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Household location in response to changes in transport/accessibility using SimDELTA

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[EDITED TRANSCRIPT]

Olga Feldman – Before I start talking about our microsimulation model I would like you to know that actually have aggregate model and we usually work with the aggregate model which is called DELTA and the microsimulation model was built especially for the Department of Transport as a research project.

So if we start with the focus of our film, I work for David Simmonds Consultancy, you can probably get that from the programme, and I didn't know why this is white, it was a different colour on my computer, I apologise for these white lines.

So you can see different markets here, we have property market, we have labour market, we have product market and we have transport markets, and around these four markets we have a different agents, developers, firms, residents and transport service suppliers and infrastructure suppliers and as you can see there are different interactions between them and only a few lines are drawn here but obviously they're much more complex than you can see here, and the focus of what we're doing is actually on this but not on the transport model. So as you know my presentation is called accessibility, how accessibility basically affects household location but the focus of our firm is not on transport but only on household location. So we do take inputs from the transport model and we deal with them.

And first of all the ground to the DELTA package. The DELTA started to be built in 1995 and it has two key characteristics. First of all it's add-on to otherwise free-standing transport models. We usually work with other transport consultancies, MVA for example and others, and there's a model be constructed in terms of processes of change. And we've done various applications of these DELTA package. And one important thing which I should have probably told you before is that in our case the meaning of land use, so DELTA's land use model is completely different from what Gary was talking, you know the previous presentation, so we are not dealing with land itself but we're dealing with household and population with employment and building stock and interactions between all of these. So we basically don't care which sort of land all people build but we're just dealing with people who live there and with jobs.

And the DELTA model itself it has a number of sub models which can be aggregated into three main models, one is the economic one, the urban land use model which is the zonal model, the migration model and then the transport model which all these can be linked but we don't want to have it so it's not a part of the DELTA package.

And here you can see that usually when we run the transport model with DELTA as a whole land use interaction model, we pick up generalised costs from the transport model and those are input in DELTA where disability is calculated and then impacts on other issues. But usually transport model is not run every year because of the time, it's quite time consuming to do it, usually the transport models around every fifth year, with DELTA it's run every year and then we use outputs from the transport model for a number of years, usually five, in some cases two.

And here you can see different links between DELTA sub models, in this case the economic model, zonal model and migration model which I mentioned before and you can see that there is a transport system from which we take the transport costs and different land use outputs, say from the transport model. And some of those systems they are very complex and transport model requires loads of information from DELTA, for example households by different household types, but some transport models they're only interested in total population and total employment, in this case only this information is passed through the transport model.

And in order to calculate accessibility we use this logsum approach and from the transport model we get generalised costs and then all these is rated by their opportunities, total number of jobs at each destination. So this is quite a standard approach which is implemented in DELTA. And accessibility is used in DELTA impacts of employment, location, household

location, development on regional economic model and on car ownership. So these are the five main sub models which deal with accessibility.

And in terms of the DELTA, DELTA has simple sequence of processes within one year, I will show you one of them and very complex time lag linkages over time. As I mentioned before it's usually around every year and it's an incremental model.

We start usually from the observed database for example 2001 census, a lot of our models start from the 2001 census and 2001 is the base year and it produces a database for each forecast year. And I would show you this slide and this is again still an aggregate model and later on I'll show you where simDELTA, the microsimulation comes into play. So again we deal, zonal model deals with space and activities and regional economic models, migration and economic model as discussed before.

Some linkages we're not going to talk about all of them but they are quite complex and you can see we have first year and then second year, so we start with the calculations which affect them and we go through housing quality, housing supply, housing location, travel to work, employment and other calculations and then outputs from the previous year they usually affect the inputs to the next year and they can change the outputs.

And again simDELTA as I mentioned before is a research project which was commissioned by DfT and the aim was to build a new microsimulation based model, household location and related processes of change. And as a result of this project we've built a package which is called simDELTA and is was developed and then calibrated for the south and west Yorkshire and the reason for using this particular area is because before that we built a standard DELTA application and there were two transport models which were used as well. So there was not, the purpose of this research wasn't to build a full land use and transport microsimulation type interaction, but in theory simDELTA is linked to DELTA and DELTA is linked to the transport model, so in theory you can run the whole cycle but we haven't done it.

