

MODERN SLAVERY AND OTHER TOPICS: SCIENCE IN GOVERNMENT

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It is a great pleasure to be here. I am well aware that the Manchester Statistical Society is even older than the London one, which I was the president of for about three weeks, and I have never been before, so it is really kind of you to invite me.

I was an academic for a long time and then, in 2009, I decided it was time to do something a bit different, so for seven years, I was the Home Office's Chief Scientific Adviser. I thought it might be interesting, first of all, to talk a bit about what the Chief Scientific Adviser does. My job was to provide the Home Secretary, ministers and officials with impartial and expert advice. During the decade before I started, the idea of every government department having a Chief Scientific Adviser took off. There have always been scientific advisers in government and there was always a Government Chief Scientific Adviser, but there was never a CSA in every department.

The job requires you to be the scientific conscience of the department; one former minister described me as the departmental boffin. It is an interesting role, because you have to be able to advise with authority on any scientific topic whatsoever. The Home Office covers crime, migration (which includes both immigration and also the HM Passport Office), and of course, stuff I cannot talk about, like national security and counter terrorism. You could end up in a room where you would be expected to answer a question, but you would not have any resources at all to do it, because you might in a high security area where you are not even allowed to have a mobile phone, so you could not look anything up. Usually you would have prior notice, but on one such occasion, an issue suddenly

came up that I really knew nothing about; all I could do was to ad lib (convincingly I hope) but then to follow up later on with a succinct but better informed brief!

Basically, you live in the department, and you have to interact with whoever you can, and you do not actually see the Home Secretary that often. You have to work with ministers and officials to try and get a bit of rigour and science into what they are doing. Almost always, they are extremely receptive, but it is a matter of making difficult things simple and trying to explain things in a way that will actually land in the right way. It is one of the most important parts of the job.

But I did not do it on my own; I had 500 staff, in many different areas: economists, statisticians, even vets. I had to manage a large group, I was responsible for science and research, and then, of course, I was a member of the government's Chief Scientific Adviser Network. I warn anyone thinking of getting this job, that they used to meet at quarter to eight on a Wednesday morning, so do not do it if you are not a morning person. But those meetings were fascinating because you sat around the table and heard what was going on in other government departments (and contributed your own expertise) and we were one of the only networks who actually worked across different civil service departments. Anyone who has been a civil servant will know that different departments can be quite siloed. But the work was quite international and, in particular, I did a lot of work with the Americans on counterterrorism and I got to know my counterparts in Homeland Security, who were fantastic people and very interesting to work with. On one occasion, my counterpart asked me if I use my networks to find out something about what one of the other US departments was thinking. Silos are not just a British phenomenon.

We also had to foster links to industry, academia, and scientific advisory committees. One of the things I had to do was to broker the advice given on topics like drugs, animals in science, and DNA ethics. I also had to bring my own expertise as a statistician, which is what I will cover in the main part of my talk.

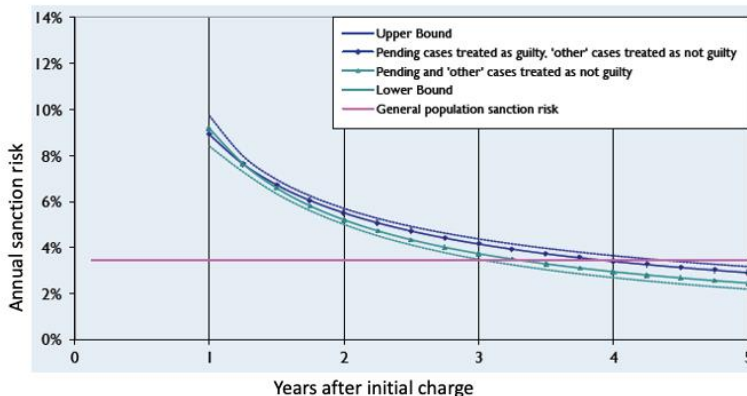
I think we ought to be proud, as a country, that we have this system. I never found any other country I worked with where scientists actually have this level of influence. In nearly every other country, it is too political. While the big-ticket

items will be a matter of policy and what the Government said it was going to do, once you get down below that, there is an awful lot of careful thinking and evidence-based work behind these policies. I hate to say it, but I think the politicians are often more responsive to evidence than some of the officials.

