Predicting irregular migration: high hopes, meagre results

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SWP Research Paper

Steffen Angenendt, Anne Koch and Jasper Tjaden

Predicting Irregular Migration

High Hopes, Meagre Results

Stiftung Wissenschaft und Politik
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- German and European migration policy operates in permanent crisis mode. Sudden increases in irregular immigration create a sense of loss of control, which is instrumentalised by populist forces.
- This has generated great interest in quantitative migration predictions. High expectations are placed in the AI-based tools currently under development for forecasting irregular migration.
- The potential applications of these tools are manifold. They range from managing and strengthening the EU's reception capacity and border protections to configuring humanitarian aid provision and longer-term planning of development programmes.
- There is a significant gap between the expectations placed in the new instruments and their practical utility. Technical limits exist, medium-term forecasts are methodologically implausible, and channels for feeding the results into political decision-making processes are lacking.
- The great demand for predictions is driven by the political functions of migration prediction, which include its uses in political communication, funding acquisition and legitimisation of political decisions.
- Investment in the quality of the underlying data will be more productive than developing a succession of new prediction tools. Funding for applications in emergency relief and development cooperation should be prioritised. Crisis early warning and risk analysis should also be strengthened and their networking improved.

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Predicting Irregular Migration: High Hopes, Meagre Results

The desire to anticipate and prepare for future developments is ubiquitous in politics. That is especially true for German and European refugee and migration policy since the large-scale immigration of 2015/16. The recent increases in refugee arrivals via the Balkan route and the Mediterranean, and above all from the war in Ukraine, have boosted the wish not to be surprised by future migration movements.

Investments in migration predictions are aimed at better preparing for future migration movements. Numerous areas of refugee and migration policy are involved. These include the ability to provide rapid and effective assistance in humanitarian crises, to ensure control of external borders, to maintain appropriate refugee reception capacity, and to manage labour migration in line with the actual needs of the labour market.

The broad interest in such predictions is reflected in a dynamic research landscape. Quantitative prediction tools are improving rapidly, and are increasingly based on big data analytics. New sources, such as mobile phone data, and rapidly expanding computing power open up new worlds of prediction. A proliferation of competing approaches leaves policymakers wondering what to make of a growing range of different instruments.

To date academic engagement with these developments has been largely restricted to assessing the validity of migration predictions. Less attention has been devoted to the question of whether and how they are used in political decision-making processes and what impact they really have on migration policy and humanitarian practice. That is the gap that the present study sets out to address. The objective is to contribute to a better understanding of the political functions and practical benefits of migration predictions. The empirical basis comprises background conversations conducted with twenty-six representatives of German federal ministries and agencies, European institutions and agencies, research consortiums and NGOs that are involved in planning, preparing or using quantitative migration predictions. The study focuses on two fields in particular: firstly, predictions of irregular migration to Germany and the EU; and

secondly, predictions of forced displacement in regions of conflict and crisis outside the EU, including cases of climate-related displacement.

The following observations can be made:

- There is a noticeable gap between the expectations that political decision-makers place in quantitative tools, in particular AI-based migration predictions, and their actual practical utility.
- Despite the limited utility of migration predictions, there is great willingness to invest in their development. One reason for this is that as well as expanding knowledge, migration predictions fulfil other functions that are beneficial to political decision-makers, for example offering justification and legitimation for their decisions.
- The practical benefit of (in particular AI-based) migration predictions varies greatly between policy areas. The current technologies cannot fulfil the policy-driven desire for precise data on arrivals in the EU months in advance; the prospects are better for short-term predictions of acute forced displacement and for understanding longer-term structural trends.
- Predicting irregular migration is associated with fundamental risks and ethical problems. In the context of the overheated and polarised debate about forced displacement and migration, quantitative predictions are inherently political and open to instrumentalisation — for example to conjure threat scenarios and to stoke fears. Furthermore, certain AI-based approaches are essentially "black boxes" that make it impossible to identify which factors were decisive for a given outcome. This reduces the potential knowledge gain to the blank prediction, without offering any broader insights into underlying causalities.

On the basis of these findings, we make five recommendations on the preparation and use of predictions of irregular migration:

Firstly the possibilities and limits of migration predictions should be communicated openly and the validity of the applied approaches continuously reviewed. Funding should prioritise those areas of application that offer the greatest practical benefits, in particular emergency relief and development cooperation.

Secondly better use should be made of the potential synergies between different prediction tools. That will require improvements in data exchange and closer collaboration on data gathering and processing. Overall, investment in the quality of the underlying data promises greater gains than successive innovations in the instruments.

Thirdly crisis early warning and risk analysis need to be strengthened because crises and conflicts remain the most important causes of forced displacement. Integrating general and migration-specific crisis early warning could also reduce the gap between the expectations placed in predictions and their actual practical utility.

Fourthly more investment needs to be made in contextual analysis and scenarios, both in its own right and as a complement to quantitative (in particular AI-based) instruments. The premises and methods on which predictions are based should be published in the interests of transparency.

Fifthly high normative standards should be adhered to and continuously updated. On the one hand, predictions are always subject to a degree of uncertainty and can easily be politically instrumentalised if this is not clearly communicated. On the other, data privacy issues arise, especially where artificial intelligence is concerned.

Predicting Migration in Policy and Research

Interest in predicting migratory movements has grown apace in many industrialised countries in recent years. Three key developments have contributed to this:

Firstly: Internal and cross-border migration has increased globally. National and international statistics show record numbers of refugees and displaced persons. If migration is to be shaped and managed, and the causes of (forced) displacement addressed, information is required about why people leave their homes, where and under what conditions they seek protection or a better life, and what this means for countries of origin and destination. It is increasingly important for political decision-makers to know what migration movements are to be expected, not least in light of the increasing polarisation of the public debate about forced displacement, migration and integration.

Secondly: There is heightened political pressure in many countries, on account of multiple and in some cases intersecting political, economic and ecological crises. This creates a demand for policy to be more evidence-based and quantitatively grounded. Voters expect political leaders to anticipate developments, again implying an interest in actionable predictions of future migration.