And here you can the area which was covered in microsimulation, so I also put some local services but not all of them are actually in our modelling system for microsimulation model, and the reason for that is because we've done some, we completed the project, another project for DfT in identifying functional areas which are areas of more or less for self containment which mean that people live and work in the same areas, so in terms of travel to work and we decided to use land use and transport, we tend to use these functional areas, boundaries to build land use and transport interaction model and to build, to select the areas of microsimulation.

And as you can see up here, this is a schism modelling area and the area which was covered aggregate model which was done before and it's much larger, so microsimulation was only part of it.

In terms of the data sources they're quite standard, so we used 1991 and 2001 census of population. We used 1991 sample of anonymised records and the reason for that is that we started in 2004 and the 2001 SARS was not available yet. And we also decided to start from 1991 census and then to run the model forward to 2001 census to see how the model will predict the population compared with census 2001. And the idea was later on maybe to use 2001 SARS as well but it hasn't happened because it was released quite late and we also ran out of budget, etc, and we also realised that it's much limited than 1991 SARS so it hasn't been done.

We also use some other data, some national statistic, British Household Panel Survey and Annual Survey of Hours and Earnings.

And SWISMS or whatever they're called, so simDELTA model can be part of this large system, so, but even if we have a look at this microsimulation model it consists of three parts. First of all it's a study part to design the initial database and it's what other people were talking about Leeds team and today and during the previous seminar as well, and another thing is we actually had to have another starting part when we had to add various tables, various data which were not in census and also dynamic one. And I forgot to mention that this project was completed in collaboration with NVA Consultancy who developed the transport model and also with the University of Leeds who helped with the static part and also Professor Richard ? from the Imperial College London, he helped a lot with his advice on the dynamic part of simDELTA.

And again to remind you of the aggregate structure of DELTA and those boxes in yellow is what we replaced. So instead of now dealing with total number of people in each area and total number of households etc, we're dealing with individuals and we model transitions, cars, location and employment in terms of microsimulation. And we also had to disaggregate some of the data, so for example migration is part of the aggregate package but when people arrive from here, yes from the aggregate model, we only know the total number of people, the total number of households and some other totals, but we don't know anything about them, so we had to simulate some and this is done by finding sort of around the household with similar characteristics from the microsimulation model and simply cloning another household or another individual, etc.

And the model run starts from running the transport model in 1991 or sort of not running but there was some general response actually passed to us estimated by the transport model, so a special run but not in terms of the interaction. And because the base year of the transport model was 2000 so they had to remove some networks and to give results for us for 1991. And then for this particular area, ? accessibilities, we've done as you can see the different processes which were run in the aggregate model, so we run a development regional economic model, car ownership, household transitions, household migration, location in the static model and then we used microsimulation which was run from 1991 to 1992, those samples were passed to the aggregate model and some of those locations etc they were actually updated, so information from here was used and that was the second year so there was a slight …

And two transport models were developed before and then they were used in this way and one of them is a strategic model with about 90 zones and involving aggregate representation of highway and public transport supply and then there is a detailed model which has 570 zones and involving explicit representations of highway links and public transport services.

The first of simDELTA is a static model, so we used a JAVA coded simulated annealing process and we used 91 census and 91 SARS and then output from simulated annealing contains all census variable from the SARS which member of which household, we used one main control table which we put quite significant weight in it and 6 other constraint tables, and then we also done quite a lot of comparison with tables and data which were not constrained and the study is somewhere there but I haven't included this in the presentation. But I think we've ended up with very similar, I don't remember the actual figures and errors but in terms of the aggregate it was almost the perfect fit, but when we have a look at some individual characteristics like tenure again, it wasn't that perfect, so it's a very similar result. And after that we, as I mentioned before we had to take some other characteristics like household incomes and driving licences in particular.

I don't want to talk about simulated annealing process, it was more or less discussed already just keep with the slides. And this is the full list of additional inputs which were added within phase of the static model. We also had lots of problems with student households and shares and how exactly to represent them. We also problems with people leaving together but not married, so it's potential co-habitees and we had to add economic status or wage/income, driving licences and socio economic status and also we had to assign more places for workers in the base here.

And here you can see outwards from the static model. So the static model gets dwelling data, supplies area data, household data, personal data and job data, and I have your slides which simply lead to all sorts of data is output from the model. First of all we have a look at the area data, it has area ID, population, households, families, jobs taken internally by socio-economic group, jobs available internally by social economic groups, jobs taken externally etc, accessibility, deprivation index, so different characteristics of the area and sum totals as well. But if we have a look at the dwelling data, dwelling ID, number of rooms, tenure, area code, dwelling type. But for each dwelling we also know in which area it is, so there is a linkage here.

