

Predicting the stability of non-EU+ long-term international migration estimates

Method for predicting the stability of non-EU+ long-term international migration (LTIM) estimates, with supporting revision analysis, to provide a probabilistic revision range for the current estimates.

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1 . Main points

- As part of the transition to administrative-based migration estimates (ABMEs), our long-term international migration (LTIM) estimates have been subject to revisions.
- In this methodology, we focus on the stability of our non-EU+ LTIM estimates; stability is the degree of change in the estimates over time because of revisions.
- We aim to introduce precocity error as a quality metric that measures the difference between the preliminary and the latest revised non-EU+ LTIM estimates.
- We explore how modelling revisions can provide information to users on the stability of current estimates, through predicting a probabilistic revision range based on the trend and pattern of previous revisions.
- To support our model specification and conceptual framework, we provide a revision analysis that evaluates the predictive accuracy, bias and variance in the estimates that have been subject to revisions; we also outline the reasons why revisions are made to our non-EU+ LTIM estimates and their impact.

2 . Overview of long-term international migration estimates

The Office for National Statistics (ONS) produces timely long-term international migration (LTIM) estimates. However, there is a trade-off between producing timely estimates and the need to revise the estimates. As additional information on migrants' behaviour becomes available, we gain a more complete picture of migration activity and this leads to estimates being revised. The stability of our estimates can also be affected by quality improvements, by incorporating additional data or methodological changes.

We focus on the stability of our non-EU+ LTIM estimates in this methodology. Stability is the degree of change in estimates over time that is associated with revisions.

Our LTIM estimates are currently accompanied by uncertainty intervals, which inform users that our estimates come with uncertainty. The uncertainty intervals aim to quantify some of the doubt associated with the estimates. Our current [simulation-based approach](#) focuses on the uncertainty associated with the adjustments made to the LTIM estimates, which is one source affecting the stability of our non-EU+ LTIM estimates. However, the approach does have some limitations.

This methodology explores the possibility of providing alternative accompanying intervals for our non-EU+ LTIM estimates, by focusing on revisions and predicting the stability of our current estimates. Our alternative approach models precocity error as a quality metric.

Precocity error measures the extent to which preliminary estimates differ from our latest revised estimates. Precocity error prediction intervals will capture more sources that affect the stability of the estimates, as outlined in our [International migration research, progress update: February 2025 article](#). This will provide more information to users by indicating a plausible range within which the estimates could be revised. The accompanying prediction intervals will be based on the multiple sources affecting the revisions of estimates, whereas our previous simulation-based approach only attempts to quantify uncertainty associated with adjustments.

Our assumption is that by analysing revisions, we can quantify the size and direction of revisions. This will allow us to predict a range around the current estimates that will reflect a likely scale of future revisions.

Aim of this analysis

In this methodology, we will:

- outline the causes of revisions in official statistics and in our non-EU+ national LTIM estimates, differentiating between regular revisions and methods and data source improvements
- explain the impact of revisions to our non-EU+ LTIM estimates and present the results from our revisions analysis, focusing on predictive accuracy, bias and variance in estimates
- introduce the conceptual framework for modelling of revisions by outlining how we aim to use precocity error as a quality metric
- explore the feasibility of modelling revisions made to our non-EU+ LTIM estimates, with the aim of predicting a plausible revision range for the current estimates to give users additional information on the stability of the current estimates

Our revision analysis focuses on the stability of estimates. It is not an assessment of the accuracy of our LTIM estimates.

When focusing on the stability of estimates:

- high stability is the closeness between the initial estimate and the revised estimates
- low stability is a substantial shift between the initial estimate and revised estimate

Accuracy assesses the closeness of estimates to the true value and potential sources of error, which would therefore require a different research approach and the use of different methods.

Scope of this methodology

Throughout this methodology, we focus on non-EU+ national LTIM estimates only. We do not consider EU+ or British national LTIM estimates because of ongoing transformation research, as described in our [International migration research, progress update February 2025 article](#). Asylum and resettlement-based LTIM estimates are produced using different estimation processes and are also not considered in this methodology.

Concept and definitions

We use the United Nations (UN) definition of a long-term international migrant. This means we need to wait for 12 months of travel data to confirm people's long-term migration status.

The EU+ nationality category includes all current EU countries, in addition to Norway, Iceland, Liechtenstein and Switzerland. British nationals are not included in these numbers. The non-EU+ LTIM estimates refer to the sum of the rest of the world, including the rest of Europe that are not included in the EU+ category.

Data sources

It is helpful to have background information on the estimation process for non-EU+ estimates to understand revisions in our LTIM estimates. We outline some of the data sources and methods we use in this subsection.

For non-EU+ national LTIM estimates, we use Home Office Borders and Immigration (HOBI) data. HOBI data are produced by combining information on an individual's visa and travel into and out of the country, using passport information. We assign a long-term international migrant status based on the derived length of stay in or outside the UK.

To provide timely estimates, we publish an estimate of migration around five months after the reference period. We do not have complete travel information available when we publish LTIM estimates, so this means we must make assumptions and use temporary adjustments. We then update the initial estimates once we have the complete 12 months of travel data. Further information is outlined in our [Publication schedule for admin-based population and migration statistics methodology](#).

Users should note that when referring to adjustments for non-EU+ estimates, we refer to the early leaver's adjustment for immigration and re-arrivals adjustment for emigration.

The early leaver's immigration adjustment is applied to avoid overestimation, because of an assumption being made to accommodate for individuals whose arrival occurred within 12 months preceding the end of the data period. We use their visa end date as a proxy for a future departure date, as we do not have the data to estimate a long-term stay of 12 months or more.

The emigration re-arrivals adjustment is applied because the system records emigrants as long-term migrants if their visa has ended and they do not return to the UK within 12 months. Some of these individuals are classified as long-term emigrants and may return later to the UK for another long-term stay.

3 . Causes of revisions

In this section, we categorise the different types of revisions in official statistics. We then briefly outline the long-term international migration (LTIM) process for non-EU+ estimates to explain why we revise our estimates.

Revisions in official estimates

We differentiate between revisions and corrections of errors according to our [Revisions Policy and Correction of Errors Policy](#).

Revisions are usually scheduled updates to previously published statistics, analysis or data that improve quality by incorporating improved methods, additional data sources, or statistics that were unavailable at the point of initial publication.