One of my early projects was The Protection of Freedoms Act 2012. It concerned the length of time your DNA profile could be retained if you are arrested but not charged. In 2013, the national DNA database held four and a half million subject profiles. Interestingly, in Denmark, the government holds an actual DNA sample of everybody. We do not do that, but what we do have for those on the database is a DNA profile, which is just a list of numbers. They do not say how tall you are, what colour your hair is, or anything like that, but it is a string of numbers that are unique to you, and if applicable, your identical twin. One in 30 or 40 of the population is a twin and many do not realise the incidence of twins is much higher than people realise. Unless you are an identical twin, you will not have the same profile as anyone else in the world, and this is vital when detecting both high volume crimes, like, burglary, and other serious crimes, like, homicide and rape. It is not about proving someone did the murder, because you have got them in custody already so you can easily take a new DNA sample. Instead, this is about finding someone just from their profile on the database.

When the DNA register was set up, they just arbitrarily put DNA profiles onto it, but the European Court ruled in 2009 that you were only allowed to hold someone's profile if there was a good reason for doing so. So as with many aspects of government, it has to be necessary and proportionate. But what is proportionate? How long is it reasonable to hold a DNA profile of someone who has been arrested, but not actually charged? Ultimately, we went to the police database and looked at the number of people arrested but not charged, and then we worked out the risk that they are subsequently prosecuted. This chart shows the 'hazard rate'.

Figure 1: Arrest-to-sanction hazard rates and general population sanction risk for 'CSA+' offence list



One year later, one in ten of those who have been arrested and not charged, will be arrested again and convicted. However, after just over three years, people arrested but not charged are no more likely to be convicted of an offence than a member of the general public. This was used in the law, so this is an example of a statistical study which led to an actual law.

The graph also shows an odd but crucial trend: the offender line eventually goes below the general population line. When they had the London riots in the early 2010s, there was a shocking statistic released in a paper; three quarters of the people being prosecuted already had criminal records. In fact that isn't at all surprising; most crime is committed by a fairly small number of persistent offenders, and in general the majority of people being prosecuted have criminal records. Think simplistically and imagine the general population as being a mixture of criminals and non-criminals. So, if you arrest someone and do not charge them, they are either a non-criminal or a criminal who just got away with it. As time goes on, the ones who are criminals commit crimes that they are eventually caught for. So, those incorrectly arrested are the ones who cause this decline on the graph.

Three and a half per cent is the conviction rate per person per year of the whole population. Pursuing our very simple model, this includes a mixture of the criminals, who average 50 per cent, and non-criminals, who average zero per

cent, which I am sure includes everyone in this room. I think everyone in this room is at zero because, I hate to say this, most crime is committed by people under 30. So we have had our chance haven't we?

We now move on 'queueing at the border'. At the time of the Olympics, they were very worried that there would be an infinite queue of people at the border trying to get into the country, so they approached myself and my team for help. Now we use e-gates, but this was in the days when humans used to look at passports.

Time gets wasted during queueing for both the passengers at the end of a long queue, and the staff when they are sitting at a desk and there is no queue. Staff time is also wasted by standing people down and putting them back again, especially if you have a Home Office computer, which takes rather a long time to start up when you switch it on because of security issues. Queueing theory says there is a trade-off between these things; in order not to have enormously long queues, you have to have times when the staff are just sitting there. You may mistakenly believe that if people wait ten minutes, then you could halve the number of staff and they would wait 20 minutes. Anyone who has studied queueing theory will know that that is not true. Halving the number of staff could actually turn things from a ten-minute wait to a point where you'd still be waiting ten years later (obviously after a long time building up!) There is no linear relationship. Instead, there is a critical phenomenon with queues, that when explained, is obvious. When people arrive faster than they are being served, the queue just gets longer and longer.

We observed the number of desks open at Heathrow Terminal 4 arrivals for flights from outside the European Economic Area. The blue line on the graph shows there are a lot of desks open early in the morning and the evening, because the flights at Terminal 4 arrive either from America in the morning, or they arrive from Asia in the evening. The passengers from Asia need the most processing, because they are from countries that must have visas. So, there is a high workload in this period, of course outside nine-to-five working hours.

We used this real data and then produced an algorithm that allocated staff to desks with a number of constraints. For example, there should never be more than 12 desks, nor should there be too much "churn" in staff deployment. The

red line on the graph shows the algorithm increasing the number of desks before the big peak, which is important and makes a big difference for wait time for passengers.

