factors, such as the locations of toxic waste dumps or contaminated water sources. We do not claim such statistical tests would provide us with a definite answer to what caused the disease but we would have a better basis on which to judge the existence of a possible relationship.
4. The mathematical modelling and prediction of spatial processes. The calibration of spatial models provides extremely useful information on the determinants of processes through the estimates of the models' parameters. Spatial models also provide a framework in which predictions can be made of the spatial impacts of various actions: examples include the effects of building a new shopping development on traffic patterns, and the building of a seawall on coastal erosion.

The goal of quantitative geography is therefore a very simple one, but a very important one: *to add to our understanding of spatial processes*. This might be done directly, as in the case of store choice modelling, where mathematical models are derived based on theories of how individuals make choices from a set of spatial alternatives. Or it might be done indirectly, as in the analysis of the incidence of a particular disease, from which a spatial process might be inferred from a description of the spatial pattern of the incidence of the disease.

Quantitative geographers would argue that their approach provides a robust testing ground for ideas about such spatial processes. Particularly in the social sciences, ideas become accepted only very gradually and have to be subject to fairly rigorous critical examination. Quantitative spatial analysis provides the means for strong evidence to be provided either in support of or against these ideas. For these reasons, quantitative geographers have skills which are much in demand in the real world and are sought after to provide inputs into informed decision-making.

Positivism and Quantification

The terms 'positivism' and 'quantification' are not synonymous, even though many people use them interchangeably.[1] One can be a quantitative geographer, for example, without necessarily being a positivist. This fundamental misunderstanding has arisen because many geographers, I suspect, have misconstrued the meaning of one or both of these expressions. It is not difficult to see why this has happened: the term 'positivism', in particular, is laden with ambiguity. As Couclelis and Golledge note:

> Although there is usually little disagreement as to what argument or piece of work is in the positivist tradition, positivism itself as a philosophy turns out to be extremely difficult to define … popularized accounts, *ad hoc* reformulations, working philosophies, methodological credos, and several contrasting sets of ontological beliefs, all sought and found a place under the umbrella of 'positivism'. (1983: 332)

However, it is possible to identify two of the more central tenets of positivism, which are (in lay terms) as follows:

1. The only meaningful items of study are those that can be verified. Strictly speaking this means we should be able to judge absolute truth, which in geographical studies we generally cannot; hence, more loosely, we often relax this condition to mean we can judge a statement to be either true or false.[2]
2. Items of study can be verified only when they can be directly measured and observed.

Taken together, these tenets imply that our ability to generate knowledge is restricted to those things that we can observe in reality. For instance, religious discussions are seen as irrelevant to positivists because the beliefs that people hold can be neither proved nor disproved. Since we cannot measure emotions and thoughts, strict positivists would also exclude these items from investigation. Clearly, empirical testing is an important element of positivism: knowledge cannot be gained on those issues which do not lend themselves to such testing.

When geographers use the word 'positivist', they generally imply a somewhat broader set of beliefs and often ascribe the term to someone who follows scientific principles in his/her research. Gatrell, for instance, defines quantitative geography as that which

> relies on accurate measurement and recording and searches for statistical regularities and associations. It emphasises, via mapping and spatial analysis, what is observable and measurable. Because it then seeks to establish testable hypotheses, in the same way that a natural scientist would, it has many of the characteristics of a positivist or naturalist approach to investigation. (2002: 26)

A positivist therefore is perceived as someone whose focus is the search for order and regularities with the ultimate goal of producing universal laws (a weaker version of positivism that is applied to human geography is one that attempts to make generalizations about spatial processes rather than 'laws'). The methods used to achieve this are typically quantitative: data might be analysed, hypotheses might be tested, theoretical relationships might be established, and mathematical models might be formulated and calibrated. Quantitative geographers, being labelled as positivists, are typically perceived as ignoring all the emotions and thought processes that are behind what is sometimes, at least in the case of human geography, highly idiosyncratic behaviour. In essence, positivism, science and quantification are all seen as synonymous, unemotional, mechanistic approaches to the study of geography.

