EUROSTAT WORKING PAPERS

Investigation of the methods of estimating migrant totals

(3/1999/E/n° 3)

CONTENTS

INVESTIGATION OF THE METHODS OF ESTIMATING MIGRANT TOTALS

1.   Overview

The UK International Passenger Survey (IPS) is a primary source of migration statistics for the Migration Statistics Unit (MSU) of the UK Office for National Statistics (ONS). The process of weighting IPS data to UK totals influences the quality of migrant estimates which the office produces. The survey has been running continuously since 1961 and has been carried out since its beginning by Social Survey Division (SSD) of ONS on behalf of several government clients. The main client for the survey is currently the IPS Branch within the Socio-economic Division of ONS.

There have been a number of changes to both the sample design and the approach to weighting over the years. The weighting methods have grown up over time. The aims of this project are to document precisely how the migrants are weighted; as far as possible to identify why the weighting is done in the way it is and to identify and evaluate improvements which could be made or alternative approaches which could be considered. In addition the report identifies some areas where further research is needed.

The sampling and weighting, which are outlined in the following sections, differ in approach for 'main air' (Heathrow, Gatwick and Manchester airports), 'residual air' (other UK airports included in the sample) and sea/ Channel tunnel. The majority of migrants arrive through the main airports. The report therefore concentrates on the weighting for this group. Throughout the study use has been made of the 1994 data, as this was the most recent available at the time when work began. As there were some problems with the first quarter data, at points in the study estimates have been run using the last three quarters of data only. Several important changes to the sample have been introduced since 1994 and these are described briefly in an Appendix. The available documentation of both the sampling and weighting procedures for these new routes and ports is not complete and it was not possible to follow the empirical approach used in the remainder of this report in order to discover precisely what is done so this is an area where more research would be useful.

2.   Description of the IPS sample

The International Passenger Survey is a continuous survey of air, sea and Channel Tunnel passengers entering and leaving the UK. The IPS covers all except the minor ports of entry and exit to the UK. Figure 1 shows the ports covered by the IPS during 1994.

Figure 1. Airports and seaports covered by the International Passenger Survey in 1994

Main Air

Heathrow	-	Terminals 1, 2, 3 and 4
Gatwick	-	North and South Terminals (including transit channels)
Manchester	-	Terminals 1 and 2

Residual air

Birmingham   -   Main and Eurohub Terminals
Bristol
Cardiff
East Midlands
Edinburgh
Glasgow
Leeds/Bradford
London City
Luton
Newcastle
Stansted

Sea

Dover-Calais   - ferries, hovercraft, Seacat
Folkestone-Boulogne - ferries, Seacat
Newhaven-Dieppe
Southampton, Portsmouth and Poole routes to Cherbourg, Caen, St Malo, Le Havre
Ramsgate-Dunkirk
Ramsgate-Ostend   - ferry, Jetfoil
Plymouth-Santander/Roscoff
Harwich-Hook of Holland/Gothenburg/Hamburg/Esbjerg
Felixstowe-Zeebrugge
Newcastle-Stavanger/Bergen
Hull-Rotterdam/Zeebrugge
QE2
Channel Tunnel freight shuttle

The main UK airports in terms of volume of international traffic are termed 'main air' . These are always included in the sample. The 'residual air' sample contains airports which are reviewed each quarter for inclusion. Their inclusion depends in part on their volume of international traffic. In practice many sites are included every quarter, but for example Edinburgh airport may in some quarters be sampled for arrivals only or be dropped from the sample altogether depending on the traffic. The weighting system differs for main air and residual air.

The 'sea' routes are treated similarly to residual air; they are included or excluded from the sample based on considerations of their international traffic, the type of traffic and the cost of interviewing. In practice many of the sea routes (such as Dover-Calais) are always included in the sample.

The sample has a multistage stratified design. At all the airports a certain number of shifts (am shifts, pm shifts and in rare cases night shifts) are selected randomly each quarter, stratified by am and pm and by weekday and weekend. The sample is balanced across days of the week. In most cases (except small residual airports), separate shifts are run for passengers arriving in the UK and passengers departing from the UK. At most sites, the arrivals flow is sampled at half the rate of the departures flow. The reason for this is that a primary purpose of the IPS is the collection of tourist expenditure information for the travel account of the balance of payments. Expenditure information is collected from informants at the end of their visit, in other words it is collected from foreign residents on departure from the UK and from UK residents on arrival back in the UK. The UK residents are a more homogeneous group and are therefore only sampled half as intensively. This presents a problem for migrant estimates as a primary interest is in foreign residents migrating to the UK, who would of course be sampled on arrival. This feature of the sample is part of the reason for running additional separate migration filter shifts on arrival flows. The passengers at all airports are sampled systematically as they cross an imaginary line, usually just after passport control.

On the sea, the shift differs by port and route. At some seaports passengers are sampled on the quayside as they embark or disembark. The approach here is similar to air; the shift is a time period on a day selected in a stratified random sample. The shift covers several sailings (in the same way as a shift at an airport covers many flights). The passengers are sampled systematically as they cross an imaginary line.

At other sites interviewers travel on the boats. Here brochures are used to list the crossings for a particular route by time of day and crossings are paired into outward and return crossings. A pre-determined number of each crossing pair is selected per cycle (for example one each of a 09.00 Dover-Calais P+O boat linked with a 13.00 return, the 12.00 Dover-Calais Stena boat linked with the 16.00 return and so on). The passengers are sampled systematically. On the Dover-Calais route for example this is done by sampling them at all the entrances to the boat as they board.

The main sample was about 227,000 interviews in 1994. Of these, very approximately, 1,000 were migrant interviews. The Migration Statistics Unit sponsors additional 'Migration Filter

shifts' on the inward (arrivals) flows at the four Heathrow and two Gatwick terminals to boost the sample size of migrants. The interviewer team sizes and the sampling intervals on these shifts are smaller; contacts are asked a brief series of questions to identify whether or not they are migrants, and only migrants are given a full interview. These shifts yield approximately another 1,000 migrant interviews.

At Heathrow Terminals 3 and 4, there is a 'Port Health' Channel on arrivals. This is just the last in the line of immigration desks on arrivals. Certain groups of passengers are directed to this desk and there is a higher probability of sampling migrants at this desk than at the others. For this reason, three types of shifts are run at Heathrow terminals 3 and 4; ordinary shifts covering both the non-Port Health and the Port Health channels; migration filter shifts covering the non-Port Health and Port Health channels and migration filter shifts covering the Port Health Channels only. Appendix 2 gives more detail of the definition of the channels at Heathrow Terminals 3 and 4 for the purposes of weighting.

Figures for the numbers of migrant contacts, weighted contacts and simple sampling errors by main air terminal, residual air and sea are given in Table 1. The MSU formula for simple sampling errors is given in Appendix 1. The definition of a migrant used for tables in the work is not quite the standard definition as it includes the category 'Don't know how long will stay in the UK/abroad, possibly 12 months'. The figures given in the table should not be quoted.