Thirdly: We live in an era of "datafication", of rapid digitalisation of research, technology and everyday life, and of exponential expansion of data.[1] As well as driving social changes, digital technologies can also help us to understand them, and create a basis for evidence-based policy-making. New technologies — including the use of artificial intelligence (AI) — and the availability of non-traditional data, for example from social media, improve the granularity, scope and availability of data ("real-time").

As in the case of earlier migration events, the heightened immigration of 2015 and 2016 caught many political decision-makers completely unprepared. The same applies to the current increase in migration to the European Union via the Mediterranean and the Balkan route — and to the far greater challenge presented by the influx of refugees from Ukraine since the Russian invasion in February 2022. Political decision-makers feel an urgent need to be better forewarned of crisis-driven and irregular migration and better prepared both institutionally and organisationally.[2] This applies both to migration to Europe and to conflict-driven and environmental displacement within countries in the so-called Global South.

"AI-based" suggests a qualitative leap in precision and reliability.

Investment in predicting (forced) displacement and irregular migration is essentially aimed at facilitating the timely (re)allocation of financial resources and capacity-building in key infrastructures to meet the challenges of existing and future migration movements. There is also an aspect of hoping to avert or mitigate undesirable developments before they occur. New quantitative prediction tools based on machine learning and agent-based modelling are currently generating particularly high expectations. The term "AI-based" suggests a qualitative leap in precision and reliability. Many of the concepts now used in this field — such as "forecasting", "nowcasting" and "early warning" — suggest a causality based on laws of

1 See Marina Micheli et al., "Emerging Models of Data Governance in the Age of Datafication", *Big Data and Society* 7, no. 2 (2020), doi: 10.1177/2053951720948087.

2 See Sulin Sardoschau, *The Future of Migration to Germany: Assessing Methods in Migration Forecasting*, DeZIM Briefing Notes, no. 4 (Berlin: Deutsches Zentrum für Integrations- und Migrationsforschung [DeZIM], 19 August 2020), https://www.dezim-institut.de/fileadmin/user_upload/Demo_FIS/publikation_pdf/FA-5005.pdf (accessed 2 November 2022).

nature that could be anticipated in detail if only sufficient data and computing capacity were available.[3] Politically there are also great expectations concerning time horizons, specifically that predictions will allow the development of tailored instruments whose horizons are aligned with policy planning cycles.

In certain respects these expectations rest on problematic assumptions. The idea that a social phenomenon like migration could be predicted with scientific objectivity is predicated on an unrealistic and mechanistic understanding of human mobility. Moreover, awareness of the difference between migration prediction and crisis early warning is lacking. It is widely assumed that predicting sudden large refugee movements, such as those out of Ukraine in February and March 2022, is a core concern of "migration forecasting". In fact, these quantitative models are not designed to predict sudden escalations and their repercussions. The major crises of recent years, such as the collapse of international mobility during the Covid-19 pandemic and the war in Ukraine, demonstrated the limits of quantitative predictions and could not have been anticipated using the available models.

Detecting the signs of impending escalation and assembling an overview of the situation is the task of crisis early warning. The quantitative models used to predict migration build on information from crisis early warning to calculate the probability of future movements. To return to the example of Ukraine, the idea that algorithmic models could have supplied actionable information on major refugee movements before the fighting even started is simply illusory. On the other hand, once it had broken out, it was certainly plausible to apply quantitative models developed in other contexts to the Ukraine situation in order to elicit information about potential internal and cross-border refugee movements.

Ultimately the hope that such models will reliably predict fluctuations in migration rests on an assumption that lack of data was the principal problem in the past. In fact, if we reconstruct the developments leading up to the so-called European "refugee crisis" of 2015, it is clear that there was no shortage of indications of a significant increase in migration from Jordan, Lebanon and Turkey towards the EU. What was lacking was political attentiveness for the impending signs.

3 For meteorology see Elliot Jacks et al., *Guidelines on Early Warning Systems and Application of Nowcasting and Warning Operations*, WMO/TD, no. 1559 (Geneva: World Meteorological Organization [WMO], 2010).

Methodologies

So how promising are attempts to predict irregular migration? Despite important deficits in the data, migration is an eminently quantifiable phenomenon, and the trends in global refugee numbers and migration to the EU are widely discussed in the public sphere. It would be mistaken, however, to deduce from this that migration is especially suitable for forecasting, still less comparable to a phenomenon like climate change. Simply projecting past and/or current migration trends into the future will not supply meaningful results. On the other hand, more sophisticated models that take into account the complex influences of economic, political, social and environmental factors on individual migration decisions are methodologically and empirically highly challenging.[4]

Predictions of crisis-driven migration movements are subject to both epistemic and aleatoric (chance) uncertainties.[5] For instance epistemic uncertainties concern the forces that influence irregular migration, how those forces develop, the quality and quantifiability of the data, and the validity of the explanatory models. And then there are the unforeseeables: To what extent is migration influenced by random events and therefore unpredictable? In other words, epistemic uncertainty represents lack of knowledge about the processes, while aleatoric uncertainty reflects their inherent randomness.[6] When predicting irregular migration, we must always consider how — with what approaches and methods — the epistemic uncertainties can at least be reduced.

Migration – too complex to predict?

The difficulty of predicting migration is a long recognised scientific and political problem.[7] There are two principal reasons for this:

Firstly, forced displacement and migration are so-called "wicked problems": phenomena whose complexity and dynamism makes them inherently difficult to explain and predict. A large proportion of migratory movements are caused not by slow structural changes but by sudden events such as the Arab Spring, the war in Syria, the Russian invasion of Ukraine or the resumption of civil war in Sudan. Events of that nature can cause hundreds of thousands of people to migrate in a short space of time. In other words, migration is strongly contextual. There are many theories about forced displacement and migration, but no broad validated consensus on what the influencing factors are or how they should be treated in forecasting.[8]

Different theories lead to different assumptions, upon which different forecasting models are then based. Until the 1980s for example, simple push-pull models were widespread, differentiating between push factors acting in the country of origin and pull factors emanating from the destination. A growing realisation that these factors were often interlinked and analytically inseparable led to the development

4 Mathias Czaika and Constantin Reinprecht, *Drivers of Migration: A Synthesis of Knowledge*, IMI Working Papers, no. 163 (Oxford: International Migration Institute [IMI], April 2020).