It is therefore tempting to label all quantitative geographers as positivists or naturalists (Graham, 1997) but this disguises some important differences both within quantitative geography and between quantitative geography and positivism. For example, while quantitative geography has some adherents who believe in a search for global 'laws' and global relationships, others recognize that there are possibly no such entities. The latter concentrate on examining variations in relationships over space through what are known as 'local' forms of analysis (Fotheringham, 1997; Fotheringham and Brunsdon, 1999; Fotheringham et al., 2002). Here the emphasis is on identifying areas of exception where something unusual appears to be happening; the approach does not necessarily concern itself with establishing any laws, or even generalities, and hence is contradictory to the spirit of positivism. Local types of investigation are increasingly finding favour among quantitative geographers who recognize that global methods of analysis can mask important local variations and that these variations can shed important light on our understanding of spatial processes.

As well as being less concerned with the search for global laws than some might imagine, quantitative geography is also not as sterile as some would argue in terms of understanding and modelling rather abstract concepts such as human feelings and psychological processes (Graham, 1997). There appears to be a strong undercurrent of thought amongst those who are not fully aware of the nuances of current quantitative geography that it is deficient in its treatment of human influences on spatial behaviour and spatial processes. While there is some validity in this view, quantitative geographers increasingly recognize that spatial patterns resulting from human decisions need to account for aspects of human decision-making processes. This is exemplified by the current interest in spatial information processing strategies and the linking of spatial cognition with spatial choice (see Fotheringham et al., 2000,

Chapter 9 for an example), and also by the attempts of researchers such as Openshaw (1997a) to incorporate qualitative issues into modelling through the application of fuzzy logic. Indeed, I suspect it would be a real eye-opener for many critics of quantitative geography to read works such as Openshaw (1997a) and to see the efforts some spatial analysts have made to capture qualitative issues within their research.

Quantitative geographers believe that quantification generally provides strong evidence towards understanding spatial processes – much stronger, for example, than is provided by any other competing methods. However, we recognize that, counter to one of the tenets of positivism, rarely can we prove anything absolutely. The usual goal of quantitative analysis in geography is to accrue sufficient evidence to make the adoption of a particular line of thought compelling. As Bradley and Schaefer note in discussing differences between social and natural scientists:

> the social scientist is more like Sherlock Holmes, carefully gathering data to investigate unique events over which he had no control. Visions of a positive social science and a 'social physics' are unattainable, because so many social phenomena do not satisfy the assumptions of empirical science. This does not mean that scientific techniques, such as careful observation, measurement, and inference ought to be rejected in the social sciences. Rather, the social scientist must be constantly vigilant about whether the situation being studied can be modeled to fit the assumptions of science without grossly misrepresenting it ... Thus, the standard of persuasiveness in the social sciences is different from that of the natural sciences. The standard is the compelling explanation that takes all of the data into account and explicitly involves interpretation rather than controlled experiment. The goals of investigation are also different – the creation of such compelling explanations rather than the formation of nomothetic laws. (1998: 71)

Hence, whereas the goal of a positivist would be to uncover the truth about reality in the form of absolute laws, quantitative geographers realize that such absolutism is extremely difficult to find in most instances and they hold to the more acceptable goal of simply accruing sufficient evidence on which to base a judgement about reality that most reasonable people would find acceptable. Judgements or hypotheses about reality that are found unacceptable are discarded, so that knowledge accumulates via a process of retention or rejection. Of course, retention does not imply validation, but merely that the idea survives that particular test. Ideas in social science tend to become generally accepted only when they survive a large number of such tests.

Related to this issue, and one of the strengths of a quantitative approach, is the measurement of error. Suppose we wish to understand the spatial distribution of some phenomenon in terms of a set of explanatory variables that influence this distribution in some way. In most cases there are actually two sets of explanatory variables: those which we know to have an effect on the spatial distribution under investigation and which we can measure, and those whose effects we are unaware of or which we cannot measure. A large advantage of a quantitative approach is that it enables the measurement of the determinants that can be measured (and in many cases these provide very useful and very practical information for real-world decision-making) whilst recognizing that, for various reasons, these measurements might be subject to some uncertainty. We can measure this uncertainty and report it as a guide to the degree of belief one should have in the

reported results. If, for instance, the errors in the modelling procedure are large, we would probably conclude that something important has been omitted from the model and that the results are not very reliable. Being able to assess the likelihood that a model of the real world is a reasonable one, and hence the degree of belief to ascribe to the outcomes from such a model, is a big advantage of the quantitative approach. Ironically, it also allows to us to be highly self-critical, a trait that is less obvious in what are termed 'critical' approaches to human geography.