Table 1. Migrant flows by main air terminal, residual air and sea 1994

PORT NUMBER AND DESCRIPTION	INBOUND MIGRANTS			OUTBOUND MIGRANTS		
	CONTACTS	WEIGHTED CONTACTS	STANDARD ERROR	CONTACTS	WEIGHTED CONTACTS	STANDARD ERROR
1 LHR T1 ORD. SHIFT	20	7288	1684	43	15493	2517
2 LHR T2 ORD. SHIFT	31	11916	2464	47	16435	2491
3 LHR T3 ORD. SHIFT ORD CHANNEL	140	28841	2592	341	55957	3232
4 LHR T4 ORD. SHIFT ORD CHANNEL	68	15747	2465	155	25331	2155
5 LGW SOUTH ORD.	46	21775	3384	51	19835	3099
6 MCR T1	12	7883	2511	8	4135	1519
7 LGW NORTH ORD. SHIFT	22	10044	2284	35	14380	2601
8 LHR T3 PH MFS	160	7330	598			
9 LHR T3 PH ORD SHIFT	75	3752	449			
10 LHR T3 ORD CHANNEL MFS	212	14701	1065			
11 LHR T4 PH MFS	75	4523	576			
12 LHR T4 PH ORD SHIFT	35	3370	676			
13 LHR T4 ORD CHANNEL MFS	62	5260	697			
14 LHR T1 MFS	16	3977	1039			
15 LHR T2 MFS	38	9305	1681			
16 LGW SOUTH MFS	27	6022	1201			
17 LGW NORTH MFS	10	2061	698			
18 LGW NORTH NIGHTS	1	403	403			
19 LGW SOUTH TRANSITS				2	1654	1248
20 LGW NORTH TRANSITS						
43 MCR TERMINAL 2	15	8620	2430	15	6854	1840
44 LHR T3 PH ONLY MFS	327	14784	880			
45 LHR T4 PH **ONLY** MFS	87	4991	546			
TOTAL MAIN AIR	1479	192593	7786	697	160074	7159
RESIDUAL AIR	26	21388	4949	11	10199	3397
SEA	60	58824	8343	48	45941	7393
TOTAL	1565	272804	12439	756	216213	10837

Key:
LHR - London Heathrow airport, LGW - London Gatwick airport, MCR - Manchester airport,T1 - Terminal 1,T2 - Terminal 2,T3 - Terminal 3,T4 - Terminal 4

ORD - Ordinary (either shift or channel), MFS - Migration filter shift, PH - Port Health channel, PH ONLY - a shift running on the Port Health channel only (i.e. no simultaneous shift on the corresponding ordinary channel)

3. Weighting the 'Main Air' sample

Figure 2 shows the stages of weighting for main air. Migrant contacts receive the weights which are shaded. Non-migrants receive all the stages of the weighting. (Weight 2 applies to residual air and sea contacts and is hence not shown). IPS data are weighted by quarter, port and direction of traffic. The initial weights are supplied by SSD to the IPS Unit. The subsequent stages of weighting are carried out by the IPS Unit.
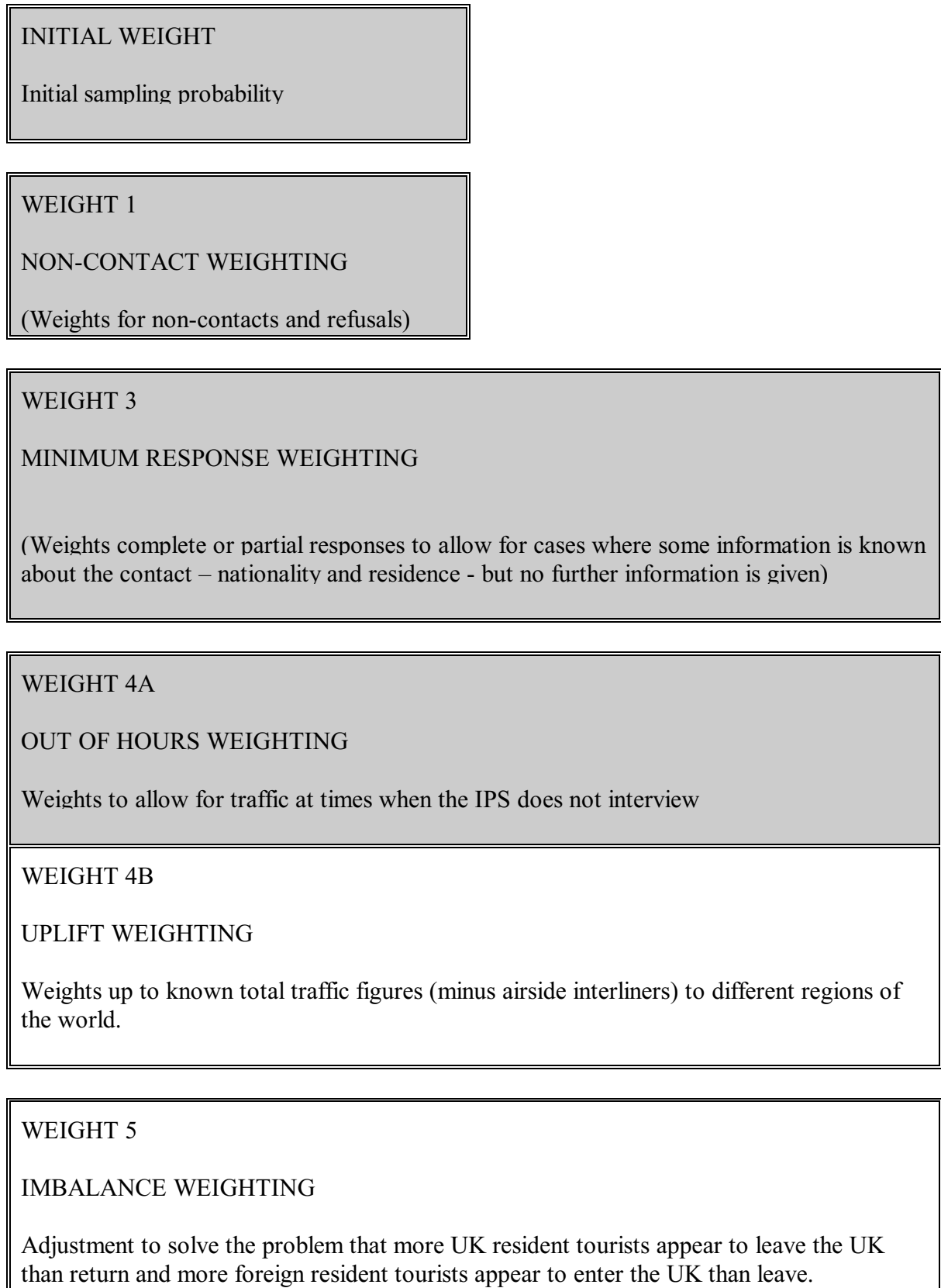
Main air contacts receive an initial weight. This is basically the inverse of the probability of selection within the sample. The precise calculation of this weight differs by three categories of site. The study identified an inconsistency in the calculation of these weights. This will be discussed in the next section.

The main air sample is next weighted for non-response and non-contacts (Weight 1). Non-respondents on ordinary shifts on the survey are categorised by the interviewers into:

i)   UK nationality
ii)   Other EC nationality
iii)   EC but don't know whether UK nationality
iv)   Foreign nationality (non-EC) and
v)   DK nationality

People in these groups are assigned as either 'UK nationality' or 'foreign nationality' and contacts on the database within the same port, month and weekday/weekend group are weighted to account for the non-contacts and refusals.

Figure 2.   Weighting the IPS sample - Main Air

INITIAL WEIGHT

Initial sampling probability

WEIGHT 1

NON-CONTACT WEIGHTING

(Weights for non-contacts and refusals)

WEIGHT 3

MINIMUM RESPONSE WEIGHTING

(Weights complete or partial responses to allow for cases where some information is known about the contact – nationality and residence - but no further information is given)

WEIGHT 4A

OUT OF HOURS WEIGHTING

Weights to allow for traffic at times when the IPS does not interview

WEIGHT 4B

UPLIFT WEIGHTING

Weights up to known total traffic figures (minus airside interliners) to different regions of the world.

WEIGHT 5

IMBALANCE WEIGHTING

Adjustment to solve the problem that more UK resident tourists appear to leave the UK than return and more foreign resident tourists appear to enter the UK than leave.