More complex data for households, even more complex for people, so for households we know their ID, dwelling ID, area ID, so where they live, with whom do they live, in what sort of house, what do they prefer, whether they have mortgage or not and how many years they still have to pay for their mortgage etc and the different sorts of household type. And this model we are talking about 108 household types, starting from young single, older single, retired single and then a young couple, older couple, three plus people with children, without children, couples with children etc. Also they are segregated by four socio economic groups and then they are disaggregated by the number of workers in each activity type. So, and the person data, so we know again in which household they live, therefore we know in which dwelling they live and which area etc, and then we know who else lives in this household, and for this particular person we know their age, sex, relation to head of household, marital status, socio economic group, ethnicity, economic category, work area,

driving licence, and if it's a parent then we know his or her children unless they are not specific relation before 1991, so later on with few children, they appeared with their parents. Then education level, job ID, preferred economic status. So it's really very detailed data, so we had to first of all create it and then all this is available for every single year in the simulation process. And job data much more simple but still job ID, socio economic group, economic status, I think it's here twice, area code, current wage, whether it's vacant or not, and if it's not vacant then we do know who exactly occupies the place.

Then as soon as we created all this static database we start with the dynamic model and with the dynamic model we have different processes, individual demographics, household changes, household vocation, interface with aggregate DELTA and then work related processes. And just to give you an idea again with individual demographic changes we model almost everything you can think of. So it's age, survival, move into institutions, births, multiple births, redundancy, entering labour market, staying in education, leaving/re-entering the labour market, change job or retiring etc, so we can see the full list here.

Then household changes, so student households and other shares, absence from households, separation, couple formation/marriage, household division, household expenditure, housing income, obtaining/losing car.

Then for work related processes, we have job supply, identifying main earner, seeking to change job, wages, accepting/rejecting job/candidate, job and workplace choices. In terms of the dynamics here we do deal with the same individuals, so every single individual is going through these processes, so it's not like we are dealing in 2000, say 1991 with one set of households and individuals and then we forget about them. Somehow jump into 2000 and model and those individuals, no, we start with 1991 with a group of people in Leeds and surrounding areas and we do take them through the times, through all this household, person and job related processes.

One of the main focus of the model was in household location. For household location the model housing stock process, housing prices or rents, household in/out migration, whether the household is seeking to move, housing tenure choice, dwelling choice, location choice and household location/relocation, all this is done at a micro level.

We have to complete the loops of microsimulation as you've seen before is a small part of the whole process, so we have to pass data from aggregate model to microsimulation and vice versa, so in terms of the data which I pass from SWYSM from the aggregate model to microsimulation, those are changes in labour demand and the conversion of aggregate model results for employment into effects on job availability and redundancy. Also deeds and changes in housing supply, which converts aggregate model results for housing development or demolition into addition/removal of dwelling objects and then the conversion of SWYSM forecasts of migration from the rest of the world, so migration is not part of the microsimulation system.

And we also used some other information from the aggregate model as probabilities, for example changes in car ownership. So in microsimulation model we do know which household has a car and which one doesn't, we don't know anything about their car, what car it is or whatever, but we still do know that they have a car or the they don't have a car, and if they have 2 cars we also have this information. In the aggregate model we only know proportions of households in each area having no car, one car or two cars. So from those, if those probabilities proportion change then we can pass this information to the microsimulation and to find out the person who suddenly lost his/her car or suddenly gained another car or their first car. So we had to have this link and pass information to the microsimulation model.

Again we deal with migration as I mentioned before, we have to clone individuals if somebody arrives and if they leave the area then they're simply deleted from the microsimulation system.

A couple of slides about the transport model which was used. The transport model has the base year 2000 and has three time periods, morning peak, inter peak, evening peak and its validated road traffic assignment models for each time period, using SATURN software.