Differences between Quantitative Human Geography and Quantitative Physical Geography

To this point I have ignored the differences between quantitative human geography and quantitative physical geography, and this failing should be redressed. Most, if not all, of the plethora of 'isms' that abound in geography originate from, and dwell entirely within, human geography. Indeed, it could reasonably be argued that the rise of the new 'isms' within human geography, with their non-quantitative or even anti-quantitative stances, has widened the intellectual gap between human and physical geography. This division is now so wide that some physical geographers see little point in remaining in departments that to them appear more rooted in sociology than geography. As Graf notes:

> While their human geographer colleagues have been engaged in an ongoing debate driven first by Marxism, and then more recently by post-structuralism, post-modernism, and a host of other isms, physical geographers are perplexed, and not sure what all the fuss is about … They do not perceive a need to develop a post-modern climatology, for example, and they suspect … that some isms are fundamentally anti-scientific. (1998: 2)

One argument for an increasing emphasis on the quantitative approach within human geography is that it acts as a bridge between human and physical geography rather than as a barrier. The common language and purpose of a quantitative approach allows human and physical geographers not just to talk the same language but also to pursue meaningful joint research.

However, despite the relative similarities in the approach of many quantitative human geographers and their colleagues in physical geography, there are some differences in subject matter that lead to somewhat different analytical approaches becoming prominent in the two areas. At least four such differences are apparent.

For physical geographers their subject matter can sometimes be completely separated from our perceptions and therefore analysed entirely objectively. In some instances this is also true in human geography. For instance, if we are measuring death rates across a region there is no perceptual issue in measuring who is dead and who is not.[3] However, in general, perceptions of the real world are important in understanding much of human geography. Most, if not all, spatial decisions are made on the basis of perceived reality and not reality itself. It might therefore be argued that quantitative approaches that use objective measures of reality to explain human behaviour are inappropriate. Indeed, some would use this argument to defend their

own non-quantitative approach to human processes. However, the quantitative approach can be defended in two ways. First, various quantitative models in human geography do take account of people's perceptions of their environment to understand their behaviour in that environment. For instance, quantitative geographers have used information on perceived realities to model spatial choice behaviour such as the choice of shopping destination. People's choices of supermarkets, for example, depend on their perceptions of the various supermarkets they can feasibly patronize and on their perceptions of how easy it is to get to each of them. Quantitative geographers have even included within their models people's perceptions of the arrangement of alternatives in space and their mode of making decisions between them. Notions of hierarchical information processing and mental maps are used to produce more accurate models of human spatial decision-making (Fotheringham et al., 2002: Chapter 9). Second, quantitative approaches can be defended by recognizing that in most cases our perceptions of reality closely resemble our objective measurements of reality, and that models that use only objective measures of reality are still useful. Arguing that the whole of the quantitative approach should be thrown out because quite often information on perceived reality is not available ignores the fact that models based solely on objective measures of reality are still very useful and far better than any alternative.

The concept of rationality is irrelevant to most physical processes. When we deal with the human world we immediately have to recognize that not everyone will act like automatons and behave in a manner predicted by a mathematical model. Again, some of the adherents of various non-quantitative approaches to human geography seek to use this as an argument against quantification. However, there are two issues that are at odds with such an argument. One is that while we cannot hope to model the actions of each human being, the actions of humans *in aggregate* are often quite predictable. Hence, quantitative models of shopping behaviour by groups of consumers or models predicting population movements between regions are frequently used by private companies and various government agencies. A second is that quantitative models of human behaviour increasingly seek to include seemingly irrational behaviour (see the recent developments in spatial interaction modelling, for example, as described in Fotheringham et al., 2000: Chapter 9). This is a difficult and challenging task but it is one that makes the quantitative approach interesting. It also brings into question whether people ever do act irrationally. Perhaps seemingly irrational behaviour is simply behaviour for which we have not determined the proper set of determinants? For instance, a person in a shopping survey who buys groceries from a store that is 20 miles farther away than another identical one might be deemed to be behaving irrationally. However, the shopping trip might be entirely rational if that person has a relative living close to the selected store and combines a shopping trip with a family visit.