On migration filter shifts the weighting at this stage accounts for non-response and non-contacts as above and also for non-migrants encountered in the shift. The non-response is treated in a similar way to non-response on ordinary shifts. Information on the nationality of the non-migrants is collected during the filter stage. This is finally categorised into 'UK' and 'foreign' nationality and non-migrant contacts on the 'ordinary' shifts at the same terminal in the same time period are weighted to account for these contacts.

The weighting at this stage was traced through for a selection of terminals and time periods and appeared to be correct.

The third stage of weighting is for 'minimum' contacts. Complete and partial responses are weighted up to allow for cases where some information is known about the contact - nationality and residence - but no further information is given. This again has been traced for a selection of ports. The approach used by the IPS unit is iterative. On the first iteration the attempt is made to assign the weights for 'minimum' contacts to contacts with the same nationality and residence within the port, direction and quarter. The majority of cases are assigned this way. In cases where there is no match the second stage is to assign them across a slightly wider weighting group. Weighting groups appear to be constructed by first merging across nationalities but keeping residence unmerged, then if necessary merging across residence as well. It appears that the only formal criterion for merging groups is that an empty group is reached, although it is possible that some consideration is given to the size of the weights.

The majority of cases are assigned during the first iteration. Examples of cases assigned at the second iteration are:

Passport/residence	Assigned to:
Spain passport USA resident	Group of: Ireland/Holland/Denmark/Germany passport USA resident
Israel passport Germany resident	Group of: Turkey/Croatia passport Germany resident

The approach to weighting at this stage seems reasonable.

The weighting up to this stage should result in the production of an unbiased estimate of the total number of migrants arriving and departing from the UK through 'main air' terminals within the hours of the survey. The main omissions from a complete national estimate for main air are:

(i)   night-time arrivals and departures
(ii)   omissions resulting from migrants who for some reason do not cross the IPS counting lines.

With the exception of the reservations over the treatment of the initial weight at sites where two types of shifts are being run (ordinary shifts and migration filter shifts), the weighting seems appropriate and contains no consistent cause of bias.

There are three further stages of weighting of IPS data in general, only one of which currently applies to migrants. These stages are more problematic.

Main air contacts are weighted for out-of-hours traffic. This allows for traffic at times when the IPS does not interview. On most sites, at most times of the year there is no night-time interviewing (between the hours of 11.00pm and 6.00am). This is the first part of Weight 4 (termed Weight 4A in the study). This concludes weighting for migrants.

Non-migrants receive two further weights. In the second part of Weight 4 (termed Weight 4B in the study) they receive a form of post-stratification. The contacts are weighted up to 'known' total traffic figures supplied by the Civil Aviation Authority (CAA), after an adjustment has been made to remove 'airside interliners' from the figures, for flights to and from different regions of the world, within each port and terminal. ('Airside interliners' are passengers who transfer between international flights and who do not pass through UK immigration. They do not technically enter the UK and are excluded from both the IPS sample and the target population. They are however included in the traffic figures collected by the CAA and an adjustment has to be made to remove them). The reasons for the original decision to exclude migrants from this weighting have not been documented. The quality of this weighting and the case for and against applying it to migrants is considered below.

Weight 5 is an adjustment for 'imbalance' in the sample. A consistent problem over the years has been that the survey results have implied more foreign visitors arriving in the UK that departing from the UK and more UK visitors leaving the UK than arriving back. An adjustment is made for this for non-migrants. This is discussed more briefly below.

4. Initial weighting

The initial weight accounts for the different sampling probabilities. It is calculated in three slightly different ways at different ports.

Method (i)   Used at all sites where only one type of shift is run. This includes all terminals for departure shifts and Manchester [1]Terminals 1 and 2 for arrivals shifts. At these sites there are no migration filter shifts.

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[1] Migration filter shift have since been introduced at Manchester on arrivals

Method (ii)   Used at sites where two types of shifts are run on the same passenger flow. This includes all sites where there are ordinary shifts and migration filter shifts - arrivals shifts at Heathrow Terminals 1 and 2, Gatwick terminals and on the ordinary channels at Heathrow Terminals 3 and 4.

Method (iii)   Used on the Port Health Channels on Heathrow Terminals 3 and 4, where three types of shifts are run on the same passenger flow. The shifts are: ordinary shifts; migration filter shifts (run simultaneously on the ordinary and Port Heath Channels); and migration filter shifts (run on the Port Health Channel only).

For all three methods separate values of the initial weight (IWEIGHT) are calculated within each quarter for:

(a)   Weekdays in month 1
(b)   Weekdays in month 2
(c)   Weekdays in month 3
(d)   Weekends

Method (i) is the simplest method. The weights are calculated as:

$$IWEIGHT = \frac{N}{X} * Y$$

(1)

Where:

N = maximum possible number of shifts in the time period

X = shifts run in the time period

Y = sampling interval within shifts

Thus for example for weekdays in October 1994 at Manchester Terminal 1 arrivals, 3 shifts were run at a sampling fraction of 1 in 25. There were 42 possible shifts on October weekdays (21 days each with one possible am and one possible pm shifts). IWEIGHT took the value of 350. The weight is the reciprocal of the probability of selection for each contact.

For method (ii)

The formula for the weight on the ordinary shift is:

$$IWEIGHT = \frac{N}{X_o + X_m} * Y_o \tag{2}$$

and on the migration filter shift is:

$$IWEIGHT = \frac{N}{X_o + X_m} * Y_m \tag{3}$$

Where the notation is as above and:

X_o = number of ordinary shifts run in time period

X_m = number of migration filter shifts run in time period

Y_0 = sampling interval within ordinary shifts

Y_m = sampling interval within migration filter shifts

This method of deriving the weight is inappropriate though perhaps understandable, particularly if the filter shifts were introduced after the main shifts. Clearly the probability of selection for each person in the population does not depend on the type of shift in which they were actually selected, as is implied here. While the estimate of total migrants at the port produced by these weights will be unbiased, these weights do not reflect the true probabilities of selection of the contacts.

For method (iii) (on the Port Health Channels) extending the notation, suppose we sample:

X_o out of a maximum possible N ordinary shifts at a sampling fraction of 1 in Y_o

X_b out of a maximum possible N Migration Filter shifts (running on both ordinary and Port Health Channels) at 1 in Y_b and

X_p out of a maximum possible N Migration Filter shifts (running on the Port Health Channel only) at 1 in Y_p

The weight on all contacts in these shifts is:

$$IWEIGHT = \frac{N}{\dfrac{X_o}{Y_o} + \dfrac{X_b}{Y_b} + \dfrac{X_p}{Y_p}} \qquad \textbf{(4)}$$

The weight here is easily interpreted as the reciprocal of the probability of selection of a passenger passing through the Port Health Channel.

While both methods result in unbiased estimates of total migrants, it can be shown that, since extra variation is being introduced to the weights in method (ii), method (iii) results in smaller sampling errors. As the difference in sampling intervals in the different types of shift is not large, and only a proportion of migrants is affected, the effect should be small. A small reduction in simple sampling errors was found when the weights were recalculated for 1994 data.

It is recommended that the calculation of initial weights at sites currently using method (ii) is replaced by the equivalent of the formula for method (iii).

5.   Out of hours weighting

Out of hours weighting accounts for passengers who travel from each of the main terminals at times when interviewing does not take place. Typically the interviewing times of the am and pm shifts cover from between 6.00 am and 7.00 am to between 8.45 pm and 11.00 pm. Times vary by arrivals and departures and by airport and terminal depending on flight times, but stay constant within a quarter. Times are the same on migration filter shifts at a terminal as they are for ordinary shifts and are the same at Heathrow terminals 3 and 4 on the Port Health Channels as they are on the ordinary channels.