5 Jakub Bijak and Mathias Czaika, *Assessing Uncertain Migration Futures: A Typology of the Unknown*, Deliverable, no. 1.1 (Southampton and Krems: University of Southampton and Danube University Krems, June 2020).

6 Ibid., 4.

7 Frans Willekens et al., "International Migration under the Microscope", *Science* 352, no. 6288 (2016): 897—99; Richard E. Bilsborrow et al., *International Migration Statistics. Guidelines for Improving Data Collection Systems* (Geneva: International Labour Organization [ILO], 1997); Jakub Bijak and Arkadiusz Wiśniowski, "Bayesian Forecasting of Immigration to Selected European Countries by Using Expert Knowledge", *Journal of the Royal Statistical Society: Series A (Statistics in Society)* 173, no. 4 (2010): 775—96.

8 On the latest research into the causes of displacement, see Fachkommission Fluchtursachen, *Krisen vorbeugen, Perspektiven schaffen, Menschen schützen. Bericht der Fachkommission Fluchtursachen* (Berlin, 2021), https://www.fachkommission-fluchtursachen.de/fileadmin/user_upload/pdfs/FK-Fluchtursachen-Bericht-2021.pdf (accessed 7 November 2022).

of more complex models based on the "aspirations-capabilities framework".[9] These more complex models treating migration and forced displacement as a function of those two factors, and examining how they are influenced by macrostructural change, contributes to understanding the complex and often counterintuitive ways in which social change and development shape patterns of migration.

The second reason is that quantitative forecasts rely almost entirely on administrative sources, and the international data on (forced) displacement and migration remains sorely inadequate. Many countries fail to gather or publish central statistics on arrivals, departures and relocations. In cases where data is published it is often incomplete, based on incompatible definitions, or insufficiently disaggregated by core criteria such as gender and age.[10] All these factors stand in the way of more precise forecasting.

Despite these obstacles, efforts to predict migration movements are growing. Three developments in particular have injected new energy into migration prediction. Firstly, new and improved data is available, including mobile phone and digital data, and official statistics are more accessible, for example via internet platforms. Secondly, new methods of statistical analysis are emerging, including AI applications.[11] Thirdly, growing migration confronts governments with considerable challenges and generates growing demand for evidence-based policy recommendations.[12] Yet the results of forecasting efforts to date have been mixed at best and frequently disappoint the expectations of political decision-makers.

Core approaches and methods

Forecasting, foresight, prediction, early warning: the multitude of terms used to describe efforts to anticipate future developments reflects the heterogeneity of the methodological approaches. In the following we use *prediction* as the umbrella term. Prediction can take the form of *forecast* or *foresight*. A forecast is understood as a quantifiable estimate of the size of a migration movement occurring with a specific probability during a defined future period, while foresight refers to the largely qualitative and narrative preparation of scenarios that draw attention to the key factors influencing migratory movements and seek to anticipate future behaviour. While forecasts supply information for operational planning and execution, foresight is productive for long-term strategic planning and exploration of possible future developments. The two approaches employ different data sources, time horizons and methods.

Data sources

The complexity of methods such as machine learning and econometric and stochastic (Bayesian) modelling-can easily distract from the fact that although methodological progress and technical innovations can make predictions more precise, the robustness of the findings always remains constrained by the data upon which they are based. Incomplete or missing data and tendentious or implausible expert opinions reduce the reliability of forecasts. However, the question of data quality is not adequately reflected in the day-to-day business of politics. This can present a risk for the political acceptance of predictive methods.

Data quality is overlooked in everyday politics.

In contrast to foresight, forecasts are generally based on numerical data that has been gathered systematically over a particular period. The longer the period the more precise the forecast. Dependable (statistical) forecasts frequently require data covering a span of ten to twenty years. But shorter periods may be sufficient when forecasting by the quarter, month or day. The required data relates principally to the historical development of the indicator of interest: numbers of people displaced, border crossings, immigration, emigration, visa applications and asylum applications, as well as survey data on intention to migrate.

Forecasts are generally based on migration-related data gathered by state agencies. This includes administrative data from population registers, border police, and asylum and visa statistics. Census data is also important, providing overall information on the num-

9 Hein de Haas, "A Theory of Migration: The Aspirations-Capabilities Framework", *Comparative Migration Studies* 9, no. 1 (2021): 8.

10 Willekens et al., "International Migration under the Microscope" (see note 7).

11 Carl Friedrich Gethmann et al., *Künstliche Intelligenz in der Forschung*, Ethics of Science and Technology Assessment, vol. 48 (Berlin: Springer Nature, 2021).

12 Joint Research Centre, *Data Innovation in Demography, Migration and Human Mobility: Opportunities and Challenges of Non-traditional Data* (Luxembourg, 2022), 3.

Figure 1

Quantitative forecasting approaches

bers and characteristics of new arrivals. In the context of displacement and humanitarian disasters, where state actors often lack the political will or technical ability to gather data on migration movements, international organisations frequently step in. The two most important are the Office of the United Nations High Commissioner for Refugees (UNHCR) and the International Organisation for Migration (IOM). Data gathering by NGOs on the ground is often relevant too. In addition, the use of mobile phone and digital data is increasing, for example tapping Google search data and social media to assess the size of migration movements.[13] Depending on the specific forecasting method, other migration-relevant information may be taken into account: data on political conflicts, natural disasters, weather and climate, GDP and balance of trade, labour market trends, and education, as well as demographic indicators (such as birth and mortality rates). The inclusion of contextual data (for example survey data on employers' labour needs) can also enhance forecasts.

In the case of foresight, on the other hand, the central aspect is the expert opinion. The output of foresight may be quantitative, or it may take the form of qualitative information on the general trend and/or the extent and direction of a migration movement.[14] "Qualitative" does not mean that quantitative data is excluded, but merely that it does not form the exclusive basis for the prediction. Experts are generally drawing on a multitude of quantitative indicators to form their assessments. Qualitative approaches tend to be less formalised than quantitative.

Time horizons

The time horizon of a forecast is a function of the available data and the users' needs. It may be as short as a few days or as long as several decades (see Figure 1).