In physical geography there are some fundamental relationships that are the same everywhere. For instance, the rate at which temperature decreases with altitude or the infiltration rate of water through soil are entirely predictable given the right information. This is probably not true in human geography, or at least if there are such fundamentals, we have not yet discovered what they are. Yet again, this seems to have been used as a reason why a quantitative approach to human geography is doomed to failure. However, one only has to look at the huge literature now emerging on local statistics and local modelling techniques to realize that quantitative human geographers have solved this problem by developing techniques that recognize intrinsic local differences

in processes (Fotheringham et al., 2002). We now have the tools by which we can measure not only *if* there are local differences, but also *what these local differences look like*. The latter provide a very good mechanism for a better understanding of locality as a determinant of human behaviour.

Some results in physical geography can be replicated, and in this sense they are truly 'scientific'. Results in human geography are usually not replicable. Due to the nuances of the subject matter in human geography, the calibration of the identical model in two or more different systems generally leads to different results. Fortunately, in some cases these differences are small; in other cases the differences have meaning in terms of the effects of location upon behaviour; in still other cases the results vary because we have a poor model and the variation is therefore a useful diagnostic indicator that we should try to improve the model.

Given the above, it is hardly surprising that quantitative geography has evolved slightly differently in human and physical geography. Typically, human geographers are more concerned with stochastic models because their subject matter is less predictable. Typically, human geographers draw more on concepts from psychology and economics, again because of their subject matter. Some elements of physical geography, such as climatology and meteorology, are more closely allied to physics and others, such as fluvial geomorphology, to engineering.

However, despite these differences there is a great deal of common ground between quantitative human and physical geographers, because both groups share an interest in understanding spatial processes and both believe that a better understanding of these processes can be obtained through quantitative analysis. The common framework of quantitative methodology is thus a potentially very powerful mechanism to stop the slow disintegration of geography as a discipline, as the gap between physical geographers and the proponents of various non-quantitative isms in human geography grows ever wider.

What Quantitative Geographers Find Problematic about Some Non-Quantitative Approaches

Until recently, most quantitative geographers tended to view the various non-quantitative approaches within human geography with some bemusement; the currently fashionable 'ism' seemed to change on a 5–10-year cycle and some people seemed to jump on whatever bandwagon rolled by. The only commonality amongst the 'isms' that we could perceive was an anti-quantitative bias. However, the increasingly marginalized treatment given to quantitative methods has produced a reaction not dissimilar to the broader scientific response to the anti-science attacks of the postmodernists. For example, consider the following two quotations:

> I discern a disturbing implication of relativist accounts of the sciences. A generation ago, the British sociologist Stanislav Andreski depicted the social sciences as sorcery, as gibberish designed to placate special-interest groups (Andreski, 1972). More recently, Alan Bloom compared the humanities to the old Paris flea market: Among the masses of rubbish, one can, by diligent searching, find the occasional under-valued intellectual nugget (Bloom, 1987, p. 371). One's first reaction is to dismiss the authors of the remarks as

> crabbed reactionaries. But my encounter with cultural studies of science leads me to conclude that such views must be taken seriously. (Sullivan, 1998)
>
> Whatever the correct explanation for the current malaise, Alan Sokal's hoax has served as a flash point for what has been a gathering storm of protest against the collapse in standards of scholarship and intellectual responsibility that vast sectors of the humanities and social sciences are currently afflicted with … Anyone still inclined to doubt the seriousness of the problem has only to read Sokal's parody (Koertge, 1998)

The Sokal parody referred to can be found in Sokal (1996a; 1996b) and can be downloaded, along with a great deal of other interesting material related to the hoax, at Sokal's website: http://www.physics.nyu.edu/faculty/sokal. For those unaware of it, the paper in question is a complete fabrication published as a hoax in a supposedly highly regarded journal of critical studies. It highlights a major problem that quantitative geographers have with some of the recent 'isms'. If there is no value system whereby research can be assessed, then how does one differentiate 'good' research from 'bad' research?