We've done a number of tests with this model but because first of all it was a research project but it wasn't somebody's PhD or it wasn't somebody's research work, it was work for a consultancy so as soon as money ran out, time ran out etc, you have to move to a different project. So we would like to do more on this model but we didn't have a chance. And afterwards wh have done some tests to see whether it makes reasonable forecast reasonable changes in household and

population so we've run this model for about 20 years, it's quite slow in running but as soon as it gets some results it can do lots of analysis, it can trace individuals with any changes, you can trace households. And we also, because this work was with the DfT they were particularly interested in how accessibility would change housing location. And when we discussed the very first test or made some assumptions about the first test, we assumed that we built a new junction around here, so there is a connection from one to another, but we haven't realised that, we can see the transport here, what we hadn't realised is that this test is not significant enough for the microsimulation models. So first of all you have this noise, every time you run the model you can have slightly different outcomes, but the changes in accessibility which were brought as a result of this were really really small, we're talking about 0.19 and so minus 0.5 in percentages, so it's really very small changes. And then when we run the model it didn't produce any significant result there. The test which was designed sort of failed and run instead of, looking at the real policy which could be done in the fututre we've decided just to change accessibility and to see whether it will affect the results with the household who arrive or move from this area and what sort of changes we can get from …

So in this test we've changed accessibility quite significantly, there were, I think it was about, it was between 5 and 20% depending how much we've changed accessibility, still similar yeah but now artificial change as a result of the transport model improvements, and of the network improvements. And depending on how much we've changed those accessibilities and what different results. And as you can see in this case there is a threshold here which is defined by the total number of dwellings particularly. So even if you improve accessibility by 100%, 200%, whatever, households when they're moving, they need to find a vacant dwellings and as soon as all dwellings are occupied, no more households can arrive into that area. This is a completely different result from what you would get from an aggregate model, so the aggregate model will still push or attract more people to a particular area, so you would have a sort of linear growth depending on how much you change accessibility. But in this case it's quite clear that the growth is not linear and there is a saturation level and as you can see 20% and 10% changes in accessibility produce almost identical results in terms of the number of households who move out of this area. And this is the reverse graph so it shows people, this shows other areas from where people move out, so as you can see there are reductions here. So that's what we would expect.

This is our experience with the microsimulation model. Some conclusions. We believe that the present project it did achieve quite a significant step forward. This model is now delivered, not now, it was delivered to the DfT a couple of years ago. Unfortunately nothing has been done with the transport model, even it wasn't installed properly at the DfT, I think it's still somewhere on CDs there. And we are very interested to do more with this but we are very interested to be booked with this or any other research for developing the project. But we're not sure that the model is really suitable for particular policy tests and it would be interesting to see what sort of results we would get from it.

And if you are interested in the report which is available on the DfT website, there is a link here. If there are any problems with downloading we can always send you the report. It consists of a number of parts, one is a technical one and general description of the model and there are some tests, some algorithms and models. And we are grateful to project members and to members of the project steering group for their help and for numerous discussions which we had during this project.

QUESTIONS

Paul Williamson – Thank you very much. Any questions? My question is how long was the timescale for doing the project?

Olga Feldman – I think originally we envisaged like one year or 9 months but we ended up with about 2 years doing it.

Paul Williamson – And how many people were working on it?

Olga Feldman – I think we didn't have a person who worked for 2 years continuously on this project every day, so I was involved in other projects as well, but say no more than one person continuously, if you add up everyone's time.

Paul Williamson – To construct that whole microsimulation model and capture the whole household dynamics and labour force dynamics and car ownership changes. You must have made some simplified assumptions to be able to do all those.

Olga Feldman – Yes, some of them are not that you know sophisticated. In the report we described every single model so you can see what sort of marriage model we used, what sort of divorce model we used, or for example people were selecting their potential, cohabiting potential, wife or husband, so we had to make some assumptions there obviously. So we can't claim that they're the most sophisticated and advanced solutions but they're reasonable and I think they are definitely in line with what other people have done before.

Paul Williamson – What was the feedback from the DfT?

Olga Feldbman – They were quite pleased but I don't know whether they were pleased that we'd finally finished or whether they were please with the output. So we don't know exactly, but I think you can judge from the report. In general yes we got very good feedback from them, but unfortunately they don't use the model which is a negative sign.

David Simmonds – In some sense that is because we argued that it was potentially valuable as a tool for research but because of the issues of noise and so on or what to do to deal with noise arising from the Monte Carlo simulation it wasn't something that was really suitable for adoption as a standard policy testing tool. And given that that recommendation on the one hand and the effort which DfT has been putting into getting even fairly basic conventional aggregate models more widely used where previously they've not been used at all is understandable that they've left this where it is. So we have made some use of it as a means of generating data for use in standard applications such as the project that have been described here. And I think there are further opportunities to do that in the future.