Nowcasting enhances situational awareness and seeks to predict the course of migration events as they happen. Generally there is a certain delay before migration data is published. Nowcasting fills that gap by predicting developments weeks, days or mere hours ahead. The approach is widely used in meteorology, where the weather is frequently forecast on an hour-by-hour basis, but is increasingly also applied in the field of migration. One example is the attempts to predict displacement driven by natural disasters and political upheavals on a day-by-day basis.[15] Short-term forecasts in the range of weeks and months fall under early warning; their purpose is to ensure that the relevant actors are prepared.[16] Migration forecasting tools

13 Jasper Tjaden, "Measuring Migration 2.0: A Review of Digital Data Sources", *Comparative Migration Studies* 9, no. 1 (2021); Marcus H. Böhme et al., "Searching for a Better Life: Predicting International Migration with Online Search Keywords", *Journal of Development Economics* 142, no. 102347 (2020); Nina Cesare et al., "Promises and Pitfalls of Using Digital Traces for Demographic Research", *Demography* 55, no. 5 (2018): 1979–99; Alina Sîrbu et al., "Human Migration: The Big Data Perspective", *International Journal of Data Science and Analytics* 11, no. 4 (2021): 341–60.

14 Eduardo Acostamadiedo et al., *Assessing Migration Scenarios for the European Union: Relevant, Realistic, and Reliable?* (Berlin: IOM, 2020); Rhea Ravenna Sohst et al., *The Future of Migration to Europe: A Systematic Review of the Literature on Migration Scenarios and Forecasts* (Berlin: IOM, 2020).

15 Ayaka Oishi et al., "Forecasting Internally Displaced People's Movements with Artificial Intelligence", in *Digital Innovations, Business and Society in Africa*, Advances in Theory and Practice of Emerging Markets, ed. Richard Boateng et al. (Cham: Springer International Publishing, 2022), 311–39.

16 Early warning systems that issue a warning when predefined thresholds are exceeded and a humanitarian disaster is likely are increasingly widely used in the humanitarian aid sector. Donor countries also use early warning systems for their operational planning and budgeting, in particular

generally have a time horizon of a few months to a few years and serve operational planning. Longer-term estimates of migration movements may cover multiple decades on the basis of demographic trends.

Estimation methods

Various estimation methods are used to derive actionable conclusions from existing information and data. Statistical forecasts tend to be methodologically complex; their preparation and interpretation demand significant expertise.[17] The most widely used methods are time series analysis and gravity models, while innovations such as agent-based modelling and machine learning algorithms are currently attracting much attention. The methods employed for foresight are equally diverse. The principal distinguishing features are how the participating experts arrive at their assessments, what information is available to them, and whether they arrive at conclusions individually or work as a collective.

Forecasts

Time series analysis is one of the most widely used predictive methods, for example for weather forecasting and predicting share prices. Essentially it extrapolates the experience of the past into the future. Time series analyses are based on existing information about the variable of interest. In the case of migration that might mean the number of displaced persons at a particular place. They tend to lend greater weight to more recent data and can take into account seasonal trends, one-off events and expert opinions.[18]

Gravity models are widely used econometric regression models that apply the logic of Newton's law of gravity to economic and social phenomena. The hypothesis is that masses attract one another with a force proportional to the sum of their masses. Migration data reveals similar patterns. Countries that are more attractive to migrants, for example on account of their GDP, experience greater immigration. But migration movements decrease in proportion to the geographical distance between countries. Gravity models can be incrementally expanded and are often used to predict migration in relation to various characteristics of the source and destination countries.[19]

Agent-based modelling (ABM) simulates complex systems on the basis of the behaviour of individuals (agents). In connection with migration ABM predicts movements by modelling how individuals with different characteristics behave in different contexts. It can thus be used to estimate how many displaced persons will arrive in particular places, for example following an outbreak of armed conflict.[20]

Machine learning algorithms (ML) represent a subfield of artificial intelligence whose use in the field of migration is also expanding. The forecast generally unfolds in several steps. First data on past migration movements is used to create training datasets. Then various algorithms are tested to identify which best replicates the known movements for particular periods in the past. Finally, the most successful model is used to predict future migration movements (the actual migration forecasting). One drawback of these models is that their training datasets are generally context-specific and therefore not transferable to other situations.

Many ML algorithms are "agnostic", meaning that the researchers make no prior assumptions about which factors most strongly influence migration. The system ascertains autonomously which information is (most) relevant. ML algorithms are especially useful

for forecast-based financing (anticipatory financing). See E. Coughlan De Perez et al., "Forecast-based Financing: An Approach for Catalyzing Humanitarian Action Based on Extreme Weather and Climate Forecasts", *Natural Hazards and Earth System Sciences* 15, no. 4 (2015): 895—904.

17 George Disney et al., *Evaluation of Existing Migration Forecasting Methods and Models: Report for the Migration Advisory Committee* (Southampton: University of Southampton, 2015); Sulin Sardoschau, *The Future of Migration to Germany: Assessing Methods in Migration Forecasting*, DeZIM Project Report, no. 1 (Berlin: DeZIM, 2020); Tobias Heidland et al., *Analyse und Prognose von Migrationsbewegungen*, Kieler Beiträge zur Wirtschaftspolitik, no. 34 (Kiel: Institut für Weltwirtschaft, May 2021).

18 Bijak and Wiśniowski, "Bayesian Forecasting of Immigration" (see note 7); Jakub Bijak, *Forecasting International Migration in Europe: A Bayesian View*, The Springer Series on Demographic Methods and Population Analysis, vol. 24 (Dordrecht: Springer Netherlands, 2011), doi: 10.1007/978-90-481-8897-0.

19 Heidland et al., *Analyse und Prognose von Migrationsbewegungen* (see note 17); Michel Beine et al., "A Practitioners' Guide to Gravity Models of International Migration", *The World Economy* 39, no. 4 (2016): 496—512.