Table 25.1 Sample quotations

To recognize the performativity of discourse is to recognize its power – its ability to produce 'the effects that it names'. But the process of repetition by which discourse produces its effects is characterized by hesitancies and interruptions. Unlike the coherent and rational modernist subject, the poststructuralist economic subject is incompletely 'subjected'. Her identity is always under construction, constituted in part through daily and discontinuous practices that leave openings for (re)invention and 'perversion'.
This reinscription lays bare the constitutive relationship between the conditions that make possible a given phenomenon in the apparent fullness of its identity or meaning, and how these same conditions also mark the impossibility of such phenomena ever being realized in their ideal purity. Deconstruction therefore involves an exposure of conditions of possibility and impossibility. This does not refer to two separate sets of opposed conditions. Rather, possibility and impossibility are doubled up in the same conditions. This doubling of (im) possibility excludes an emphasis solely on the pole of either enabling or disabling conditions.
The dialectic untranslatability between empiricism and 'vanguardist theoreticism' continues to befuddle geographic epistemology. For some, the duality is predetermined as essentially semantic; for others, it represents an oscillation between articulation and disarticulation. However, there is little doubt that the irreducible differences in the hermeneutics of theoretical versus empirical research have created a division that is beyond either ontology or metonymy. The aporetic 'spacebetween' is an example of a binary conceptualization of methodology that has led to an extreme schism within parts of geography.
The semiotic is where a not-yet subject deals with objects and spaces that are not-yet demarcated. This is a space of 'fluid demarcations' of yet unstable territories where an 'I' that is taking shape is ceaselessly straying, where the not-yet-subject experiences 'above all ambiguity', 'perpetual danger' and is engaged in a 'violent, clumsy breaking away' from the mother. The mapping of the body, then, its initial territorialization, takes place in this primary ('maternal') arena, already social and meaningful (at least partly because the mother is a social subject), but not yet linguistic, that is, prior to the subject's advent into language and the ('paternal') law.

As an example, try this test. Read the four quotations in Table 25.1. Three of these are either paraphrased or direct quotations from prestigious geographic publications; one of them is complete gibberish. Can you tell which is which?

The answer is given in note 4 to this chapter. If you are in *any* doubt about the correct answer, then you probably share at least some of the concerns of quantitative geographers.

The Sokal hoax and the recent attacks on critical studies (see Koertge, 1998 for a sample of these) highlight the current low esteem in which much of the so-called critical theorist school of social science is held by others. It mirrors the view of many quantitative geographers who cannot see what distinguishes good from bad research in much of what now passes for human geography. It is also indicative of the strength of the feelings that have been aroused in some quantitative geographers about what they see as the excessive proliferation of the adherents of anti-science and anti-quantitative views within the discipline. For example, consider this from Openshaw:

> Maybe human geography is about to experience a new age of extreme technophobic Ludditism advocated by an uncomfortable mix of well-intended scholars and nasty minded voyeurs who are steadfastly intent on navel gazing and nihilistic destruction by seemingly endless and rampant deconstruction of anything for which there is a publication opportunity. (1997b: 8)

Another problem many quantitative geographers have with some (although not all) of the work done under the banner of various other 'isms' in human geography is that we often cannot see where the 'geography' is in the research. Much of the research published in ostensibly geographical journals looks to us very much like sociology or political science: in many instances, the role of space seems secondary or even non-existent.

If geography is to survive as a discipline, it needs a common theme that separates it from other disciplines. Quantitative geographers make it explicit that we need to investigate *spatial* processes and tend to be quite critical of research conducted under any philosophical banner that purports to be geography but is not concerned with space or spatial issues. We are not convinced that the adherents of some other approaches to the study of geography share our vigilance in this regard.