Olga Feldman – And we've analysed results and they do make sense so the outputs which we get from the model they are quite reasonable outputs. There's another example, another test which we did, in which you can look at the distribution. There was a particular ward which was chosen and this was done so it was increasing ? supply of 1000 extra buildings built in 1993. And then just before you can see where changes households populations have arrived and then you can also see distribution like where's that coming from and they do come from the surrounding areas, so it's quite reasonable result there.

Paul Williamson – There's the noise, stochastic noise drowning out the impact of the new motorway junction quite surprisingly, that's quite a major change in accessibility?

Olga Feldman – I think it was, there was, maybe I made a mistake there, maybe it wasn't just a junction, maybe it was extra flares there, no?

David Simmonds – I thought it was just a junction and it was intended to create a very localised, but what we expected to be a significant change in accessibility for that semi rural area, or rural area. I suspect part of the lack of effect was that the difference in travel times was not between, as a result of adding an intersection, it's not as great as we had hoped, and technically without wishing to blame our transport modeling colleagues' for the deficiency of the system, it doesn't pick up any difference in perception between motorway travel and other travel, only the raw difference in travel time which turned out to be very limited. But one of the reasons for doing that was in the hope of showing plausible but convincing results for that one area and I'd probably say what we've had was doing that in a genuine microsimulation with those particular effects was swamped by the stochastic noise in the model. And that was a key point, that was with hindsight the foreseeable one. In conclusion that this would be difficult to use for regular policy making purposes where those kind of impacts would be subject to question of public enquiry.

Olga Feldman – But I think even for the aggregate models the changes were still very small, so this particular case they were really small even to see any real changes, real, in the aggregate model any reasonable changes are marginal because 0. something % in accessibility changes, usually they are maybe 5% or 2 or 3% at least but not 0.5%; the household probably wouldn't notice such a change.

Howard Redway – Can I make an observation from a policy environment? I mean certainly of our policy colleagues are very uncomfortable with doing too much when they just change one policy and to introduce a whole lot of new random numbers. They like to make sure the results appear in two different runs.

Olga Feldman – We've done it, we've created, we can repeat different policies with the same random numbers, this is done.

David Simmonds – That was something which we added very late on the project for exactly the same reason that you mentioned in relation to the tax and benefits …

Howard Redway – Yes, one of the points, it's in the nature of policy makers that they love to just see the pure effect of their policy and not the statistical variation of the model run.

Male question 5 – Isn't that an issue if the policy has some sort of effect at some point and in your sampling of random numbers and after, it may not be an issue for microsimulation, well no but it was, you know your policy will have an effect, your 2 runs are going to diverge, as soon as the 2 runs stop showing the same behaviour whether you are using the same sequence of numbers or not.

Howard Redway – We don't use the same sequence …

Male question 5 – Are you using the same sequence?

Howard Redway – No we're not using the same sequence of numbers, we're ensuring that the same event need to be simulated by the person in the same year into 2 parallel, the same random number was used which is a much tighter criteria than just saying we'll have the same random numbers. But yes they want to say OK these 2 runs is only because of the policy change, the random numbers are the same. They might then want to be repeat several of those parallel lines to see whether they make the same difference. What they don't want is not to be able to see the difference due to the policy without having a large amount statistical variability.

Male question 6 – What in effect this is doing is removing any element of variation due to the order in which the households or the individuals or the tax units are processed in the sample, so that the fact that you may have done something which requires one additional number near the top of the sample doesn't modify the choice you made earlier on.

Howard Redway – Exactly yes, it has an effect yes.

Michael Murphy – The choice of primary numbers is very sensitive to that choice, whatever you do, reflecting is random noise and presumably you always need to do enough runs to reduce the amount of stochastic variability with like you said the underlying model, and so then you get the…

David Simmonds – Yes I didn't mean to suggest that doing, running this with or without a motorway intersection with the same sequence of random numbers would be sufficient. What you would need to do would be to do each of those tests maybe 30 times, the usually quoted number, with and without each ? test using the same sequence, and you'd still have to average the variability within that.

Michael Murphy – The thing should not be sequenced, it is very difficult problem I think, that if the order in which the things model might be important in ....