20 Christa Searle and Jan H. van Vuuren, "Modelling Forced Migration: A Framework for Conflict-induced Forced Migration Modelling According to an Agent-based Approach", *Computers, Environment and Urban Systems* 85, no. 101568 (2021); Diana Suleimenova et al., "A Generalized Simulation Development Approach for Predicting Refugee Destinations", *Scientific Reports* 7, no. 1 (2017).

where abundant data is available but clear theories or hypotheses concerning the relationships between variables are lacking.[21] One potential problem with ML approaches is that it is often impossible to identify which factors were decisive for a specific outcome and how they were weighted (the so-called black box effect).[22]

Foresight

Foresight typically involves ad-hoc assessments prepared by experts. In order to represent a broader spectrum of opinions, bodies such as committees and advisory boards may also be consulted. Formalised foresight approaches employ a multitude of methods, including scenario development, the Delphi method, prediction markets and role play.

Scenario development is a widely used method. First of all, the most important factors influencing the migration movements of interest are identified.[23] The next step is to prioritise the central factors, often using a two-by-two matrix. Now the effects of each combination of two influencing factors are discussed. The primary objective of scenario development is not to precisely predict future developments, but to gain a better understanding of how specific courses of action may interact with broader societal trends, and what long-term effects this may produce. The process of scenario development can contribute to revealing the participants' implicit assumptions, making them aware of possible future scenarios and thus enabling anticipatory policy-making.[24]

The *Delphi method* is a technique for promoting the emergence and clarification of a consensus about a foresight question among a group of experts.[25] In the first round the participants outline their views on the future development of a migration trend, frequently also stating concrete numbers. The next round is a structured discussion where the participants are confronted with their colleagues' responses. This process, like scenario development, brings implicit assumptions to light, reveals the spectrum of opinions, and builds a consensus on the most likely scenarios.

Participants in prediction markets trade financial bets on the outcome of a specific scenario. In other words, they compete with each other for the most exact estimate. Certain studies suggest that this method produces better predictions than more conventional methods.[26]

Role playing begins by identifying all relevant actors capable of influencing the migration movements of interest. Their roles are distributed among the participants, who seek to represent their interests and anticipate their behaviour. This approach promises a better understanding of future migration as a consequence of interactions between actors.

In addition to those outlined above, there are many other variants of foresight, including Causal Layered Analysis,[27] Horizon Scanning[28] and Stress Testing[29] to name but three.

Advantages and drawbacks of prediction methods

There is no academic consensus about the best forecast and foresight methods. The choice of method depends strongly on the required time horizon and the availability of data and resources. Nevertheless, it is possible to summarise key strength and weaknesses of the different methods to help decision-makers to choose a method suitable for their aims, and/or to interpret the results produced by a specific approach (see Table).

21 Spyros Makridakis et al., "Statistical and Machine Learning Forecasting Methods: Concerns and Ways Forward", *PloS One* 13, no. 3 (2018).

22 Yavar Bathaee, "The Artificial Intelligence Black Box and the Failure of Intent and Causation", *Harvard Journal of Law and Technology* 31, no. 2 (2018): 890–938.

23 Sohst et al., The Future of Migration to Europe (see note 14).

24 Rhea Ravenna Sohst and Jasper Tjaden, "Forecasting Migration: A Policy Guide to Common Approaches and Models", *Migration Policy Practice* 10, no. 4 (2020): 8–13.

25 Acostamadiedo et al., *Assessing Migration Scenarios for the European Union* (see note 14).

26 Kenneth J. Arrow et al., "Economics: The Promise of Prediction Markets", *Science* 320, no. 5878 (2008): 877–78; Philip E. Tetlock and Dan Gardner, *Superforecasting: The Art and Science of Prediction* (London: Random House, 2016).

27 Sohail Inayatullah and Ivana Milojević, eds., *CLA 2.0.: Transformative Research in Theory and Practice* (Tamsui: Tamkang University Press, 2015).

28 European Commission, *Models of Horizon Scanning: How to Integrate Horizon Scanning into European Research and Innovation Policies* (Brussels: Publications Office of the European Union, 2016).

29 UK Government Office for Science, *The Futures Toolkit: Tools for Futures Thinking and Foresight Across UK Government*, November 2017 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/674209/futures-toolkit-edition-1.pdf

Table

Forecasting and foresight

	Advantage	*Disadvantage*
Forecast (quantitative)	■ Produces quantifiable and easily interpretable, actionable predictions. ■ Frequently formalised and replicable. ■ Permits statements on the degree of uncertainty. ■ Can include many influencing factors.	■ Potentially a black box, where reasons for predictions are not apparent. ■ Requires high volume and standard of data. ■ Demands methodological expertise. ■ Is context-poor. ■ Mainly suitable for short-term predictions
Foresight (qualitative)	■ Potentially participatory. ■ Expands horizons and promotes long-term strategic planning. ■ Requires little prior knowledge. ■ Requires few resources. ■ Permits inclusion of unquantifiable influencing factors.	■ Relatively unformalised and largely unreplicable. ■ Typically used for longer time horizons that are less relevant for operational decisions. ■ Relies on subjective opinions of participating experts. ■ Provides no information about the degree of uncertainty. ■ Often unclear how experts arrive at their findings.

One growing trend in forecasting is to combine different (quantitative and qualitative) methods and data in such a way that the strengths of each compensate the weakness of the other. In particular, the differences between statistical models and expert opinions can sharpen our understanding of migration developments. Statistical models may identify developments missed by the experts, while qualitative methods can validate and contextualize quantitative forecasts.

Growing interest in improving migration forecasting — especially after the high level of immigration of 2015/16 — has led the EU and its member states to invest in numerous related initiatives, research projects and pilot projects. Nevertheless the research field is still in an explorative and experimental phase.

Predicting Irregular Migration in Practice

The preceding overview of approaches and methods of migration prediction demonstrates how diverse the spectrum has become. At the same time, many of the quantitative approaches discussed in academic contexts are very complex and demanding — especially the innovative approaches based on machine learning. The measure of their practical utility must be the extent to which they contribute to political decision-making processes and lead to better outcomes. In order to judge this we need a more precise understanding of the needs and applications of quantitative migration predictions, as well as knowledge about the relevant actors and their instruments.

Needs and fields of application

Broadly speaking, there are three fields of application for predictions of forced displacement and irregular migration: (1) boosting national reception capacity when rising numbers of refugees are expected; (2) adapting border security and management to meet predicted challenges; and (3) anticipatory planning of humanitarian aid (and increasingly also development cooperation) in the context of crisis-driven migration the so-called Global South. In all three areas the efficient use of scarce resources is a central challenge. Quantitative forecasting tools in particular promise better orientation and greater planning security.