The final problem quantitative geographers have with the non-quantitative 'isms' concerns the lack of strong and impartial evidence that emanates from these latter domains. Research, for instance, in which only a handful of people might be interviewed, to us does not constitute a reliable sample. Often there is no discussion of how the sample was obtained and what the level of uncertainty is in the inferences drawn from such a small sample (it is undoubtedly extremely high in most cases). In many cases, the writing style resembles more that of a newspaper report in which a few selected quotations are taken (possibly out of context) to support the author's viewpoint. In this way, we see such articles as potentially very biased, inevitably supporting the author's political or cultural stance. Thinking in terms of a court of law, or the quotation from Bradley and Schaefer reported above in which they describe the need to accumulate evidence, to most quantitative geographers a great deal of qualitative 'evidence' just does not stand up to a good cross-examination. In many ways the acceptance of such weak evidence in the various anti-quantitative and anti-science 'isms' is a worrying trend that is mirrored in society by a growing belief in things such as creationism, astrology, angels, alien encounters and faith healing. If there is no logical framework in which to reject false claims, essentially anything becomes acceptable: there is no basis for distinguishing between good research and nonsense – as the Sokal hoax aptly demonstrated.

So Why Has Quantitative Geography Been in Decline until Recently?

It is difficult to say exactly when geographers began to turn to quantitative methods in their search for understanding, but it is generally agreed that it began in earnest at some time in the late 1950s and early 1960s, although much earlier examples of individual pioneering work can be found. Certainly, the decades of the 1960s and 1970s were periods when quantitative methodologies diffused rapidly throughout the discipline. Throughout the 1980s and through much of the 1990s quantitative geography then suffered a reversal of fortune. Elsewhere, my colleagues and I note there are several possible reasons for this (Fotheringham et al., 2000: Chapter 1).

Certainly the growth of many newer paradigms in human geography, such as Marxism, postmodernism, structuralism and humanism (Johnston, 1997; Graham, 1997) attracted adherents united in their anti-quantitative sentiments and their lack of quantitative ability. There was also the seemingly never-ending desire for some new paradigm or, in less polite terms, 'bandwagon' to act as a cornerstone of geographic research. The methodology of quantitative geography had, for some, run its course by 1980 and it was time to try something new. As de Leeuw observes of the social sciences in general:

> This is one of the peculiar things about the social sciences. They do not seem to accumulate knowledge, there are very few giants, and every once in a while the midgets destroy the heaps. (1994: 13)

Another reason for the relative demise of quantitative geography was that as it developed into a well-established paradigm, it became, inevitably, a focal point for criticism. Unfortunately, much of this criticism originated from individuals who had little or no understanding of quantitative methods. As Gould notes:

> few of those who reacted against the later mathematical methodologies knew what they were really dealing with, if for no other reason than they had little or no mathematics as a linguistic key to gain entry to a different framework, and no thoughtful experience into the actual employment of such techniques to judge in an informed and reasoned way. Furthermore, by associating mathematics with the devil incarnate, they evinced little desire to comprehend. As a result, they constantly appeared to be *against* something, but could seldom articulate their reasons except in distressingly emotional terms. (1984: 26)

A final reason is that quantitative geography is relatively 'difficult', especially for those with limited mathematical or scientific backgrounds. It is perceived by many to be easier to follow other approaches to geographical enquiry and, consequently, they obtain remarkably little exposure to quantitative research even in the substantive areas in which they undertake research. This makes it virtually impossible for many geographers to understand the nature of the debates that have emerged and will continue to emerge within the broad field of spatial analysis. It also makes it tempting to dismiss the whole field of quantitative geography through criticisms that have limited validity rather than trying to understand it. As Robinson states:

> It can be argued that much of the antipathy towards quantitative methods still rests upon criticisms based on consideration of quantitative work carried out in the 1950s and 1960s rather than upon attempts to examine the more complete range of quantitative work performed during the last two decades. (1998: 9)

It is true that the early examples of quantitative geography were overly concerned with form rather than with process and with the establishment of nomothetic laws, but the retention of such criticisms as almost an anti-quantitative mantra indicates a woeful lack of understanding of much of the quantitative geography that has been undertaken over the past 20 years. In fact, I suspect many of the criticisms of earlier quantitative work stemmed originally from quantitative geographers themselves who, recognizing some shortcomings within a very youthful part of the discipline, strove to improve it as part of the natural evolution of a vital research area.