According to the policy, there are situations in which revisions are required to ensure data quality and to certify that estimates align with the [Code of Practice for Statistics](#). Revisions can generally either be because of changes in data or methods.

Revisions may occur when further data become available because of:

- incorporating data into estimates that were not available at the time of the initial publication
- benchmarking, where short-term statistics can be benchmarked against higher quality data sources when they become available and when appropriate adjustments can be made

Revisions can be required because of changes to methods or systems, including:

- new methods or improved methodology and additional data
- statistical index rebasing, because either individual component items have been re-evaluated and the “weight” attributed to each item has changed, or the reference period has been updated

Corrections of errors are unplanned revisions that occur when mistakes have been identified in published statistics. Corrections are viewed as an improvement to data quality. We aim to correct an error as soon as mistakes are identified, following best practice and our revisions policy. We do not cover corrections of errors in this methodology, and focus instead on our non-EU+ LTIM revision analysis.

Revision to long-term international migration estimates

Our current LTIM estimates are released following a schedule that outlines the process for regular revisions to these estimates. Regular revisions include:

- provisional estimates, which are based on the earliest available data to produce estimates; these estimates are released around five months after the reference period
- six-month revised estimates, which are based on obtaining more detailed data or new available information (for example, new travel data giving a more complete picture of travel behaviour or obtaining more information on Ukrainian visas); these estimates are released around 11 months after the reference period
- 12-month revised estimates, which are based on receiving the most comprehensive data to produce our estimates, where previous relevant assumptions and data adjustments are replaced with actual data reflecting observed behaviour; these estimates are released around 17 months after the reference period

The revisions process is outlined further in our [Publication schedule for admin-based population and migration statistics methodology](#).

Our LTIM estimates can be subject to scheduled revisions including regular or methods and data source improvements.

Regular revisions

We regularly revise our initial non-EU+ LTIM estimates when we receive more travel information, to align with the United Nations’ (UN’s) definition of 12-month LTIM.

Revisions to our non-EU+ estimates are also affected by our use of different supplies of data. Differences in the underlying data can occur because of:

- data-cleansing exercises
- updated information on individuals that allows for better identification and matching
- development of improved methods
- improved coverage

This means that different supplies of data can produce different estimates for the same reference period. The nature of these changes should mean that later supplies of data are more reliable than earlier ones.

Methods and data source improvements

Methods and data source improvements can occur when new or additional data become available, or when we have developed improved methods for LTIM estimation.

When the improvements occur, our approach is usually to update all the estimates in the time series that are affected. Methodological changes can occur when we have developed or refined methods for LTIM estimation. We then update our time series to improve the quality of the estimates, which in turn affects the stability of previously published estimates.

4 . Revision analysis of long-term international migration estimates

This section outlines our analysis of revisions to our non-EU+ long-term international migration (LTIM) estimates, which informs our model specification. We compare estimates from publications from November 2022 to May 2025 to understand the stability of estimates, the impact of revisions, and whether there have been any systematic trends in the revisions.

Impact of revisions on estimates

Figure 1 shows the impact of revisions to our non-EU+ LTIM estimates for immigration, emigration and net migration, with three key findings:

- the preliminary estimates appear to capture the direction in trend, with respect to the previous reference period
- there have been some substantial revisions to our non-EU+ LTIM estimates between our November 2022 and May 2025 publications; we have been working towards more stable methods to estimate LTIM, but revisions remain substantial in magnitude
- there is a systematic pattern where the latest immigration and net migration estimates have been revised upwards and emigration estimates have been revised downwards from their corresponding provisional estimates

Figure 1 also shows the impact of step changes associated with noteworthy amendments made to the methods or data sources used in our non-EU+ LTIM estimation processes. A step change refers to a sudden, substantial shift in estimates. This is typically caused by substantial changes in methodology or data sources, rather than an actual observed change in migration patterns.

We define a step change in our LTIM estimates as a revision prompted by an innovation change that results in the revision of more than 12 months of the time series. They are different to more typical methods and data source improvements. For example, emigration estimates have a large number of substantial revisions, evidenced by the increase in LTIM estimates published in November 2023, compared with May 2023, and November 2024, compared with May 2024.

Methods and data source improvement revisions

There have been five methods and data source improvements to estimates for all three migration flows included in our non-EU+ LTIM estimates. We have only published regular revisions in May 2025. Two of these methods and data source improvements can be considered as step changes (November 2023 and November 2024) that substantially change from the baseline of the estimation process used in November 2022.

We have backdated the time series for the publications subject to these improvements by:

- 24 months for our November 2022 publication
- 12 months for our May 2023 publication
- 24 months for our November 2023 publication
- 12 months for our May 2024 publication
- 36 months for our November 2024 publication

The differences between November 2024 and May 2025 are smaller, compared with previous revisions. This shows that we would likely produce more stable non-EU+ estimates over time, if only regular revisions affected our non-EU+ estimates.

For more information on previous methods and data source improvements, see Section 4: Impact of revisions to provisional estimates of migration in our [International migration research, progress update: November 2024 article](#).

Figure 1: There were substantial revisions to our non-EU+ long-term international migration estimates between November 2022 and May 2025

Long-term international migration (LTIM), non-EU+ estimates by publication and by flow

Notes:

1. These non-EU+ LTIM estimates do not include asylum or resettlement.
2. Data are rounded to the nearest 1,000.

Methodology changes causing step changes

The associated methodology changes that contribute to the step changes in non-EU+ LTIM estimates are outlined for both November 2023 and 2024.

Methodology changes for November 2023 include:

- improvements to travel not matched to a visa
- updated assumptions to produce provisional estimates of migration (for year-ending June 2023 estimates)
- immigration early leaver adjustment
- emigration re-arrivals adjustment
- early exits adjustment
- emigration visa transitions adjustment

Further details are provided in Section 2: Improvements to methods for non-EU migration using Home Office data of our [International migration research, progress update: November 2023 article](#).

Methodology changes for November 2024 include:

- adjustments to avoid overestimation because of visa transitions
- updated method to exclude individuals with a missing first arrival date
- improvements to our adjustment for long-term travel outside of UK within a visa period
- update to exclude all instances of visit visas from estimates, as these only permit maximum stay of six months
- improved early leavers adjustment by including more characteristics

Further details are provided in Section 2: Improvements to the method for estimating non-EU+ migration of our [International migration research, progress update: November 2024 article](#).