The CAA supply the IPS Unit with figures on passengers who travel during times when interviewing does not take place. An allowance is made for the delay between passing through immigration (where passengers are usually interviewed in the IPS) and flight arrival and flight departure times.

During each interview interviewers note the origin or destination of the flight which the contact has taken or will take, using the flight number and the day's flight list.

Contacts at each terminal are grouped into 7 regions of the world by flight origin or destination. The out of hours traffic is grouped into the same 7 regions. The contacts are then weighted within each region to account for the out of hours traffic. Irish Residents are excluded from this stage of the weighting. The 7 regions are shown in figure 3.

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Figure 3.   Regions used in out of hours weighting

Group	
1	Europe (including all former USSR)
2	Africa
3	Pacific (incl. Australia and New Zealand) and Asia (Exc. Hong Kong)
4	Middle East, South America and other
5	Hong Kong
6	Japan
7	North America

As might be expected, out of hours weights can vary considerably between different region groups at each terminal.

The treatment of out of hours weighting at terminals where only one type of shift is run is straightforward. The weight accounts for the total out of hours traffic within the group, direction and quarter. On arrivals at the four Heathrow and two Gatwick terminals more than one type of shift is run at each terminal. At Heathrow Terminals 1 and 2 and the two Gatwick terminals, both ordinary and migration filter shifts are run. At Heathrow Terminals 3 and 4 ordinary shifts and migration filter shifts are run on the ordinary channels. Ordinary shifts, migration filter shifts (which cover both ordinary and Port Health channels) and migration filter shifts (which cover the Port Health channel only) are run on the Port Health Channel.

In deciding the best form of the out of hours adjustment, one would ideally have some prior information on the nature of the traffic in the out of hours shifts, in particular on the relative probability of migrants entering the countries on these flights compared to the probability of their entering on flights within the same groups during the day. In practice we have no prior information. In these circumstances it may well be that the best assumption one can make is that the probability of finding a migrant during the day is the same as at night within each group. It is also possible that the set of regions used for out-of-hours weighting is sub-optimal for migrants and that one would do better by splitting off those countries that have produced larger numbers of migrants in the past. This is something that should be looked at in more detail.

More serious though is the current differential treatment of migrants identified in different types of shift. It is clearly the case (see last section) that there is no difference between a migrant who happens to have been selected on an ordinary shift at a port and a migrant who has been selected during a migration filter shift at that port so that these migrants should be treated equally in the weighting.

The current practice is to divide the CAA out of hours traffic between ordinary and migration filter shifts at a port or channel using earlier weights and non-contacts. On ordinary shifts

migrant and non-migrant contacts within the same group receive the same weight. The weights for Heathrow Terminal 3 are shown in Table 2 below. The first two sets of weights, for the Ordinary Channels, correspond to the two types of shift distinguished in method (ii) for the initial weights, and the last three sets of weights correspond with the three shift types distinguished in method (iii) for the initial weights. The weights on migration filter shifts are generally lower than for the corresponding groups on ordinary shifts. The migrants on the Port Health Channel only migration filter shifts currently receive no out of hours weighting.

Table 2. Out of hours weights for Heathrow Terminal 3 arrivals. Quarters 2, 3 and 4 1994

Region group	'03' Ordinary Channel - ordinary shift			'10' Ordinary Channel Migration Filter shift			'09' Port Health Channel ordinary shift			'08' Port Health Channel migration filter shift on both ordinary and Port Health			'44' Port Health Channel – Migration Filter shift on Port Health Only		
	Q2	Q3	Q4	Q2	Q3	Q4	Q2	Q3	Q4	Q2	Q3	Q4	Q2	Q3	Q4
Europe	1.02	1.03	1.05	1.05	1.01	1.04	1.02	1.04	1.08	1.01	1.02	-	1.00	1.00	1.00
Africa	1.04	1.03	1.05	1.01	1.01	1.02	1.07	1.08	1.11	1.00	1.01	1.02	1.00	1.00	1.00
Pacific	1.12	1.14	1.24	1.02	1.02	1.04	1.21	1.32	1.36	1.01	1.01	1.03	1.00	1.00	1.00
Middle East, South America & other	1.01	1.00	1.07	1.00	1.00	1.03	1.02	1.00	1.10	1.00	1.00	1.01	1.00	1.00	1.00
Hong Kong	1.21	1.71	2.43	1.03	-	1.42	1.13	1.34	1.74	1.01	1.04	-	1.00	1.00	1.00
Japan	1.00	1.00	1.03	1.00	1.00	1.01	1.00	1.00	1.03	1.00	1.00	1.01	1.00	1.00	1.00
N. America	1.01	1.00	1.04	1.00	1.00	1.05	1.01	1.01	1.11	1.00	1.01	1.02	1.00	1.00	1.00

Table 3. Revised out of hours weights for Heathrow Terminal 3 arrivals all channels, quarters 2, 3 and 4 1994

	Q2	Q3	Q4
Europe	1.02	1.03	1.06
Africa	1.04	1.05	1.07
Pacific	1.15	1.19	1.27
Middle East, South America & other	1.01	1.00	1.08
Hong Kong	1.16	1.44	2.03
Japan	1.00	1.00	1.03
N. America	1.01	1.01	1.06

Table 3 shows the revised weights for Heathrow Terminal 3, using a simple assumption that the probability of a migrant travelling on an out of hours shift is the same as on a day time shift, within each group, quarter, terminal and direction. As the weights for migrants selected on filter shifts are increased on this assumption, estimating the total weighted migrant count at Heathrow using these revised weights results in a 6% increase in the estimated migrants arriving at Heathrow Terminal 3 during the three quarters of data.

Although the assumption of equal proportions of migrants in in-scope and out of hours traffic may not hold exactly and further research in this area may produce a better model, there can be little justification in retaining the current approach.

It is recommended that a single set of out of hours weights be produced as outlined above for each combination of time of day, region, quarter, terminal and direction. It is also recommended that alternative regional breakdowns be investigated.

6. Uplift

Table 4. Uplift weights - quarters 2, 3 and 4 1994

Route	Arrivals			Departures		
	Q2	Q3	Q4	Q2	Q3	Q4
1 LHR T1 ORD. SHIFT	1.08	1.12	1.13	1.11	1.14	1.16
2 LHR T2 ORD. SHIFT	1.07	0.84	1.13	1.00	0.93	0.94
3 LHR T3 ORD. SHIFT ORD CHANNEL	1.07	1.08	1.11	1.17	1.18	1.16
4 LHR T4 ORD. SHIFT ORD CHANNEL	1.11	1.09	1.04	1.15	1.19	1.12
5 LGW SOUTH ORD.	1.04	1.04	1.00	1.02	1.03	1.09
6 MCR T1	0.99	1.00	1.03	1.07	1.03	1.09
7 LGW NORTH ORD	1.17	1.09	1.16	1.06	1.05	1.03
8 LHR T3 PH MFS	1.07	1.08	1.11			
9 LHR T3 PH ORD	1.07	1.08	1.11			
10 LHR T3 ORD CHANNEL MFS	1.07	1.08	1.11			
11 LHR T4 PH MFS	1.11	1.09	1.04			
12 LHR T4 PH ORD	1.11	1.09	1.04			
13 LHR T4 ORD CHANNEL MFS	1.11	1.09	1.04			
14 LHR T1 MFS	1.08	1.12	1.13			
15 LHR T2 MFS	1.07	0.84	1.13			
16 LGW SOUTH MFS	1.04	1.04	1.00			
17 LGW NORTH MFS	1.17	1.09	1.16			
18 LGW NORTH NIGHTS			1.16			
19 LGW SOUTH TRANSITS				1.02	1.03	1.09
20 LGW NORTH TRANSITS				1.06	1.05	1.03
43 MCR TERMINAL 2	0.99	1.00	1.03	1.07	1.03	1.09
44 LHR T3 PH ONLY MFS	1.07	1.08	1.11			
45 LHR T4 PH ONLY MFS		1.09	1.04			

Table 4 shows the uplift factors for calendar year quarters 2, 3 and 4 of 1994. The total passenger figures by terminal (or airport in the case of Manchester) to which the IPS is weighted are supplied by the Civil Aviation Authority to the IPS unit. An allowance is made

for 'airside interliners', passengers who transfer from one international flight to another, without passing through UK immigration. Such passengers appear in the raw CAA figures, but are excluded from the IPS sample and population. The interliner adjustment is based on percentages derived from a survey carried out approximately once every 5 years by the CAA. (But since 1996 it has become annual.)