Figure 2: Actual and proposed desk allocations

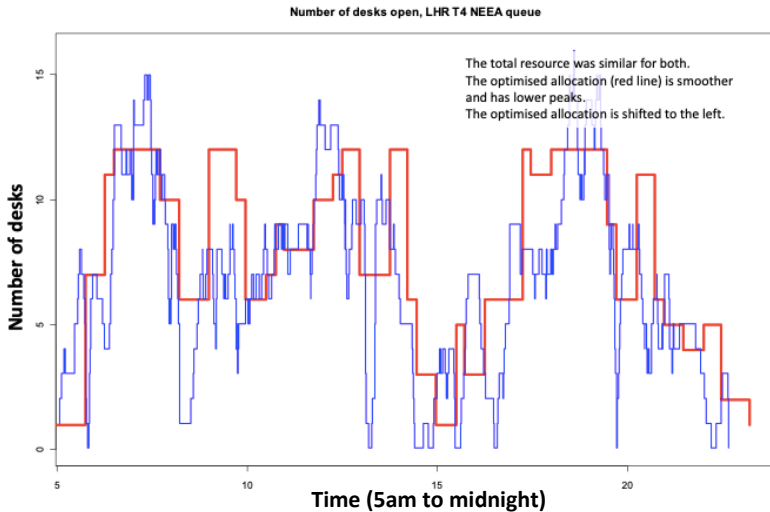
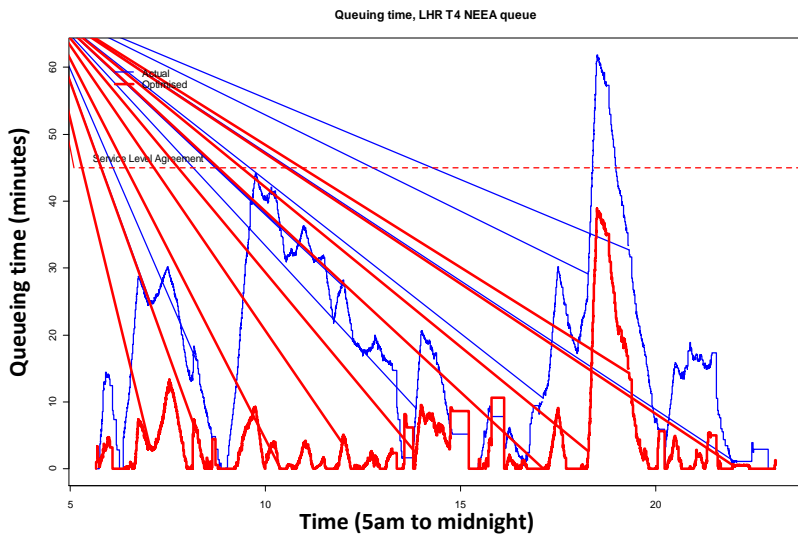


Figure 3: Comparison of the time people have to queue



When comparing the real arrivals data with both allocations, the reduced wait time because of the algorithm, shown with the red line, means the service level agreement, that no one should have to wait for more than 45 minutes, is achieved, and for most of the day there is a dramatic improvement. Nobody has to wait at all except for the big peak in the evening, but even there, it only gets up to about 40 minutes and, furthermore, it dies away quicker.

I will finish with my main topic of modern slavery. I was approached by Theresa May's advisers to help them with the 2015 Modern Slavery Act. They wanted to know how many victims there were likely to be, both so they could make the case for having the act and also understand the effect it might have on crime statistics.

Modern slavery is a whole panoply of different really unpleasant things. It includes debt bondage, domestic servitude, labour exploitation in mining, agriculture, car washes, nail bars, cannabis farms, sexual exploitation and forced prostitution. It has been around forever, and I think it is fantastic that now we all worry about it, because, frankly, we never did and we should have done.

I started my role with a Labour government and I finished in 2017, but without being political, I think one of the major achievements of the last government was the Modern Slavery Act. It is world changing and we were the first country to have an act specifically about this. None of this behaviour was legal, but the act created a single offence, with the potential for life imprisonment, and it said, we take this seriously. At the time, no one really knew about it, but now it is something everybody thinks about and that is a real achievement. I am very proud that the figures we produced went on to form the strategy that launched the act.