Boosting reception capacity

The arrival of refugees is associated with obligations to be fulfilled by the state, especially where asylum applications are involved. In the EU context for example various directives require member states to observe minimum standards in housing, basic medical care, access to education and asylum procedures.[30] When a country is confronted with a larger number of refugees within a short period of time, as was the case in Germany in 2015/16 and again in 2022, the state structures will inevitably experience major logistical and administrative challenges. EU member states have repeatedly underlined to the EU Commission that they expect precise, up-to-date information about expected migration movements and national reception capacity — especially during crises. The uppermost question is often whether the existing capacity will suffice to cope with the challenges.[31]

Adjusting reception capacity is a complex business. In Germany it involves multiple actors at the national, state and local government levels. As well as administrative capacity, physical infrastructure also has to be adapted. Apart from rapid provision of emergency accommodation, this will often involve increasing the number of places in language and integration courses, schools and nurseries, employing additional personnel to process asylum applications, and in the medium term also in the court system to deal with appeals against asylum decisions. On top of this comes the expansion of capacity for recognising qualifica-

30 In particular the Reception Conditions Directive ("Directive 2013/33/EU of the European Parliament and of the Council of 26 June 2013 laying down standards for the reception of applicants for international protection (recast)", *Official Journal of the European Union*, L 180/96, 29 June 2013, https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:180:0096:0116:EN:PDF) and the Asylum Procedures Directive ("Directive 2013/32/EU of the European Parliament and of the Council of 26 June 2013 on common procedures for granting and withdrawing international protection (recast), *Official Journal of the European Union*, L 180/60, 29 June 2013, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013L0032&qid=1692105245851).

31 Background conversation with a representative of the Directorate-General for Migration and Home Affairs (DG Home), March 2022.

tions acquired abroad, planning longer-term accommodation, and labour market integration. All these fields ultimately involve the distribution of scarce financial resources. Germany for example experiences recurring conflicts over funding between the different levels of government. The strong fluctuations in arrivals also raise the question of whether and where it makes sense to keep additional capacity in reserve for a potential new spike and what happens to the capacity created in response to crisis when it is no longer required.

Investment in improving quantitative forecasting of irregular migration and asylum applications is frequently based on an expectation that better predictions will expand the planning horizon for the necessary tasks, allowing resources to be deployed more effectively. This would help to avoid overstretching state structures, with all the associated negative effects on individuals and society as a whole.

Border security

In the case of border security and management, it is hoped that quantitative predictions will allow the physical border installations and personnel to be adapted to meet expected challenges.

Increased capacity at the border can serve to prevent immigration – or to protect human rights.

The level of border reinforcement considered adequate in the event of increasing irregular migration will depend on context and political standpoint. Fundamentally, increased capacity at borders can serve both to prevent immigration and to protect human rights. The latter applies for example where maritime patrols are conducted primarily for purposes of search and rescue or additional border guards are used to ensure that asylum applications are accepted and processed. But in contemporary European practice the objective is generally to deter unwanted arrivals.

Against this background, forward planning of border infrastructure is often a matter of expanding surveillance technologies, for example with drones and infra-red cameras, and externalising control measures to third states in order to stop irregular migration towards the EU. The latter case generates particular interest in precise geographical localisation of predicted migration movements in order to be able to target spending on additional surveillance measures in specific border sections or in third states. The EU member states have an elevated interest in developments along the various migration routes to the EU and have in recent years systematically expanded their monitoring, including through Frontex.[32]

Humanitarian aid and development cooperation

Acute displacement events often create immense logistical challenges for humanitarian aid. Needs must be identified, funding acquired, aid delivered where it is required and distributed to those requiring it. All these tasks have to be accomplished under time pressure. Their planning is always based on estimates of numbers of arrivals. While such estimates are routinely prepared by helpers working on the ground, there is also a place for quantitative forecasting tools capable of supplying actionable findings and expanding the planning horizon.[33] Forecasts with a time horizon of a few days or weeks serve primarily to ensure that adequate resources are available to provide housing, nutrition and medical care. Predictions with longer time horizons can identify and draw attention to the burdens borne by receiving communities and guide development measures. There is also growing demand for migration predictions in connection with the ever-growing challenges associated with human mobility in the context of climate change — for example to prepare contingency plans for cities in coastal regions that are especially vulnerable to flooding.

In view of the great practical relevance it is no surprise to find that the humanitarian sector is at the forefront of research and innovation in migration prediction. Numerous quantitative forecasting models have been developed, most of them for the purpose of documenting and analysing patterns of forced dis-

32 Frontex publishes regular quarterly and annual reports on developments along the migration routes to the EU, in which it assesses the associated security risks from its own perspective. The flagship is the annual "Risk Analysis" published each autumn; most recently Frontex, "Strategic Risk Analysis 2022" (Warsaw, July 2022), https://frontex.europa.eu/assets/Publications/Risk_Analysis/Risk_Analysis/Strategic_Risk_Analysis_2022.pdf (accessed 15 November 2022).

33 Katherine Hoffmann Pham and Miguel Luengo-Oroz, "Predictive Modelling of Movements of Refugees and Internally Displaced People: Towards a Computational Framework", *Journal of Ethnic and Migration Studies* 49, no. 2 (2023): 408—44 (409).

placement in specific countries, regions and cities.[34] This approach allows specific contextual factors to be included and ensures a close fit with the respective case. Conversely, transferability to other geographical contexts is generally limited.

The three outlined areas of application of migration prediction are not necessarily sharply differentiated in practice. Overall the demand for quantitative forecasts is growing, with an increasingly diverse set of actors engaged in the development of prediction tools.

Actors and instruments

Quantitative predictions about future migration movements are far from new. But in the past they were based largely on relatively simple extrapolation of existing trends. In recent years this has changed.