The uplift weighting is intended to serve two functions. First, it is know that the IPS sample will systematically miss certain categories of visitors, for example at some sites escorted VIPs do not cross the sampling lines. In addition in some cases injured or handicapped patients may not cross the line and it is suspected that some other categories such as military personnel may not always cross the line. It is possible, although there is no certain knowledge, that a small number of migrants may also not cross the line. In addition new channels are occasionally opened at the sites, for example transit passengers may take a separate route. While any such channel with a significant number of passengers would be sampled by the survey, there may be a slight delay in beginning sampling after the opening of the channel. The uplift factor accounts for these missing contacts by weighting existing contacts uniformly within quarter, direction and terminal to the uplift total.

The second function of uplift weighting is to correct for the sampling variability in the estimate of total passengers.

On the whole one might expect the factors to be fairly close to 1. In fact the factors vary considerably by terminal, direction and quarter. In some cases (for example Manchester Terminal 2 arrivals), all three quarters were close to one. In other cases, the factors were very high, for example on Heathrow Terminal 4 departures they ranged between a 12% and 19% uplift.

Table 5 shows the effect on migrant estimates and estimates of simple sampling errors of using the uplift factors, based on data from quarters 2 to 4 of 1994.

Table 5. Estimates of migrants and sampling errors, using weights with and without uplift factors. Main air sample, quarters 2 to 4 1994

	Contacts	Weighted contacts (weights exclude uplift)	Sampling error	Percentage sampling error	Weighted contacts (weight includes uplift)	Sampling error	Percentage sampling error
Inflow	1183	155199	7069	4.6%	164157	7333	4.5%
Outflow	548	127854	6464	5.1%	142128	7031	4.9%

It is clear that inclusion of the uplift factors would have an impact on migrant estimates. Using the three quarters of data, the effect would be a 6% increase in the estimate of inflow migration (foreign residents coming to the UK to live here for 12 months or more) and an 11% increase in outflow migration (UK residents leaving to live abroad for 12 months or more).

The case for using these factors for migrant estimates depends on the underlying reasons necessitating the correction. It is not clear given the likely causes of the underestimation why the uplift factors are as large as they are at some sites. While weights excluding the uplift factors might slightly underestimate the migrant estimates (and there are gains in terms of sample precision of post-stratification using known passenger figures), there is a danger that the estimates using the weights including uplift could overestimate migrant flows.

More up-to-date data on interliners from a recent series of CAA surveys has become available since this part of the study was completed. These surveys still use some potentially slightly biased sampling methods and also extensive imputation of the interliner question so the validity of the estimates is questionable, although they are believed to be an improvement over past estimates. This data suggests that some of the previous estimates of the numbers of interliners were too low and therefore that the true populations were lower than indicated. The average uplift weights from 1997, incorporating the latest interliner data are shown in Table 6.

Although these show a general movement towards unity, there are still one or two large anomalies that cannot be adequately explained by the factors discussed above. In particular the uplift factors applied to departures from Heathrow Terminal 3 are exceptionally large, and this flow represents some 26% of all outbound migrants. Similarly the factor of 1.17 applied to departures from Heathrow Terminal 2 in Quarter 2 is exceptionally high but in this case may be due to an error earlier in the weighting process. Any weight differing markedly from unity at this stage should be questioned but the reasons for the consistently large Heathrow Terminal 3 departure weights in particular should be investigated further .

Table 6. Average Uplift weights – 1997

	Arrivals				Departures			
Route	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1 LHR T1 ORD. SHIFT	1.09	1.05	1.00	1.00	1.06	1.05	1.03	1.07
2 LHR T2 ORD. SHIFT	1.00	1.17	1.03	1.05	1.08	1.03	1.06	0.99
3 LHR T3 ORD. SHIFT ORD CHANNEL	1.03	1.10	1.11	1.09	1.15	1.19	1.16	1.08
4 LHR T4 ORD. SHIFT ORD CHANNEL	0.95	0.95	0.97	0.94	0.93	0.99	0.99	0.92
5 LGW SOUTH ORD	1.05	1.07	1.01	0.95	1.07	1.09	1.03	1.07
6 MCR T1	1.00	1.02	1.01	1.01	1.10	1.02	1.01	1.10
7 LGW NORTH ORD	1.22	0.99	1.01	1.25	0.91	1.05	1.01	1.01
8 LHR T3 PH MFS	1.03	1.10	1.11	1.09				
9 LHR T3 PH ORD	1.03	1.10	1.11	1.09				
10 LHR T3 ORDCHANNEL MFS	1.03	1.10	1.11	1.09				
11 LHR T4 PH MFS	0.95	0.95	0.97	0.94				
12 LHR T4 PH ORD	0.95	0.95	0.97	0.94				
13 LHR T4 ORD CHANNEL MFS	0.95	0.95	0.97	0.94				
14 LHR T1 MFS	1.09	1.05	1.00					
15 LHR T2 MFS	1.00	1.17	1.03	1.05				
16 LGW SOUTH MFS	1.05	1.07	1.01	0.95				
17 LGW NORTH MFS		0.99	1.01					
43 MCR TERMINAL 2	1.00	1.02	1.01	1.01	1.10	1.02	1.01	
44 LHR T3 PH ONLY MFS	1.03	1.10	1.11	1.09				
45 LHR T4 PH ONLY MFS	0.95	0.95	0.97	0.94				

The effect of applying these uplift factors would be to increase incoming migrants by 3% and outgoing migrants by 5%, making the net change a fall of 3000, or 5%.

Despite the reservations about the quality of the CAA data and the lack of complete understanding of the reasons for some of the high uplift weights, on balance there is a case for applying the uplift weights to migrants in future. First, there is a clear risk that without this, the numbers will underestimate the true figures because of the reasons identified above. Secondly the effective post-stratification should reduce the sampling errors of the estimates. And finally it creates an opportunity to correct for any errors that have slipped through from all the previous steps in the weighting process. **However, further research should be undertaken into the reasons for the high uplift weight on departures at Heathrow Terminal 3.**

It is recommended that migration statistics include the uplift weight, 4b in future.

7. Imbalance

The IPS has long had a problem whereby once the stages of weighting from IWEIGHT to WEIGHT4 are applied to the survey data, more UK residents are identified as leaving the country than returning and similarly more foreign residents are identified as entering the country than leaving. The 'imbalance' appears to apply particularly to some countries.[2]

The overall imbalance can only be detected for tourists, as for this group we would expect that over a period departures would approximately equal arrivals for UK nationals and separately for foreign nationals.

There have been a number of investigations of imbalance over the lifetime of the survey. While many hypotheses have been put forward as to the causes of imbalance, none of these has on close examination been found to explain it.

While the existence of the problem is clearly of concern for the migrant estimates, it is felt that while little is understood of its origins, no correction should be made to the migrant estimates to account for it. This should however be kept under review.