We estimated the number of victims by using prevalence estimation. My friend James Cockayne, who works for the United Nations University, said, 'without good data on where slaves are, how they become slaves and what happens to them, anti-slavery policy will remain guesswork'. The Daily Mail reported on our work with the headline, 'UK is home to 13,000 slaves: Home Office says number is four times as many as previously thought'. Prevalence estimation is important for three reasons. The first reason is to raise public and political consciousness, as an impetus for action. The second is to guide the allocation of resources. The

third is to judge the efficacy of interventions and monitor progress. Because if you think there are X number of victims and you are only prosecuting Y number of people, and Y is a lot smaller, then you can reasonably ask, how effective are you being? A more difficult question is whether the number of victims is reducing, because to work this out you have to get accurate data. For many purposes, highly accurate figures are not important. Even approximate figures are useful and I am reminded of the statistician, George Box, who said, 'all models are wrong but some are useful'.

Our current state of understanding modern slavery is extremely partial. Think about climate change; we all have much more understanding of climate change than we did 30 years ago. People had an idea that something was going on, but they did not know much about it, and it is much the same with modern slavery now. As time goes on, I hope that we will learn more.

There is a method called multiple-systems estimation, and it is not a panacea, but it is one of a number of approaches, which I hope will help us build up a clearer picture of modern slavery.

Whatever method is used to find cases, there will be many that are not observed or detected; criminologists call this the dark figure. Wikipedia says the gap in official statistics is larger for the less serious crimes, in other words, crimes like pick-pocketing do not get reported, whereas murders do. All I will say about that is most Wikipedia articles are wrong and some are not always useful, because in a case of modern slavery, it is a very serious crime, and it is often not known about. If you think about a crime like murder, nearly all murders do come to the police's attention and most of them are solved. Modern slavery is not like that at all; there is a very large hidden figure.

In the case of modern slavery, there are many reasons why cases do not come to light. People are very ashamed if they are victims. They often do not want to say, particularly if they are forced into sexual slavery. People are frightened, so even if they escape, they are going to be afraid of the people that originally enslaved them or they may worry about their family back in Albania or Romania, or somewhere. They may not even realise what happened to them; they may just think they were badly treated. They may just be so happy to have run away they do not come to the authorities' attention. Often victims have been forced

into behaviour which it itself illegal. For example, in the United States, where prostitution is illegal, if you are forced into prostitution, you have been forced to commit a crime and a victim can end up being prosecuted. In some cases, sadly, victims may have been forced to tempt others into modern slavery. Finally, if you ask the police, agencies and charities how many victims there are, not all of them will fill in the form, so you will not get complete data. So there are many reasons why cases will not come to light and the same is true of other crimes, like domestic violence.

Mark-recapture is an old method for measuring a hidden population. It was proposed in a paper in 1895 by Petersen as a way of working out how many fish there are in a pond, although it was based on a much older idea. So, imagine you have a pond, and you catch 100 fish and mark them all, and then you throw them all back. A week later, you catch 100 fish again and 20 of the fish are in common. A little bit of arithmetic tells you that there are around 500 fish in the pond; if one in five of the ones you caught before were caught again, then that suggests that there are five times as many as you thought there were, and therefore you would estimate 500. There is an interesting article in the Royal Statistical Society Journal tracing the history of the method back much, much further to the measurement of human populations in the 17th Century.

The Census, which I advise, uses this method, because after they have conducted the Census, they conduct a coverage survey, and then compare the overlap between the coverage survey and the census to estimate the undercount. In Manchester and London, there has been a serious problem with undercount. In the Census context, there are two lists, but the method has been extended to multiple systems estimation, which can deal with several different lists or catches.

In 2013, the National Crime Agency's Strategic Assessment identified 2744 potential victims of trafficking, also known as PVOTs, who have not been through all the legal processes but for our purposes we can consider as victims. We grouped all of the victims into five groups: local authorities; non-governmental organisations, such as charities; government organisations, like the UK Border Force and the Gangmasters and Labour Abuse Authority; police forces; and the general public. The NCA removed the duplicates from this list of individuals and

ended up with 2744 victims, which we could then use as a basis of multiple systems estimation.