Initiatives at the national level

State actors have an inherent interest in anticipating irregular migration. How strong that interest is and how urgently robust predictions are felt to be required varies from country to country and depends on a multitude of factors. These include for example geographical location, current political context and institutional culture, as well as prior experience with quantitative predictions. In the European context Norway, Sweden, Switzerland and the United Kingdom were early adopters, already preparing systematic predictions of expected numbers of asylum applications in the early 2010s.[35] According to a survey by the European Migration Network (EMN) in 2020 in which most EU member states participated,[36] the governments of at least ten European states were regularly analysing the development of future migration trends including irregular migration. However the practical activities were largely restricted to preparing risk analyses and scenarios. Only three (Bulgaria, Poland and Sweden) reported using quantitative predictive tools.[37] According to a later survey in early 2022, three EU member states (Germany, Latvia and Lithuania) were planning to use AI-based models to forecast migration.[38]

In Germany interest in quantitative predictions increased noticeably after the large-scale immigration of 2015/16. That fits with German's comprehensive efforts to expand crisis early warning capacity and strategic foresight in its foreign and security policy.[39] To that end the German Federal Ministry of Defence began developing a machine-learning-supported crisis early warning instrument.[40] The German Foreign Office followed in 2020 with its own machine-learning-based instrument, "Preview", which searches publicly available data for early signs of crisis.[41] At the end of 2020 the two ministries agreed to deepen their collaboration on AI-based crisis early warning, above all by jointly funding the Centre for Crisis Early

34 Xin Lu et al., "Predictability of Population Displacement after the 2010 Haiti Earthquake", *PNAS* 109, no. 29 (2012): 11576–81; Benjamin Q. Huynh and Sanjay Basu, "Forecasting Internally Displaced Population Migration Patterns in Syria and Yemen", *Disaster Medicine and Public Health Preparedness* 14, no. 3 (2020): 302–07; John A. Sokolowski et al., "Modeling Population Displacement in the Syrian City of Aleppo", *Proceedings of the Winter Simulation Conference 2014*, (2014): 252–63.

35 Jakub Bijak et al., *Quantitative Assessment of Asylum-related Migration: A Survey of Methodology* (Luxembourg: Publications Office of the European Union, August 2017), https://euaa.europa.eu/sites/default/files/publications/Quantitative_assessment_of_asylum_related_migration_1.pdf (accessed 9 November 2022).

36 Non-member Norway participated; Denmark, Greece, Italy and Romania did not.

37 European Migration Network, *Ad-Hoc Query on Forecasting Methods That Inform Policy Making at EU and National Level*, EMN Ad-Hoc Queries, no. 49 (Brussels: European Commission, September 2020), https://www.emnnetherlands.nl/sites/default/files/2020-10/WIDER%202020.49%20Forecasting%20methods%20that%20inform%20policy%20making%20at%20EU%20and%20national%20level.pdf.

38 European Migration Network, *The Use of Digitalisation and Artificial Intelligence in Migration Management*, EMN-OECD INFORM (Brussels, February 2022), 11f.

39 Die Bundesregierung, *Krisen verhindern, Konflikte bewältigen, Frieden fördern. Leitlinien der Bundesregierung* (Berlin, 2017); idem., *Krisen verhindern, Konflikte bewältigen, Frieden fördern: Bericht über die Umsetzung der Leitlinien der Bundesregierung* (Berlin, March 2021), https://www.auswaertiges-amt.de/blob/2451522/d63bc74e7deedbccd83872f674c83eca/210330-umsetzungsbericht-krisenleitlinien-data.pdf.

40 "Blick in die Zukunft: Big-Data-Software für die Bundeswehr", *bundeswehr-journal* (online), 2 June 2018, https://www.bundeswehr-journal.de/2018/blick-in-die-zukunft-big-data-software-fuer-die-bundeswehr/.

41 Auswärtiges Amt, "Krisenfrüherkennung, Konfliktanalyse und Strategische Vorausschau" (Berlin, 7 February 2020), https://www.auswaertiges-amt.de/de/aussenpolitik/krisenpraevention/-/2238138 (accessed 5 June 2023).

Warning at the University of the Bundeswehr in Munich, to conduct "quantitative crisis and conflict research using innovative conceptual and methodological approaches".[42] Forced displacement and migration are not the central focus of these activities, but are treated as factors relevant to the broader security picture.[43]

In Europe Germany is seen as a pioneer of migration prediction.

Germany's response to the aforementioned EMN survey on forecasting methods mentions the Foreign Office's Preview instrument without specifying what it contributes to forecasting forced displacement and migration. The German response to the EMN survey was the only one to state that the current practice of foresight failed to satisfy political needs, or to propose developing better instruments. This indicates the German government's level of ambition in this area — which has in the meantime gained it a reputation as a pioneer in the field of migration predictions in Europe.[44] That effort is also reflected in public-facing activities, such as a workshop on forecasting human mobility in contexts of crisis organised jointly by IOM and the German Foreign Office in autumn 2019.[45] Further evidence of the German government's commitment to making progress in this field include the Federal Ministry of the Interior's initiative "Migration 4.0 — Digital Transformation in the Field of Migration Management" during the German EU Council Presidency in the second half of 2020 and the ongoing expansion of capacity in various ministries and government agencies.[46]

In the German context, the Foreign Office and the Ministry of Defence, the Foreign Intelligence Service (BND), the Chancellery, the Interior Ministry, the Federal Office for Migration and Refugees (BAMF) and the Joint Analysis and Strategy Centre for Illegal Migration (GASIM) are all involved in observing migration movements and analysing trends. These analyses are largely based on insights from statistical records of past events (from which for example patterns of seasonal migration can be derived); from data on current movements gathered by UNHCR, IOM and Frontex; and from qualitative assessments by liaison officers in relevant third states. But these findings have not to date been systematically integrated. While GASIM regularly provides situational reports, there is no systematic forecasting of forced displacement and irregular migration.

That deficit is now to be rectified. On behalf of the Federal Ministry of the Interior, BAMF is developing a new IT-based instrument for predictive migration analysis. Its objectives comprise preparing global analyses of the migration situation and scenarios on future migration potential from relevant countries of origin and transit, "in order for preventive support measures to take effect as quickly as possible".[47] The core intention is to anticipate migration movements in the medium term.

A multitude of data from public administrations and other sources will feed into this instrument. It currently follows a time horizon of six months, but this could be extended to twelve to fit better with political planning cycles. The instrument should offer both situational pictures and predictions, pursuing a global approach but placing its focus on asylum-relevant regions to the extent permitted by the data.