Conceptual framework for revisions analysis

Our revision analysis examines the changes to estimates because of revisions. We have based our analysis on three types of preliminary estimates that can be subject to revisions:

- “T” are provisional LTIM estimates; they are the earliest preliminary estimates published and represent our most timely published LTIM estimates
- “T6” are revised LTIM estimates published six months after the provisional (T) estimates
- “T12” are revised LTIM estimates published 12 months after the provisional (T) estimates

T and T6 are always subject to regular revisions. T12 are only subject to revisions because of methods and data source improvements.

We analyse revisions to our non-EU+ LTIM estimates using three approaches:

- the root mean square error (RMSE), to evaluate the predictive accuracy
- the mean percentage revision (MPR), to evaluate the bias; we used the direction and magnitude of percentage revisions to explore the bias and help identify if there has been any systematic trends in LTIM estimates
- the standard deviation (SD), to present and evaluate the variance (spread) of revisions to LTIM estimates

We use these following formulas to calculate the percentage revision and RMSE:

$$\%Revision = \frac{\text{latest estimate} - T|T6|T12}{T|T6|T12} \times 100$$

$$\text{Root mean square error} = \sqrt{\frac{1}{n} \sum_{i=1}^n (\text{latest estimate}_i - T_i|T6_i|T12_i)^2}$$

Where “n” is the number of observations of the preliminary estimate of interest for each flow (n equals 13 for T estimates, n equals 11 for T6, and n equals 9 for T12).

The latest estimates are the most reliable available estimates and are always published at least six months after the initial estimate of interest. We often use the latest estimates published 12 months after preliminary estimates or estimates that are later than the preliminary estimate.

Table 1 shows the publication months of preliminary estimates, and the accompanying latest estimates used in our analysis.

Table 1: Preliminary estimates used in analysis with accompanying latest estimate

| Year ending period | T | T6 | T12 | Latest Estimate |
|--------------------|----------|----------|----------|-----------------|
| June 2021 | Nov 2022 | May 2023 | Nov 2023 | Nov 2024 |
| Sep 2021 | Nov 2022 | May 2023 | Nov 2023 | Nov 2024 |
| Dec 2021 | Nov 2022 | May 2023 | Nov 2023 | Nov 2024 |
| Mar 2022 | Nov 2022 | May 2023 | Nov 2023 | Nov 2024 |
| June 2022 | Nov 2022 | May 2023 | Nov 2023 | Nov 2024 |
| Sep 2022 | May 2023 | Nov 2023 | May 2024 | Nov 2024 |
| Dec 2022 | May 2023 | Nov 2023 | May 2024 | Nov 2024 |
| Mar 2023 | Nov 2023 | May 2024 | Nov 2024 | Nov 2024 |
| June 2023 | Nov 2023 | May 2024 | Nov 2024 | Nov 2024 |
| Sep 2023 | May 2024 | Nov 2024 | N/A | Nov 2024 |
| Dec 2023 | May 2024 | Nov 2024 | N/A | Nov 2024 |
| Mar 2024 | Nov 2024 | N/A | N/A | May 2025 |
| June 2024 | Nov 2024 | N/A | N/A | May 2025 |

Source: Office for National Statistics

Notes

1. T are the earliest provisional long-term international migration (LTIM) estimates.
2. T6 are revised LTIM estimates published six months after the provisional (T) estimates.
3. T12 are revised LTIM estimates published 12 months after the provisional (T) estimates.
4. N/A means preliminary estimates are not available for that time period.

5 . Revision analysis results

In this section, we present the results of our analysis of revisions to our non-EU+ LTIM estimates. We focus on three main dimensions:

- predictive accuracy
- bias
- variance

Together, these metrics provide insight into the patterns and characteristics of revisions. They will underpin the development of precocity error-based prediction intervals that we discuss in [Section 6: Modelling revisions and prediction intervals](#).

Predictive accuracy

We began our analysis with a focus on predictive accuracy.

Figure 2 shows the root mean square error (RMSE) by type of preliminary estimate for our non-EU+ LTIM estimates. Preliminary estimate types are T (the earliest estimates), T6 (revised estimates published six months after T), and T12 (revised estimates published 12 months after T). Our first estimates (T) have the largest RMSE across all flows for international migration. Our later estimates (T6 and T12) are also more accurate with lower RMSE values.

RMSE also gives insight into the scale of revisions. Revisions to estimates are relatively substantial, especially for T estimates. Our T estimates of non-EU+ immigration and emigration have an RMSE of over 70,000. T estimates of net migration have an RMSE of over 140,000.

Our T6 and T12 estimates of non-EU+ immigration and emigration all have RMSEs below 50,000. T6 and T12 estimates of net migration have RMSEs of less than 70,000. RMSEs of T12 estimates were substantially lower than T6 in all cases. This shows the increase in predictive accuracy from T, to T6, to T12 estimates.

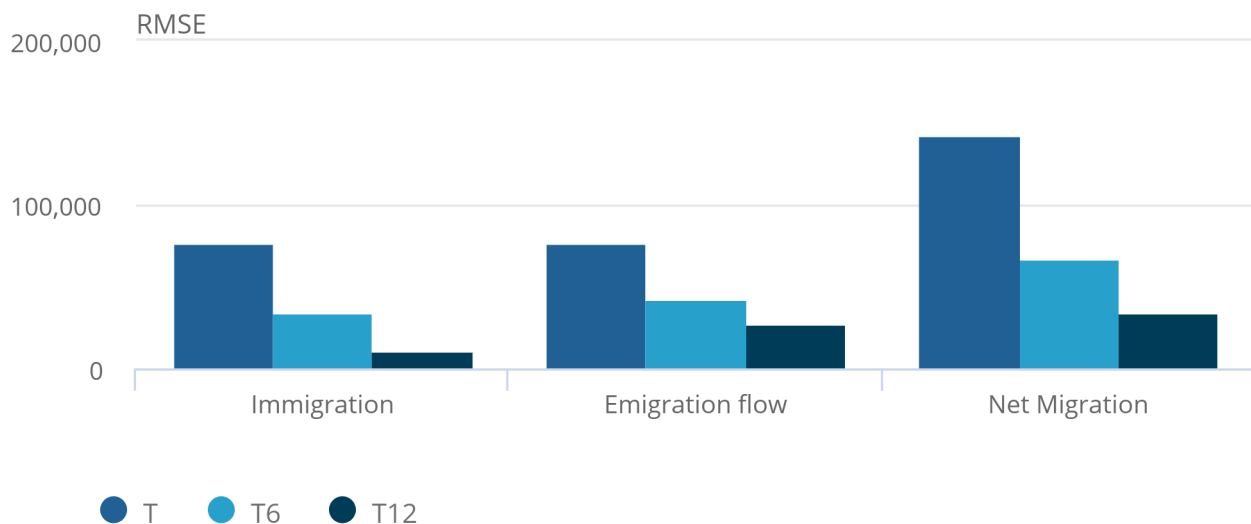
Revisions to our non-EU+ net migration estimates have been on a greater scale than for immigration and emigration. This is shown by its larger RMSEs for all flows.