Figure 4: Consolidated number of potential victims from NCA Strategic Assessment data

LA	X					X	X	X							X	X	X		
NG		X				X			X	X	X				X	X	X	X	
PF			X				X		X			X	X		X	X		X	
GO				X				X		X		X		X	X		X	X	
GP					X						X		X	X					
	54	463	995	695	316	15	19	3	62	19	1	76	11	8	4	1	1	1	??

My colleague, Olivia Hesketh, sat in the NCA for a month going through every one of the 2744 files de-duplicating the data, and produced this table. So, for example, there are 695 individuals who are known only to government organisations and there are 11 cases who are known to both the general public and police forces and there is one case which is in all four of the top ones, but not the general public. The figure marked ?? in red is the one we want to know, because that is the number which are not on any lists at all and if we can estimate that figure, we get an estimate of the total population.

After building an appropriate mathematical model, we estimated from this data there were 10,000 to 13,000 victims. This suggests that the strategic assessments earlier were aware of about a fifth to a quarter of all of the potential victims. It is only a tentative conclusion because the model is based on assumptions that are sensible, but they cannot be verified, and it uses data that have some limitations. One of the assumptions made is that every case behaves the same statistically and that is obviously not true, because if you have been forced into prostitution, you are more likely to be found in a different way than if you have been forced into block paving. If you segment the population, it will behave differently, but we do not have that information, we only have what we have in the table. The model can take account of, and demonstrate, possible correlations between various sources, for example, cases reported to NGOs are more likely to also be known to police and if the case is reported by the general public, it is less likely to be on a list. You learn more from the analysis than just

a total number, you can learn about interactions between different lists, and so on. So, the analysis gives you a greater understanding of the process.

In order to test sensitivity to some of the assumptions, I repeated the analysis leaving out the general public list and you get more or less the same total. The general public list is a bit flaky and if you leave it out, you get more or less the same answer, which is very encouraging and so that is one of the ways of testing the robustness of the whole method.

The Daily Mail reported on what we did very accurately. They printed the whole press release and they talked about what modern slavery is. Interestingly, I gave a confidence interval of 10,000 to 13,000 and they picked out the top end of that range in their headline: 'UK is home to 13,000 slaves'. I knew they would do that, and I thought that was quite interesting.

The minister, at the time, responsible for this was Karen Bradley, who went on to be the Secretary of State for Northern Ireland, and she gave an interview on the radio and they asked her, why is it you used to think there were 3000 victims and now you think there were 13000? She replied, those were the ones that we knew about and now these are the ones we did not know about. The backstory there is her officials went to her beforehand and explained that we produced this estimate, but it is not actually data on specific cases. Instead, it is based on a mathematical model. She replied, I am a maths graduate; I can imagine exactly what Bernard did! This is an example of the ministers being savvier than the officials. I saw her afterwards, and she said she was ready to start talking about fish and ponds but then they went onto the next question.

In conclusion, there is much more science and evidence in government than is commonly thought. People used to say to me, what on earth has science got to do with the Home Office? I was fascinated, I did not know about it before I went there, but it is an enormous amount. It is not just old-fashioned criminology or qualitative thinking, important though social science is, but hard science, and lots of it very interesting. Although it informs political action, most of my experience is that it is uncontroversial, but getting alongside ministers and officials is very important. Get them to trust you, get them to realise that you will make it interesting for them, and they will pay attention to what you say rather than dismissing your advice as something they don't want to hear.

You never know, of course, when something might be contentious. We had an issue around testing the age of asylum seekers; if you do not know how old they are and they do not know how old they are either, discovering whether someone is 17 or 19 is not really possible using any scientific method. It is not like a tree where you can cut it down and count the rings. The officials had a method which, I hate to say, was not actually very reliable. It was based on dental age or looking at their wisdom teeth, which is impossible to draw an accurate individual conclusion from. It was a very difficult and very contentious case, but I am glad to say that that the analysis has now been published.

The global awareness of modern slavery and human trafficking has really changed in the last 10 years. If you cast your mind back to 2009, most people had never really heard of it. Our own Act made a clear contribution, and so however inaccurate the figures were, it really woke people up. Even the figure of 10,000 to 13,000, which is probably very low, really woke people up to the importance of the issue. People suddenly thought, we have got to do something about this and, not just in this country, but, internationally, there is a lot more awareness. That has been an example where a piece of science, as I hope, has done something which will make the lives of people in a terrible situation better.