8. Weighting the residual air sample

This description of the weighting was largely taken from survey documentation except that where this was insufficiently precise, data from quarter 4 1994 were examined. The description applies to 1994 data except where explicitly stated.

Sampling at residual airports is determined by the numbers of international passengers using the airport each quarter, according to figures supplied by the Civil Aviation Authority (CAA) each year. Those with fewer than 50,000 international passengers (excluding flights to and from Ireland) in a quarter (based on the previous year) are not sampled. Sampling fractions within shifts are based on practical considerations. Where possible passengers are sampled at 1 in 10 within shifts, but at higher flow airports or in quarters with higher flows the sampling fraction may be reduced to 1 in 20 and additional shifts run. Overall sampling probabilities are set depending on CAA passenger figures. The shifts in the quarter 4 1994 set sample are shown in Table 7.

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[2] For a discussion of imbalance see 'Overseas travel and tourism' pp. 354-5. Trade and Industry 25 May 1979, updated May 1987.   HMSO

Table 7. Residual airports – numbers of shifts and sampling intervals

Residual airport	Sampling interval within shifts	Number of arrival shifts	Number of departure shifts	Probability of selection
Birmingham main terminal	1:10	4	4	0.0022
Birmingham Eurohub	1:10	4	4	0.0022
Bristol	1:10	2		0.0011 (arr.)
Cardiff	1:10	1 (all day)		0.0011 (arr.)
East Midlands	1:10	4	4	0.0022
Edinburgh	1:10	1 (all day)		0.0011 (arr.)
Glasgow	1:20 arr. 1:10 dep.	8	4	0.0022
Leeds/Bradford	1:10	1(all day)		0.0011 (arr.)
London City	1:10	2	2	0.0011
Luton	1:20	8	8	0.0022
Newcastle	1:20	6	6	0.0016
Stansted	1:20 arr. 1:10 dep.	10	5	0.0027

Except where explicitly noted shifts last half a day, denoted as either am or pm. There is no night-time sampling at residual airports. The column headed 'probability of selection' gives the design probability not taking into account out of hours traffic. The general approach to setting shift numbers is given in Table 8.

Table 8. Sample design for residual airports

International passengers per quarter	No. shifts per quarter by direction	Sampling interval	Probability
420,000 or more	6 (3 am 3 pm)	20	0.0016
300,000 – 419,999	8 (4 am 4 pm)	20[3]	0.0022
150,000 – 299,999	4 (2am 2 pm)	10	0.0022
100,000 – 149,999	2 (1 am 1 pm) arr.[4]	10	0.0011
50,000 - 99,999	1 (all day) arr.	10	0.0011
Under 50,000	Zero		

It can be seen that where sampling takes place the set probabilities of selection (not taking into account out of hours traffic) fall into one of four classes: approximately 1 in 1000 (arrivals only) for the smallest airports (in terms of international traffic flow), approximately 1 in 500 for the medium sized residual airports, and about half way between these for the

---

[3] In some airports of this size a sampling interval of 1 in 10 is practicable and is used, with an adjustment to the number of shifts.
[4] At airports with fewer than 150,000 passengers, arrivals only are sampled.

largest residual airports. The exception is Stansted with a selection chance of about 2.7 in 1000. The weighting of selected passengers differs considerably from that of the 'main air' sample and is generally much cruder. The stages of weighting are shown in Figure 4. The shaded stages apply to migrants sampled at residual airports.

Figure 4. Weighting the IPS sample - Residual Air

INITIAL WEIGHT

Initial sampling probability. In practice this is set to 1 for each residual air case (other than at Stansted).

WEIGHT 1

NON-CONTACT WEIGHTING

Weights for non-contacts and refusals. In practice this is set to 1 for each residual air case (other than at Stansted).

WEIGHT 2

GROSSING TO CAA TRAFFIC FIGURES

Weights up to CAA traffic figures for broad groups of airports

WEIGHT 3

MINIMUM RESPONSE WEIGHTING

Weights complete or partial responses to allow for cases where some information is known about the contact – nationality and residence - but no further information is given.

WEIGHT 4A/4B OUT OF HOURS AND UPLIFT WEIGHTING

An overall uplift factor appears to be used.

WEIGHT 5

IMBALANCE WEIGHTING

Adjustment to solve the problem that more UK resident tourists appear to leave the UK than return and more foreign resident tourists appear to enter the UK than leave.

Considering the stages of residual air weighting in turn.

Initial weight

For residual airports the initial weight is set at 1 apart from at Stansted where contacts are split between Sunday and Non-Sunday. Non-Sunday traffic has the initial weight set to 1 but the Sunday traffic has a calculated initial weight based on (Sunday traffic)/(Sunday contacts). All Stansted Sunday contacts for a single quarter will thus have the same initial weight.

The failure to correct for the differing selection probabilities between the various residual airports creates a bias which will overstate the numbers of migrants through the medium to large airports and understate the numbers through the small airports. As the number of migrant contacts through the residual airports is currently very small this bias is unlikely to have a significant impact on the migrant estimates at present.

Weight 1

All residual air contacts have a Weight 1 value set at 1 with the exception of Sunday contacts at Stansted. Weight 1 is a correction factor to allow for non-contacts and refusals during a shift. Thus the assumption here is that response rates are the same at all residual airports. Once again although this assumption is unlikely to be valid, the impact of failing to correct for the true response rates on migrant estimates is unlikely to be large at present.

Weight 2

This weighting is a simple inflation from the sampled contacts (weighted sampled contacts at Stansted) to the actual passenger movement statistics, supplied by the CAA. Luton and Stansted contacts are weighted to passenger movement figures for their own airports. Other residual airports are grouped. A figure for the maximum permissible weight is set, the default is 2,000. Initially weights are calculated for each residual airport in the sample by direction as the:

 (CAA figure for traffic for that port in that direction)/(number of contacts for that port and direction).

By examining these weights the airports are then grouped into high, low and possibly middle weight groups. The calculated weights are abandoned and instead an average weight is calculated for each contact within each group as:

$$\frac{Total\ traffic\ for\ all\ residual\ airports\ including\ unsampled}{Total\ traffic\ for\ sampled\ residual\ airports} * \frac{Total\ traffic\ for\ group}{No.\ contacts\ within\ the\ group}$$

If the average weight for the highest weight group is greater than the maximum permissible weight, the average weight for the highest group is set to the maximum and the weight for the medium weight group adjusted to compensate. This would in theory be done iteratively, with the weight for the medium weight group being checked to see whether it exceeded the maximum and the same procedure carried out for the lowest weight group if it did.

Alternatively the maximum permissible weight could be adjusted.

In practice Weight 2 in quarter 4 1994 appears to have been capped at 2,000 on departures but the value for the highest group was 2,389 on arrivals.

Respondents interviewed at Stansted on Sundays are weighted as part of the Main Air weighting. Non-Sunday traffic receives a Weight 2 value to weight it up to CAA Stansted non-Sunday passenger movements by direction.

The grouping of airports/terminals in quarter 4 1994 is shown in Figure 5.