Figure 2: First (T) estimates for all flows had the largest root mean square errors

Root mean square error (RMSE) for provisional non-EU+ immigration, emigration and net migration estimates

Figure 2: First (T) estimates for all flows had the largest root mean square errors

Root mean square error (RMSE) for provisional non-EU+ immigration, emigration and net migration estimates



Source: Office for National Statistics and the Home Office

Notes:

1. T are the earliest provisional long-term international migration (LTIM) estimates.
2. T6 are revised LTIM estimates published six months after the provisional (T) estimates.
3. T12 are revised LTIM estimates published 12 months after the provisional (T) estimates.
4. RMSE gives a clear picture of the overall scale of revisions, without cancelling out positive and negative differences, because of its positive nature and because it emphasises larger errors.
5. This chart includes a comparison of preliminary estimates against the latest published estimate. Table 1 shows publication dates outlined by type of estimate and reference period.

Bias

We then investigated the bias of revisions to LTIM estimates.

Figure 3 shows the mean percentage revision (MPR) by type of preliminary estimate for our non-EU+ estimates. There is generally a positive MPR for immigration and net migration, indicating a tendency for these estimates to be revised upwards. There is a negative MPR for emigration, indicating a tendency for emigration estimates to be revised downwards.

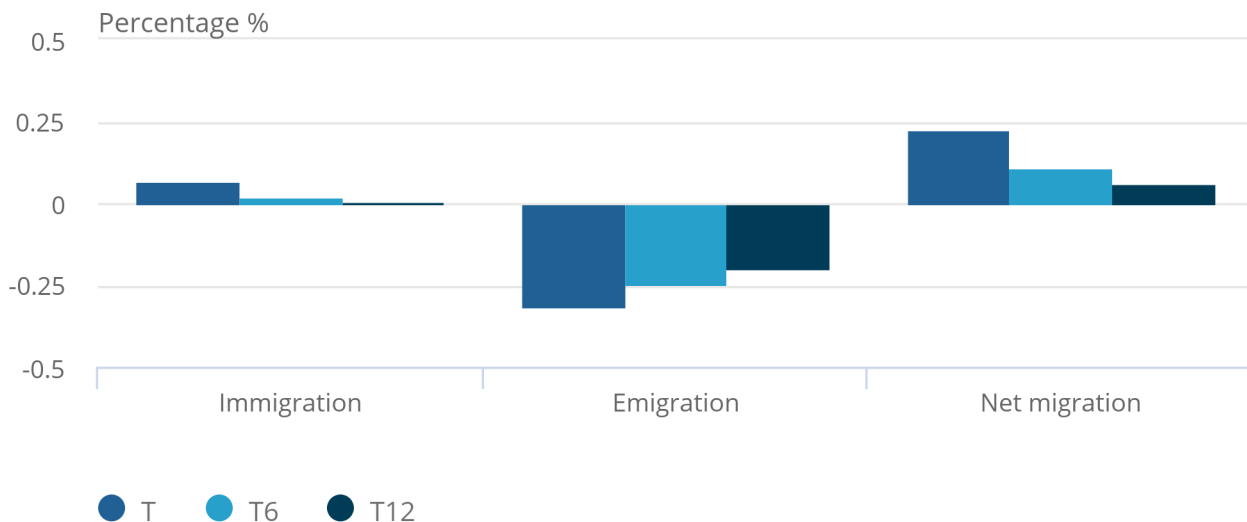
We found that our first non-EU+ estimate (T) shows the most systematic bias according to the MPR. Later estimates (T6 and T12) have smaller MPRs, but still show a systematic bias in the direction of revisions.

Figure 3: Immigration and net migration estimates tend to be revised upwards, while emigration estimates tend to be revised downwards

Mean percentage revision (MPR) for provisional non-EU+ immigration, emigration and net migration estimates

Figure 3: Immigration and net migration estimates tend to be revised upwards, while emigration estimates tend to be revised downwards

Mean percentage revision (MPR) for provisional non-EU+ immigration, emigration and net migration estimates



Source: Office for National Statistics and the Home Office

Notes:

1. T are the earliest provisional long-term international migration (LTIM) estimates.
2. T6 are revised LTIM estimates published six months after the provisional (T) estimates.
3. T12 are revised LTIM estimates published 12 months after the provisional (T) estimates.
4. MPR can be a misleading signal of quality, as a low value can result if upward and downward revision offset themselves.
5. This chart includes a comparison of preliminary estimates against the latest published estimate. Table 1 shows publication dates outlined by type of estimate and reference period.

Figure 4 shows the percentage revision by reference period for each flow of our non-EU+ LTIM estimate. There is a recent trend of percentage revisions moving closer to 0%, indicating a potential reduction in the bias of preliminary estimates. The year ending June and March 2024 estimates are the only periods that have regular revisions, which is likely a contributing factor. All other estimates since June 2021 have experienced methods and data source improvements.

There is a general trend that T estimates have the greatest percentage revision, in terms of magnitude (Figures 2, 3 and 4). T6 and T12 have smaller percentage revisions, but still show systematic bias in the direction of the revisions.

Figure 4: Percentage revisions for our preliminary estimates have decreased, suggesting a potential reduction in bias

Percentage revision by reference period for provisional non-EU+ immigration, emigration and net migration estimates

Notes:

1. T are the earliest provisional long-term international migration (LTIM) estimates.
2. T6 are revised LTIM estimates published six months after the provisional (T) estimates.
3. T12 are revised LTIM estimates published 12 months after the provisional (T) estimates.
4. This chart includes a comparison of preliminary estimates against the latest published estimate.
5. Table 1 shows publication dates outlined by type of estimate and reference period.