David Simmonds – If you naively start off using a simple random number generator and take the numbers as they come out, then if your policy change introduces one more decision that uses you know ? number then all of a sudden the position changes.

Male question 9 – If your policy doesn't change anything then yes you would expect that, so you draw an extra random number of your policy and then if the policy doesn't change anything then yes, the same sequence of random numbers thereafter should generate the same model with or without the intervention. But as soon as the policy has an effect then to me it doesn't matter whether you're withdrawing the same numbers or not, it only matters for those individuals or those cases where the policy has had no effect at all on what's available on the behaviour of the system. So if there's any exogenous driving variable for example in the samples you use, then yes that needs the same sequence of random numbers and you should make sure they're the same, but I don't think that's affected by policy, whether or not it uses the same random numbers is neither here nor there.

Howard Redway – What you want to avoid is the situation where you introduce a policy where one person takes that decision about whether they should join a pension scheme or not. Everybody else's mortality, fertility rate changes because some other outcome potentially changes ….

Male question - … that's if there are exogenous driving rules? but let's say that decision does affect someone's mortality then …

Howard Redway – Well we haven't got the mechanism in there that doesn't ?? and you wouldn't want it to.

Male question – I agree with you if anybody else in the sample finds themselves making a decision by a different set of alternatives or in the subsequent year somebody's making the same decision in a different location, then there is no reason why the that should be a problem and what we tied to do in the end was to make sure that we could control it so that if the same household or the same person was making the same decision in the circumstances then we could control the random number stream.

Male question – Well I guess in an agent based model if someone's decision is affected by someone else's decision, it's affected by someone else's decision which was affected by policy then you know this is the problem with interaction, then it doesn't matter, even if you know they're in the same situation, they're not in the same situation I suppose because they are being influenced by the agents around them, those agents have done something different. So as soon as you have an effect on policy, the problem goes through the simulation, for any variable that is affected by that change …

Edumnd Chattoe-Brown – It's actually quite revealing about microsimulation because the idea that somebody takes a new pension decision say and then that upsets all the mortality decisions, the fertility decisions, in a sense it doesn't because the point is those are just supposed to be distributions and in the model it doesn't matter whether it is agent a or agent b, so why worry about? It matters in the real world, you can't have a situation where according to some random variable a completely different person, but in simulation it doesn't matter so long as there are 14 marriages.

Howard Redway – But it does matter if the events go into people and therefore they go into households.

Olga Feldman – Yeah for example someone moved from a particular dwelling and then a completely different household arrived with children and from a different area and then (interrupted)

Male question – Yeah but these are all reasonable distributions on sample populations, you're not tracking real population. On average 57 people moved out of Sunderland, maybe not the same 57 people but what do we mean by the same …

Howard Redway – A lot of what the policy may want to do is say OK you've changed this policy, how many people gain from that, how many people are losing …

Male question – Sure but that's an aggregate, it's not, you're not saying this family.

Howard Redway – No they didn't, no matter how many people gain, you've got to make sure that outcomes in your 2 simulations, one with the policy and one without, don't affect, aren't affected by …

Gary Polhill – This can happen in agent based modeling as well, one of the earlier versions of the artificial stock market, a famous simulation had a dividend which was an external driving variable for the investment choices of agents and if you, if an agent makes, because they sampled from the same distribution for the dividends as they did for when the agents were making choices, an agent's choice can affect the dividend by affecting the random number sequence. So if you wanted to compare 2 runs you wanted a separate sequence for the dividend because you wanted the dividend to have a consistent time series over time, because that's an exogenous driving variable it's not affected by the dynamics of the model, you don't want changes in decision making of the agents to affect the time series of the dividend. I guess it's the same kind of idea here.

David Simmonds – With the added element that we're trying to look in many cases, or need to look in order to satisfy the client, say for small areas, or for all fairly small samples as I guess in your work you need to look at particular sub samples

of the population. And there's an interesting contrast I think between what we've done in this kind of spatial microsimulation and what has been done at the University of Dortmund where Michael Madum(?) I think some of you will know has developed a model over many years from which we drew a number of ideas, but he has always argued that he's used microsimulation intensively in that and has consistently argued that if you're having trouble with stochastic variation you are looking at the results in too much detail. We are starting from the view that you need to be able to look at the results in detail to convince people that the model is working correctly and that therefore we have to have things like the ability to control the random element, to even see when it applied to the same actor in the same circumstances.

END OF RECORDING