The relative difficulty of spatial analysis probably also encouraged some researchers to 'jump ship' from quantitative geography (for some interesting anecdotes along these lines, see Billinge et al., 1984) as they struggled to keep up with the development of an increasingly wide array of techniques and methods. As Hepple (1998) notes:

> I am inclined to the view that some geographers lost interest in quantitative work when it became too mathematically demanding, and the 'hunter-gatherer' phase of locating the latest option in SPSS or some other package dried up.

It is difficult to know which of the above reasons explain the actions and attitudes of particular individuals (the last reason is certainly not one to which many will admit), but whatever the cause, it is both a shame and an irony that many geographers choose to remain ignorant about the value of quantitative methods just when there is a rapid and sustained growth in spatial data analysis in other disciplines and in society in general. There is now a strong demand for students who can analyse spatial data and a need for geographers to provide leadership in this area. Unless we increase the understanding and acceptance of quantitative methods within geography, historians of the discipline will probably view this era with some bemusement and a great deal of regret.

Summary

Quantitative methods will always have an important role to play in both human and physical geography, not just for pragmatic reasons but because they provide strong evidence on the nature of spatial processes. Unfortunately, many geography students will never realize the potential of such methods in their own research because they are given outdated and heavily biased views of the use of such techniques, often from individuals who have no direct experience in this area and who seem intent on transmitting their own shortcomings and prejudices to their students. One of the saddest ramifications of the deep philosophical schism within geography currently is that many students are being robbed of a well-rounded geographic education. As Openshaw states:

> There is a risk of ideological intolerance that has not been so visible previously because the gulf is no longer just philosophical or paradigmatic but is reinforced by serious deficiencies in research training. (1997b: 22)

Consequently, I pose the following questions that geographers should ask themselves:

Can I envisage situations where quantitative evidence could be useful to support my own research interests?

Do I have sufficient knowledge to make a reasoned and impartial judgement about the role of quantitative methods within geography?

To what extent are my attitudes or those of others towards quantitative methods the result of ignorance and prejudice rather than reason and altruism?

Answering such questions truthfully might eventually lead to a greater awareness and acceptance of what quantitative geography can offer than currently exists.

If geography is to survive as a discipline it needs to demonstrate the following traits:

1. That it has a core subject area, understanding spatial patterns and processes, which defines the subject and differentiates it from all others.
2. That geography is relevant to the world outside academia and that students can gain employment using skills they have learned in geography courses.
3. That human and physical geographers can work together sharing similar goals and methodologies.

Quantitative geography provides all three; some other paradigms currently in vogue in geography appear to provide none, which is why I worry about the future of the discipline.

NOTES

This work has its origins in rather peculiar geographical circumstances. The first draft was written on the island of Rarotonga in the South Pacific. The latitude of the island was matched only by that of the administrator at the University of Newcastle who approved my travel expenses.

1 I will exhibit my philosophical ignorance here (and probably elsewhere) by using the term 'positivism' as shorthand for 'logical positivism', 'logical empiricism', 'scientific empiricism', 'neopositivism', 'logical neopositivism' and probably half a dozen other, related, 'isms'.
2 Following the work of Popper (1959), quantitative geographers tend to follow the principle of critical rationalism: that hypotheses cannot be proven as 'true' but can be demonstrated as 'false'. Strictly speaking this runs counter to the tenet of verifiability and therefore immediately puts most of quantitative geography outside the realms of logical positivism. However, the falsification *modus operandi* is still a very useful process that allows us to be critical of ideas and which is absent in competing philosophies.
3 There is an issue of what the appropriate spatial units are for which death rates are reported, but this is a separate issue.

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