Variance

We then examined variance to assess the spread of revisions made to preliminary estimates.

Figure 5 shows the standard deviation (SD) of percentage revision (in percentage points) by type of preliminary estimate for our non-EU+ estimates. Percentage revisions to emigration generally have the largest standard deviation, and immigration and net migration having smaller standard deviations and therefore, less spread.

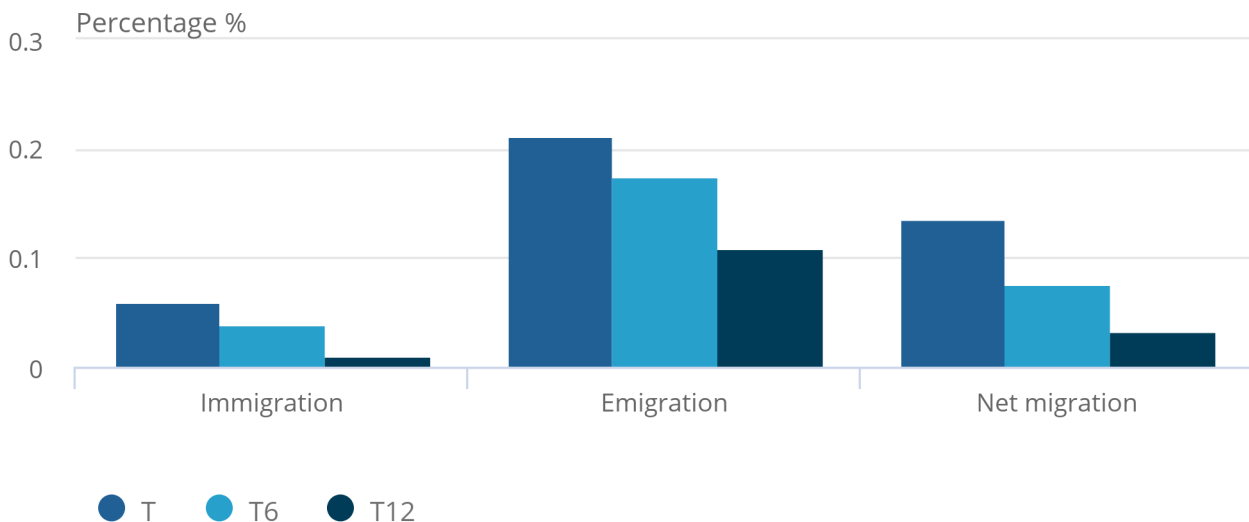
T estimates clearly have the largest standard deviations and the most spread. Not only do T estimates generally have the highest levels of bias, but also the lowest levels of consistency in their percentage revisions, compared with T6 and T12 estimates.

Figure 5: Percentage revisions for emigration have the largest standard deviation

Standard deviation (SD) of percentage revision for provisional non-EU+ immigration, emigration and net migration estimates

Figure 5: Percentage revisions for emigration have the largest standard deviation

Standard deviation (SD) of percentage revision for provisional non-EU+ immigration, emigration and net migration estimates



Source: Office for National Statistics and the Home Office

Notes:

T are the earliest provisional long-term international migration (LTIM) estimates. T6 are revised LTIM estimates published six months after the provisional (T) estimates. T12 are revised LTIM estimates published 12 months after the provisional (T) estimates. This chart includes a comparison of preliminary estimates against the latest published estimate. Table 1 shows publication dates outlined by type of estimate and reference period.

Regular revision analysis

Analysis in this section focuses on the impact of regular revisions without the presence of step changes resulting from the introduction of noteworthy methods and data source improvements. We aim to understand how stable our non-EU+ LTIM estimates would be if only regular revisions occurred.

We have taken a “what if” approach to our analysis. We consider what our May 2024 published estimates would have been if the estimation process used in the May 2025 publication had been applied. By doing this, we remove the impact of methods and data source improvements. This focuses our analysis on the impact of regular revisions, in the form of updated travel information and different supplies of Home Office Borders and Immigration (HOBI) data.

Figure 6 scatterplots compare the effects of different estimation approaches on the sizes of revisions. There is more stability in our estimates where regular revisions occur using the May 2025 methodology. We infer this from the May 2025 method points (shown as squares) that are more closely grouped around the intercept line, compared with the May 2024 method points (shown as circles), which are generally much further from the line. This is the case for estimates of immigration, emigration and net migration, and is further supported by Table 2.

Figure 6: Regular revisions using the May 2025 methodology are more stable for all flows

“What if” regular revision analysis comparing bias by estimation method and by flow

Table 2 presents the impact of revisions according to the metrics used in our revisions analysis:

- root mean square error (RMSE)
- mean percentage revision (MPR)
- standard deviation (SD)

Maintaining the same methods and data sources improves the predictive performance and reduces the bias and variance of our estimates when they are revised. We examine the impact of the step changes by comparing the differences in RMSE; the difference provides an estimate of the reduction in predictive accuracy that is attributable to the step change. For example, the RMSE for step changes for immigration increased by 32,865 (from 15,996 to 48,861) for the estimates originally published in May 2024. Step changes for emigration and net migration resulted in RMSE increases of 33,099 and 68,003, respectively.