Figure 5. Weight 2 values and groups in quarter 4 1994

Departures:

Airports in Group	Weight 2
Stansted	1.19 – 770.44
Luton	911.79
East Midlands Birmingham Eurohub	913.02
Birmingham Main Glasgow	1055.39
Newcastle London City	2000.00

Arrivals

Airports in Group	Weight 2
Stansted	1.43 – 6.41
Birmingham Eurohub	606.00
Luton	765.68
Birmingham Main East Midlands Glasgow	1055.39
Bristol Edinburgh Leeds/Bradford Newcastle Cardiff London City	2388.85

Although the weighting done at this stage corrects for the overall sampling fraction and response rates and to some extent the groups used reflect the different probabilities of selection, there is no attempt to reflect differences in response rates for different airports nor

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any variation in out-of-hours traffic. Residual airports differ considerably in the type of traffic they attract (e.g. UK vs. foreign) some being essentially UK charter airports and others having significant amounts of non-UK business traffic. The capping of the weights, although reducing the variances of estimates, will introduce a further bias. The impact on migrant estimates of all these weaknesses in the methodology is still likely to be very small because of the small numbers of migrants passing through the residual airports. However, should these flows ever increase, these weaknesses could have an impact on migrant estimates. Consequently to avoid the need for continuous monitoring and the problem of misunderstandings when staff change, **it is recommended that a properly calculated set of initial probability weights and non-contact weights should be introduced for the different airports and flows.**

Weight 3

This stage of weighting is for 'minimum' contacts. Complete and partial responses are weighted up to allow for cases where some information is known about the contact - nationality and residence - but no further information is given. The process is the same as for the Main Air minima. This concludes the weighting for migrants on residual air.

Weight 4

There are two stages of Weight 4, out of hours weighting and uplift to known traffic totals. The first does not apply to contacts on residual air. In quarter 4 1994 there was a small adjustment to non-migrant contacts as Weight4B. It is possible that this was the adjustment (nominally part of Weight 2) to take account of non-sampled airports.

Weight 5

Imbalance weighting is applied to non-migrants at residual airports in a similar way to imbalance weighting for main air contacts. The problem at residual airports is however less than at main airports and the correction factors are thus small.

9.   Weighting the sea sample

Sampling of sea passengers differs from sampling of air passengers in that passengers travelling on certain routes, rather than using certain entry/exit points. are sampled. The routes covered consist, in general, of those carrying around 500,000 passengers a year although routes with fewer passengers may be included for specific reasons. For example, the sample covers some of the less busy routes out of Newcastle in order to pick up Scandinavian traffic. Volumes of traffic on all routes are monitored year by year and decisions taken annually, based of cost effectiveness, on the inclusion or exclusion of individual routes.

Probabilities of selection once established are seldom changed. In general, they vary between about 1 in 400 (0.0025) and 1 in 960 (0.0011).

The sea sample is weighted in a similar way to residual air, however the level of disaggregation in the (Weight 2) weighting to known traffic flows is far greater for sea than

for residual air.

Thus weighting to traffic totals is currently carried out for both the residual air and the sea sample but not for the main air sample.

The stages of sea weighting are shown in Figure 6.

Figure 6. Weighting the IPS sample - Sea

> INITIAL WEIGHT
>
> Initial sampling probability. This is set to the within-shift sampling interval for each sea case.

> WEIGHT 1
>
> NON-CONTACT WEIGHTING
>
> Weights for non-contacts and refusals. In practice this is set to 1 for each sea case.

> WEIGHT 2
>
> GROSSING TO DETR TRAFFIC FIGURES
>
> Weights up to DETR traffic figures for port/route and direction

> WEIGHT 3
>
> MINIMUM RESPONSE WEIGHTING
>
> Weights complete or partial responses to allow for cases where some information is known about the contact - nationality and residence – but no further information is given.

> WEIGHT 4A/4B OUT OF HOURS AND UPLIFT WEIGHTING
>
> Not used for sea - see WEIGHT 2

> WEIGHT 5
>
> IMBALANCE WEIGHTING
>
> Adjustment to solve the problem that more UK resident tourists appear to leave the UK than return and more foreign resident tourists appear to enter the UK than leave.

Initial weight

For sea weighting the initial weight is the sampling interval within a shift. Thus only part of the sampling probability is allowed for in this weight.
It is recommended that the initial weight be extended to account in full for the probability of selection of both shifts and passengers within shifts

Weight 1

Weight 1, the non-contact weighting, is not used for sea records. The value of Weight 1 is 1 for all sea cases. For most sea routes the response rates are close to 100% but for a few where the sample of arrivals are interviewed on the quayside, response rates are lower. As migrants from the sea sample make up some 22% of arrivals and 21% of departures, biases introduced by ignoring variations in response rates could be significant.

It is recommended that Weight 1, accounting for different response rates by route/port be introduced for weighting migrants from the sea sample.

Weight 2

Weight 2, the sea route weighting, depends on whether the contact was arriving in or departing from the UK, whether he was on foot or with a vehicle, and which port /route or port/route group he used. The total number of passengers on a particular route is obtained from shipping statistics supplied by DETR. As foot passengers and car passengers are sampled differently the DETR totals are split on routes with both foot and car traffic. This is done on a route by route basis taking an average of the observed sample split over the last three years. Traffic from routes which have not been sampled is attributed to similar routes, increasing the weighting given to contacts on these routes.

Where the weight for a port/route (group) is very high, the ports are amalgamated. The default maximum permissible weight is 2,500. The amalgamation process is repeated until the weights are judged to be satisfactory. In practice there is very little additional aggregation of routes for this weighting. The only aggregation in quarter 4, 1994 was of some of the North East Coast routes and of Southampton/Portsmouth routes to France with other, longer South coast routes to France and Spain.

If there were no amalgamation of ports and no weight capping, use of Weight 2 would compensate for the partial omission of the initial weight and Weight 1. However, although there is little grouping and weight capping at present, this may happen more in the future if new routes are introduced or passenger numbers on existing routes dwindle. So to avoid the need for future reviews of the weighting system, it is recommended that the initial weight and Weight 1 be calculated in a complete and consistent way in the three groups of strata, rather than relying on the population control totals to correct for these differences in the smaller flows. However it is important to continue to apply Weight 2 to the sea sample as this will improve precision. It is also recognised that routes may need to be aggregated in producing this weight, for example when the number of sailings in the set sample is small and some are subsequently cancelled or to avoid excessive weights.

Weight 3

The weighting for minimum contacts is similar to that for air. This concludes the weighting for migrants on sea.

Weight 4

The two stages of Weight 4, out of hours weighting and uplift to known traffic totals do not apply to contacts on sea (as they have already been taken into account in Weight 2*).*

Weight 5

Imbalance weighting is applied to non-migrants on sea routes in a similar way to imbalance weighting for air contacts.

10. Summary and Recommendations

The methods used to weight the data from the 1994 IPS to produce estimates of international migrants are described in detail and some anomalies identified. Where there have been changes to the sample design and weighting methods since the study began in 1994, these are noted but not described in detail.

The sample is divided into three main groups of strata, the main airports, the residual airports and the sea ports and routes. A common structure of 7 separate steps (see Figures 2, 4 & 6) is used in deriving the weights used in this survey, although not all steps are used in the three main groups and some are combined on some routes. In practice, data from the main airports are treated differently from the other routes – here the weighting of migrants does not include a control to traffic totals whereas in the other strata it does. The imbalance weighting is not currently used at all.

Methods of weighting the data from this survey have developed over time and, perhaps as a consequence, are inadequately and sometimes inconsistently documented. In deriving this description of these methods, we have relied mainly on empirical evidence from the data itself, backed up with written documentation and discussion with colleagues in the IPS production units.

We recommend the following changes to current practice. The first three are likely to have the largest impact on migration estimates and should be introduced first. Although we have attempted here to assess their individual impact in some specific cases, it will be important to measure their combined impact before proceeding to a full implementation. Reasons for these changes are given in the relevant sections.