Table 2: Regular revision analysis metrics for current (May 2025) method, compared with metrics for previous (May 2024) method

Root mean square error (RMSE), mean percentage revision (MPR) and standard deviation (SD), compared between May 2024 and May 2025 methods for all flows

| Flow | Method | RMSE | MPR | SD |
|---------------|----------|-------|-------|-----|
| Immigration | May 2024 | 48861 | 3.5 | 4 |
| Immigration | May 2025 | 15996 | -1.4 | 1.4 |
| Emigration | May 2024 | 38229 | -23.9 | 5 |
| Emigration | May 2025 | 5130 | -0.4 | 4.1 |
| Net Migration | May 2024 | 82061 | 10.9 | 5.1 |
| Net Migration | May 2025 | 14058 | -1.6 | 1.2 |

Source: Office for National Statistics

Summary of results

- For all flows, T12 estimates show the highest levels of predictive accuracy, followed by T6; T estimates have the lowest predictive accuracy.
- Net migration shows the lowest predictive accuracy for all three types of estimates.
- T6 and T12 emigration estimates have larger RMSEs, compared with immigration, reflecting lower levels of predictive accuracy; T estimates are similar for both flows.
- Revisions to immigration and net migration estimates show an upward bias; emigration revisions show a downward bias.
- T estimates have the greatest magnitude of systematic bias for all flows, followed by T6 and then T12.
- Emigration revisions show the highest levels of bias, followed by net migration; immigration revisions are least biased, in terms of magnitude.
- For each estimate type, the SD of percentage revisions to LTIM estimates decreases from emigration to net migration to immigration; emigration revisions show the highest variance (spread), and immigration estimates show the least variance.
- For all flows, T12 estimates have the lowest variance, T6 have the second-lowest variance, and T estimates have the highest variance.
- Our May 2024 published estimates had large increases in RMSE, MPR and SD because of methods and data source improvements.
- Our regular revision analysis indicates that estimates would be more stable when they only experience regular revisions, without the impact of step changes resulting from methods and data source improvements.

6 . Modelling revisions and prediction intervals

This section outlines our modelling-based approach, which focuses on revisions and the stability of non-EU+ long-term international migration (LTIM) estimates. Through modelling revisions, we can provide users with a probabilistic prediction of the revision range for the current LTIM estimates.

We aim to model and predict precocity error in our non-EU+ LTIM estimates. Precocity error is the difference between preliminary and final estimates, as defined in Stats Canada's [specific calculation for quantifying precocity error \(PDF, 634KB\)](#). We adopt the concept of precocity error to help quantify the impact of revisions on estimates. Preliminary estimate types are T (the earliest estimates), T6 (revised estimates published six months after T), and T12 (revised estimates published 12 months after T). We estimate precocity error through log-scaling factors by comparing the difference between original estimates (T, T6, or T12) and latest available estimates.

Conceptual framework for modelling

We used the R package [Bayesian Estimation and Forecasting of Age-Specific Rates \(BAGE\)](#) to specify precocity error models for revisions to our non-EU+ LTIM estimates.

We specified the following model for each flow of migration (immigration, emigration, and net migration) for precocity error:

$$Y_{tpe} \sim N(\mu_{tpe}, \sigma^2)$$

With:

$$\mu_{tpe} = \beta^0 + \beta_t^{\text{time}} + \beta_p^{\text{publication}} + \beta_e^{\text{estimate}} + \beta_{et}^{\text{estimate:time}} + \beta_{ep}^{\text{estimate:publication}} + \beta_{s1}^{\text{stepchange1}} + \beta_{s2}^{\text{stepchange2}} + \beta_{s1e}^{\text{stepchange1:estimate}}$$

Where:

Y_{tpe}

represents the precocity error for the specific estimate by reference period of estimate (t), publication date of estimate (p), and type of estimate (T, T6 or T12) (e)

β_t^{time}

represents the fixed effect of the reference period of the estimate (for example, year ending June 2021), with an autoregressive order one (AR1) prior, which assumes that precocity error evolves over the reference period of the estimates

$\beta_p^{\text{publication}}$

represents the fixed effect of the publication date (for example, May 2022), with an AR1 prior, which assumes that the precocity error evolves with publication date

$\beta_e^{\text{estimate}}$

represents the fixed effect of the type of estimate, with a normal prior, which assumes there would be a relationship between the type of estimate being published and the precocity error

$\beta_{et}^{\text{estimate:time}}$

and

$\beta_{ep}^{\text{estimate:publication}}$

represent the interaction effects of our model (interaction effects allow us to capture patterns and trends that are specific to the interaction between the type of estimates and either reference period of estimate or publication date of estimate); each group will have its own time series and we use an AR1 prior

$\beta_{s1}^{\text{stepchange1}}$

and

$\beta_{s2}^{\text{stepchange2}}$

represent the step changes in the non-EU+ estimation process where either noteworthy method changes or new data have been incorporated, with a normal prior; we include step changes to capture the relationship between the precocity error and the impact of innovation and quality changes and step changes occurred in November 2023 (step change 1) and November 2024 (step change 2) publications

$\beta_{s1e}^{\text{stepchange1:estimate}}$

and

$\beta_{s2e}^{\text{stepchange2:estimate}}$

represent more interaction effects of our model, allowing us to capture whether step changes have specific impacts on the type of estimates (for example, a step change has more impact on T6 estimates than T12 estimates)

μ_{tpe}

represents the mean estimate of the precocity error, based on our explanatory variables in the model

σ^2

represents the variance in the residuals and is the variance in the observed values that is not explained by the model; our model assumes a common variance across different types of estimates

Autoregressive priors for our time series covariates were selected because they are mean reverting, unlike a random walk. The mean reverting feature represents the view that precocity error would be unlikely to continue to grow without some corrective actions, and the precocity error is likely to stay within a range and does not drift indefinitely.

To estimate precocity error, we use log-scaling factors (lsf):

$$lsf = \log\left(\frac{\text{latest estimate}}{\text{preliminary estimate}}\right)$$

When interpreting precocity error, a value greater than zero indicates an undercount in the preliminary estimates and therefore, that further estimates have been revised upwards. A value less than zero indicates an overcount in the preliminary estimate and that estimates have been revised downwards.

We estimated log-scaling factors by different types of preliminary estimates (T, T6 and T12) for each flow of international migration: immigration, emigration, and net migration. For the latest estimate, we used the most finalised estimate, with a minimum requirement of at least six months between the preliminary and revised estimates.

The predicted precocity error for the current estimates can be used to produce prediction intervals associated with the stability of the estimates. For each of the predicted precocity errors drawn from the posterior prediction distribution, we apply a back transformation by applying the exponential function and multiplying this by the current non-EU+ LTIM estimates for relevant type of estimate. For example, if the log-scaling factor is 0.2 and the current estimate is 100,000, this would be an estimated 122,140.

Our approach generates multiple estimated non-EU+ LTIM figures for each type of estimate, based on the number of draws from the posterior prediction distribution. In our case, we have set this to 10,000 draws. Setting a high number of draws helps to provide more consistent results and reduce interval bounds variability, which is more likely with setting a low number of draws.

We then propose three methods for deriving 95% prediction intervals of revision range for our published LTIM estimates.

Empirical intervals

Empirical intervals are where we rank the 10,000 estimated non-EU+ LTIM estimates from the back-transformation. We take the 251st and 9750th as the lower and upper bounds, respectively. If revisions to the estimates have displayed a systematic trend, this approach will take the trend into account and is not centred around the current associated estimate.

Centred intervals

Centred intervals shift the empirical intervals so that they are centred on the current non-EU+ LTIM estimates, which were influenced by [uncertainty intervals for our mid-year population estimates](#). The difference between the median value of the predicted values and the observed estimates is subtracted from each of the lower and upper bounds. The width of the confidence interval remains the same, but it does not account for any systematic trend in the direction of the previous revisions to estimates.

Mid intervals

Mid intervals lie midway between the empirical and centred prediction intervals, in terms of their central location, but maintain the same width. Mid intervals act as a balance between using the observed estimate and any systematic trend in the direction of revisions being made to the estimate.

Results

Model checking

We checked the goodness of fit by replicating data from our models, which were compared with the observed data. If the model is deemed a good fit, the replicated data should have similar characteristics to the observed data.

We began by modelling using default priors in BAGE. We then refined the parameter settings for priors by examining the goodness of fit comparison. We also replicated the data against the observed data.

Figures 7, 8 and 9 show our results, including replicated data (n equals 100) and original data for our final models. Red lines represent the observed data and shaded areas represent the inter-quantile range and 95% range of our replicated data.

We split the results by type of preliminary estimate (T, T6 and T12). In most cases, the replicated data displays similar characteristics and the fitted models provide a reasonable fit for the data.

Figure 7: Replicate data for immigration model

Mean estimate with inter-quartile range and 95% confidence interval

Notes:

1. Sample size equals 100.

Figure 8: Replicate data for emigration model

Mean estimate with inter-quartile range and 95% confidence interval

Notes:

1. Sample size equals 100.

Figure 9: Replicate data for net migration model

Mean estimate with inter-quartile range and 95% confidence interval

Notes:

1. Sample size equals 100.

Predictive analysis

We have evaluated our model's predictive performance through holdout testing, where a section of the data is withheld when fitting the model. To evaluate the predictive performance based on the revised estimates in the May 2025 publication, we have fitted the models based on information available for our November 2024 publication.

Our current method aims to quantify the uncertainty associated with the adjustments made to the non-EU+ LTIM estimates, including the early leavers adjustment for immigration and the returners adjustment for emigration. This is described in our [Measuring uncertainty in international migration estimates article](#).

In this method, we assume that the value of the adjustment is a random variable with a normal distribution. We use historical information to inform the values of the mean and standard deviation parameters for the normal distribution. Then, we draw multiple times from the normal distribution to give a range of possible values for the adjustments. Because of the approach of the current method, we only include immigration and emigration for year ending December 2023 and June 2024.

Table 3 illustrates the results from the holdout testing by different types of prediction intervals. To evaluate the point prediction accuracy of the models, we consider the mean absolute percentage error (MAPE) and root mean square error (RMSE). We assess the performance of the prediction intervals by evaluating their coverage on the held-back data. We define the coverage as the number, or proportion, of the held-back data that fall inside of the 95% prediction intervals.

Across all three types of precocity-based prediction intervals there was good coverage performance. All held-back estimates (100%) were within the 95% interval range. For the current adjustment-based intervals, only 25% (one of four) of the revised estimates were within the 95% interval range.

Centred prediction intervals tend to have a lower MAPE and RMSE, compared with both empirical and mid prediction. These results show that the median prediction in the centred prediction intervals was closer to the revised estimate than the other median estimates.

The holdout testing suggests that precocity-based prediction intervals improve the stability of estimates, compared with the current adjustment-based approach.

Table 3: Predictive accuracy results from holdback testing
Mean average percentage error (MAPE), root mean square error (RMSE) and coverage, according to method type for all flows

| Type | Flow | MAPE | RMSE | Coverage | Coverage (%) |
|-----------------------|---------------|-------|--------|----------|--------------|
| Centred | Emigration | 6.59 | 12467 | 4 /4 | 100 |
| Current method | Emigration | 9.4 | 17549 | 0/2 | 0 |
| Empirical | Emigration | 29.81 | 54902 | 4 /4 | 100 |
| Mid | Emigration | 18.2 | 33641 | 4 /4 | 100 |
| Centred | Immigration | 1.22 | 14668 | 4 /4 | 100 |
| Current method | Immigration | 4.47 | 46166 | 1/2 | 50 |
| Empirical | Immigration | 4.72 | 48916 | 4 /4 | 100 |
| Mid | Immigration | 1.75 | 19324 | 4 /4 | 100 |
| Centred | Net migration | 0.75 | 7232 | 4 /4 | 100 |
| Empirical | Net migration | 14.23 | 119748 | 4 /4 | 100 |
| Mid | Net migration | 7.08 | 60044 | 4 /4 | 100 |

Source: Office for National Statistics and the Home Office

Notes

1. Results in this table are only indicative of performance for one publication and its associated and latest estimates.
2. The performance should be monitored going forward, with more estimates to get a more comprehensive indication of model performance and prediction intervals generated.
3. A maximum of four estimates could have been within the intervals.

Table 4 shows the prediction intervals for our non-EU+ LTIM estimates that align with the May 2025 publication. For T estimates (September 2024 and December 2024), the empirical intervals propose a revision range aligned with the previous trends of revisions. For immigration and net migration, the empirical intervals assume it is more likely for an upward revision to occur, while for emigration, a downward revision is more likely.

The prediction intervals are also wider than those produced with the current adjustment-based method for uncertainty intervals for immigration (year-ending December 2024 increased from 635,000 to 680,000) and emigration (year-ending December 2024 increased from 208,000 to 226,000).

Publishing precocity-error prediction intervals with LTIM estimates would have several advantages.

They incorporate and convey more information about the sources affecting the stability of estimates, compared with current published uncertainty intervals for our non-EU+ LTIM estimates. The adjustment-based uncertainty intervals do not account for predictive uncertainty, as we only consider the observed data and their variability. The adjustments and their associated revisions are also only one component affecting the stability of our non-EU+ estimates. Modelling revisions can help to capture other sources affecting the stability of our estimates, such as the variability of supplies of data and step changes in methods and data sources.