Higher priority changes

a) It is recommended that the calculation of initial weights in the main air sample at sites running ordinary and migration filter shifts (or 3 types of shift) on the same flows be calculated from the joint probabilities of selection (page 11)

b) It is recommended that in the main airports, a single set of out of hours weights be produced for each combination of time of day, region, quarter, terminal and direction and applied consistently to all types of shift. Further research is recommended on the best choice of regional groups (page 16)

c) It is recommended that migration statistics include the uplift weight (Weight 4b) in future. However further research is needed into the reason for the unusually high weight on departures from Heathrow terminal 3 (page 18)

d) As is currently the cases, the final weight, for imbalance (Weight 5) should not be applied to migrants unless the reasons for this imbalance become clearer (page 19)

Lower priority changes

e) It is recommended that properly calculated initial weights and a non-contact weights (Weight 1) be introduced for the individual airports and flows in the residual airports group (page 24).

f) It is recommended that properly calculated initial weights and non-contact weights (Weight 1) be introduced for the individual ports/routes and flows in the sea sample (page 26).

APPENDIX 1

Simple and complex sampling errors for migrant estimates on the IPS

Results in this paper have been calculated using an approximate method. Earlier work carried out within Social Survey Division indicated that the design factors for migrant estimates on the IPS are low compared with those for visitors and expenditure, and that the simple formula for migrant sampling errors is a reasonable approximation.

For each individual i in the sample, we measure a variable z_i where

z_i = 1 if the person is a migrant
        = 0 otherwise

Associated with each individual is a weight w_i where this is the weight up to and including the out of hours weighting.

Assume the total inbound sample size is n.

The total number of migrants entering the UK is estimated from the inbound sample as:

$$t = \sum_{i=1}^{n} w_i z_i \tag{5}$$

and the simple variance is estimated as:

$$var_{MSU} = \sum_{i=1}^{n} w_i^2 z_i \tag{6}$$

The simple sampling error is the square root of this.

APPENDIX 2

Arrival shifts at Heathrow Terminals 3 and 4

The aim of this appendix is to clarify possible reader confusion over arrival shifts at Heathrow Terminals 3 and 4.

Three types of shifts are run:

(a)   Ordinary shifts which cover both the ordinary and Port Health Channels, where both tourists and migrants receive complete IPS interviews.

(b)   Migration filter shifts which cover both the ordinary and Port Health Channels, where only migrants receive complete IPS interviews.

(c)   Migration filter shifts which cover the Port Health Channel only.

For weighting purposes the ordinary and Port Health Channels are considered separately.

Referring to the port numbers in Table 1, consider arrival shifts at Heathrow Terminal 3. The diagram below shows the port numbering in relation to the three types of shift.
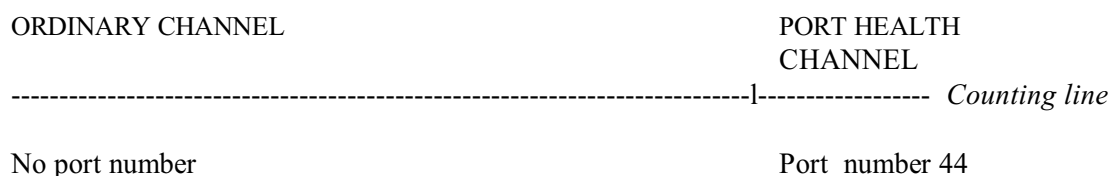
Shift type (a)

ORDINARY CHANNEL   PORT HEALTH
                                                                                                            CHANNEL
--l------------------ *Counting line*

Port number 3   Port number 9

Shift type (b)

ORDINARY CHANNEL   PORT HEALTH
                                                                                                            CHANNEL
--l------------------ *Counting line*

Port number 10   Port number 8

Shift type (c)

ORDINARY CHANNEL   PORT HEALTH
                                                                                                            CHANNEL
--l------------------ *Counting line*

No port number   Port number 44

APPENDIX 3. Additions to the sample since mid-1994

There have been several additions to the sample since mid-1994: the Channel Tunnel Shuttle routes, including the Eurotunnel Freight Shuttle and the Tourist Shuttle, the Channel Tunnel Eurostar Passenger Rail Services and the Flight Connection Centre at Heathrow airport. Also migration filter shifts were introduced at Manchester airport in 1998. Documentation of the weighting and, in some cases, the sampling on these routes and ports is limited so this part of the paper should be treated as an outline only. It has not been possible to check the steps used to derive the weights by following actual cases through the data – so the description should be treated as tentative.

Eurostar Passenger Rail Services

Eurostar passengers - both arrivals and departures - are interviewed at Waterloo station and, since its opening, at Ashford station. Sampling and interviewing of passengers is similar to air terminals. At Waterloo the sampling interval is higher on arrivals than on departures. 14 a.m. and 14 p.m. shifts are selected each quarter, spread evenly over the days of the week. At Ashford the sampling intervals are lower but fewer shifts are selected each quarter. It is not clear whether the selection probabilities are equal in Waterloo and Ashford.

The weighting of Eurostar records is similar to that of residual air. The initial weight is set to the sampling interval within a shift and Weight 1 is set to 1 for Eurostar records. At Weight 2 the records are inflated to the actual traffic volumes of the separate Eurostar routes.

Weight 3, to account for minima, is applied. This concludes Eurostar weighting for migrants.

Weights 4A and 4B are not used. Imbalance weighting, Weight 5, is applied in a limited way.

Eurotunnel Freight and Tourist Shuttles

Sampling on both the Freight and Tourist Shuttles differs somewhat from other routes. On the Freight Shuttle passengers gather together in a seating area and can be counted before interviewing begins. The sampling fraction used depends on passenger volume:

Number of passengers	Interval
1-11	1
12-20	2
21-28	3
29-40	4
40+	5

Shuttle trains do not follow a reliable timetable and the number of trains run is not fixed in advance, so interviewers work to shift times, taking the first available Shuttle after the beginning of the shift, the next available Shuttle back and so on until they have completed two

journeys out and two back. Night shifts are included.

Tourist Shuttles have two kinds of rake, single-deck and double-deck, each of which consists of 12 wagons and two loading/unloading wagons. Single-deck rakes carry high vehicles such as coaches, caravans and high cars while double-deck rakes take ordinary cars and motorbikes. Ordinary cars are allowed on single-deck rakes if there is space. Most tourist Shuttle trains consist of one rake of each kind though some may have two of the same kind or one rake only. The sample currently is a sample of rakes rather than trains. From 1998, the passenger Shuttles have been sampled with fixed sampling fractions of 1 in 15 for daytime shifts between 06.00 and 20.00 and 1 in 10 for night shifts outside these times.

Eurotunnel is aware of the numbers of vehicles of different types travelling on the Shuttles, but does not have administrative information on the numbers of passengers carried. For this reason a vehicle occupancy survey is conducted, from which estimates of the average occupancy of different vehicle types are produced and thus passenger numbers by vehicle type.

For Shuttle records an initial weight is calculated based on the sampling fraction within the Shuttle and the number of single and double deck rakes selected for the sample compared to the number run by Eurotunnel in the quarter. This is calculated separately by am/pm and night and by Monday to Thursday and Friday to Sunday. This represents the sampling fraction.

Weight 1, accounting for non-contacts and refusals is applied for the Shuttles.

Weight 2 inflates the sample to the estimated total passenger numbers, using the information obtained from the Vehicle Occupancy Survey.

Weight 3, to account for minima is the final stage of weighting for migrant records.

Flight Connection Centre

Passengers in transit between domestic flights arriving at or departing from Terminal 1 at Heathrow and international flights arriving at or departing from any of the four Heathrow Terminals may use the Flight Connection Centre rather than passing through immigration control at the terminal of the international flight. Interviewing takes place in the corridors between Terminal 1 domestic flights and the Flight Connection Centre. Respondents are assigned to one of 4 terminals according to the source of their international flight. These passengers are part of the main air sample and for many purposes in the weighting are treated in the same way as passengers passing through immigration control at these international terminals.

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