Precocity-error prediction intervals also provide users with a probabilistic revision range associated with estimates. This should allow users to incorporate more information on the stability of the estimates. This approach can be used for both our non-EU+ and asylum LTIM estimates.

If our models are deemed a reasonable fit and revisions follow a similar trend, we would expect the prediction intervals to capture the range of revisions made to preliminary estimates 95% of the time on average.

Table 4: Non-EU+ long-term international migration estimates with 95% prediction intervals
Stability intervals for most current published non-EU+ long-term international migration (LTIM) estimates

| Flow | Year Ending Period | Current estimate (May 2025) | Stability lower prediction (empirical) | Stability upper prediction (empirical) | Stability lower prediction (centred) | Stability upper prediction (centred) | Stability lower prediction (mid) | Stability upper prediction (mid) |
|--------------------|--------------------|-----------------------------|----------------------------------------|----------------------------------------|--------------------------------------|--------------------------------------|----------------------------------|----------------------------------|
| Emigration (T6) | Mar 2024 | 192000 | 168000 | 256000 | 152000 | 239000 | 160000 | 248000 |
| Emigration (T6) | June 2024 | 197000 | 170000 | 263000 | 156000 | 249000 | 163000 | 256000 |
| Emigration (T) | Sep 2024 | 206000 | 174000 | 274000 | 160000 | 261000 | 167000 | 268000 |
| Emigration (T) | Dec 2024 | 217000 | 181000 | 299000 | 166000 | 284000 | 173000 | 292000 |
| Immigration (T6) | Mar 2024 | 1035000 | 969000 | 1098000 | 972000 | 1101000 | 971000 | 1100000 |
| Immigration (T6) | June 2024 | 965000 | 901000 | 1030000 | 903000 | 1032000 | 902000 | 1031000 |
| Immigration (T) | Sep 2024 | 824000 | 789000 | 895000 | 773000 | 879000 | 781000 | 887000 |
| Immigration (T) | Dec 2024 | 663000 | 629000 | 724000 | 617000 | 712000 | 623000 | 718000 |
| Net Migration (T6) | Mar 2024 | 843000 | 742000 | 926000 | 756000 | 940000 | 749000 | 933000 |
| Net Migration (T6) | June 2024 | 768000 | 673000 | 851000 | 683000 | 861000 | 678000 | 856000 |
| Net Migration (T) | Sep 2024 | 618000 | 558000 | 701000 | 549000 | 692000 | 553000 | 697000 |
| Net Migration (T) | Dec 2024 | 446000 | 398000 | 513000 | 392000 | 507000 | 395000 | 510000 |

Source: Office for National Statistics and the Home Office

Notes

1. Figures are rounded to the nearest 1,000.

7 . Summary

We carry out regular revisions of our long-term international migration estimates when additional information on migrants' behaviour becomes available. We also update the published back series when improved methods or new data sources are introduced, where applicable. We recognise the wide-ranging use of these statistics, so we have set out how we balance timeliness and the pragmatic need for stable estimates.

Our revision analysis indicates that our non-EU+ national estimates have experienced both systematic trends and substantial revisions. Both regular revisions and step changes have affected the stability of our estimates.

The results suggest that both immigration and net migration estimates are usually revised upwards and emigration estimates are usually revised downwards. We assessed the extent of the revisions observed in our May 2025 publication and our analysis of the impact of regular revisions. Results indicate that non-EU+ revisions would be on a smaller scale if only regular revisions were implemented. However, the stability of estimates is only one quality dimension of producing estimates and must be considered with opportunities to improve the estimates through innovations in methods and data sources.

Our modelling approach can give an indication of the plausible range of revisions, and whether revisions are more likely to be overestimated or underestimated. We have modelled revisions to provide associated prediction intervals for our current estimates, which can provide users with a likely revision range. However, modelled revisions are based on previous trends of revisions. Users should recognise that the intervals are based on extrapolation and should take care when interpreting them.

8 . Quality assurance

We received feedback on our analysis and methodological approach from both internal and external sources, including:

- colleagues from the Office for National Statistics (ONS)
- other government departments
- the Office for Statistics Regulation (OSR)
- the [Methodological Assurance Review Panel \(MARP\): Migration Statistics sub-group](#)

We received technical feedback on our modelling approach and specification from:

- ONS colleagues associated with the demographic population model (DPM)
- the MARP sub-group on migration
- John Bryant, co-author of the Bayesian Estimation and Forecasting of Age-Specific Rates (BAGE) R package

9 . Future developments

We are considering further research to progress our revision analysis and modelling, including expanding our stability analysis, conducting simulation and sensitivity analysis, and developing our model.

Impact of revisions to EU+ and British national estimates

We may aim to expand our stability analysis to other long-term international migration (LTIM) estimates to cover EU+ and British nationals, if feasible. We are currently undertaking research into the estimation process for EU+ and British nationals, to introduce changes to methods and data sources. Once the planned changes have been implemented, as part of our LTIM estimation process, we can begin to consider applying our analysis and modelling approach.

Simulation and sensitivity analysis

We can conduct a simulation study and perform sensitivity analysis to further evaluate our model performance and suitability. For the simulation study, we could:

- expand our holdout testing to evaluate model performance with different simulated time series for precocity error, avoiding the limited number of observations being used to test our models
- simulate the time series with varying characteristics, such as the degree of randomness and autocorrelation, to understand how they could affect the predictive performance

For the sensitivity analysis, we could explore the impact of prior selection and their associated parameters values.

Model development

We have put forward a model to produce prediction intervals for the stability of our non-EU+ estimates for immigration, emigration and net migration. We could expand our modelling to asylum estimates, with the aim of producing prediction intervals for current estimates that give a probabilistic revision range. We can also explore options that could improve model specification, including:

- modelling the variance in the residuals specific to estimate type
- reviewing the model specification, so centred and mid prediction intervals would not be required
- pooling more information together by specifying one model, rather than three separate models, which would take into consideration the flow of migration as a component
- evaluating where we apply a reduced model specification, as it is likely that there is an identifiability issue in our two time components (reference period and publication date)
- changing our response variable to actual LTIM estimates, rather than precocity error

10 . Cite this methodology

Office for National Statistics (ONS), released 7 October 2025, ONS website, methodology, [Predicting the stability of non-EU+ long-term international migration estimates](#)