A three-stage method will be applied, with the first stage concentrating on the situation in countries of origin and supplying an AI-supported representation of migration trends there with a time horizon of about six months. In the second stage the observations will be enriched with qualitative information

42 CCEW website, https://www.unibw.de/ciss-en/kompz-kfe/.

43 Although the two ministries use similar algorithms, the approaches differ. In the Foreign Office's analyses migration movements are treated as a type of crisis to be predicted. In the Defence Ministry's version they are handled more indirectly as a driver of crisis. The two instruments also differ in their degree of transparency. The Defence Ministry's tool offers an overview of the factors that contribute to a specific outcome and reveals how these have been weighted.

44 Background conversations with representatives of the EUAA and the EU Commission, March 2022.

45 The UN Migration Agency, *Workshop Report on Forecasting Human Mobility in Contexts of Crises: Berlin, 22–24 October 2019* (Berlin: Global Data Institute, 2019), https://dtm.iom.int/sites/g/files/tmzbdl1461/files/reports/17022020%20FFO-IOM%20Workshop%20on%20Forecasting%20Human%20Mobility%20in%20Contexts%20of%20Crises.pdf.

46 Bundesministerium des Innern und für Heimat, "Startschuss für 'Migration 4.0 — Digitale Transformation im Bereich Migrationsmanagement'" (Berlin, 23 July 2020), https://www.bmi.bund.de/SharedDocs/kurzmeldungen/DE/2020/07/migration-4-0.html (accessed 5 June 2023).

47 Bundesamt für Migration und Flüchtlinge, *Entscheiderbrief 07/2021* (Nuremberg, July 2021), 7.

on migration routes, people-smuggling networks and so-called pull factors. Finally, in the third stage plausible scenarios will be developed on the basis of that data, with the participation of BAMF, the Federal Police Force and potentially other actors.[48] In other words it involves a systematic linkage of quantitative and qualitative approaches in order to generate more reliable scenarios on future migration potential. The ultimate goal is to create a situational picture that is relevant for the entire government.

Improving predictions will require systematic linkage of quantitative and qualitative approaches.

This quantitative model is being developed with the support of an external provider and in close coordination with the German Foreign Office and the Defence Ministry. The Centre for Crisis Early Warning at the University of the Bundeswehr in Munich possesses considerable methodological expertise in the development of AI-based forecasting models and plays an important role in the coordination process. The new instrument cannot be expected to become operational immediately, but given the strong demand efforts are under way to achieve this in the medium term.

All in all the potential applications of migration prediction are diverse. Domestically they can give national and subnational authorities a better understanding of the situation and indicate future reception and integration needs. And they can feed into political decisions on strengthening border protections or establishing humanitarian reception programmes. In the work of the relevant ministries, and in the coordination process between the EU member states, there are often questions as to whether liaison officers and projects are deployed to best effect. One lesson BAMF learned from the events of 2015/16 was to deploy its own personnel more flexibly. Staff working outside the field of asylum now receive training preparing them to switch roles in the event of a sharp increase in asylum applications. Reliable scenarios and situational pictures would make it possible to initiate such a temporary reallocation of personnel quickly enough to avoid backlogs in the processing of asylum claims. The planned combination of quantitative and qualitative approaches in the BAMF instrument for predictive migration analysis reflects the latest research findings on effective forecasting. If the new instrument is ready to launch soon that would confirm the existing external perception of the German government as a frontrunner in the field of migration prediction. It remains open whether the new BAMF instrument will be emulated in other European states or at the European level.

European initiatives

At the European level too, interest in AI-based migration prediction has grown strongly since 2015/16. The central actors are the European Border and Coast Guard Agency (Frontex) and the European Union Agency for Asylum (EUAA, formerly European Asylum Support Office, EASO). For the past few years the EU Commission has also been investigating the potential for an EU-wide migration forecasting instrument.

The EU Agency for Asylum

Within the EUAA, the Data Analysis and Research Sector (DARS) is responsible for predicting the development of asylum applications in the EU member states, Norway and Switzerland. DARS is a subdivision of the Situational Awareness Unit of the Asylum Knowledge Centre of EUAA and currently employs about twenty staff.[49] The tasks of DARS range from early warning and strategic analysis to migration prediction. In these areas DARS is involved in gathering, bundling and distributing relevant data and improving models and instruments.

Its spectrum of products and services is broad. First of all, EUAA supports the exchange of asylum-related data among the EU member states, Norway and Switzerland. Its Early Warning and Preparedness System (EPS), established in 2012, gathers disaggregated data on nineteen indicators, from asylum applications to resettlement.

Another line of research is the compilation, analysis and verification of factors that influence asylum-related migration to the EU, for which the EUAA has created the Push Factor Index (PFI). Based on an analysis of media reports from the Global Database of

48 Background conversation with a representative of BAMF, March 2022.

49 European Asylum Support Office (EASO), *Single Programming Document: Multi-annual Programming 2022–2024: Work Programme 2022, Revision 1* (Valletta, 20 December 2021), 3, https://euaa.europa.eu/sites/default/files/SPD_2022-24_Rev_1_final.pdf (accessed 16 November 2022).

Events, Language, and Tone (GDELT),[50] the PFI brings together information on disruptive political, economic and social factors on a country-by-country basis.[51]

Seeking to create a reliable early warning and prediction instrument, the EUAA has developed an AI-supported model that seeks to account for the complexity of migration processes and the interactions of the many relevant factors. The PFI is an important component of this model. It is supplemented with additional data that is indicative of migration intentions, including analyses of Google Trends on migration and asylum in the respective countries of origin, information on irregular border crossings derived from Frontex data, and information provided by the EU member states, Norway and Switzerland about numbers of asylum applications and recognition rates for specific nationalities. This innovative approach "models individual country-to-country migration flows separately and on moving time windows".[52]

This allows characteristics of the migration relationships between two countries to be taken into account and the changing significance of individual influencing factors to be followed. Initially the model functions as an early warning system in the event of significant changes to influencing factors in specific countries (for example concerning conflict intensity or internet searches). On that basis the EUAA issues quarterly early warning reports that draw political attention to relevant developments. In a second step the model predicts the number of future asylum applications by individual nationalities in European countries for four-week periods. A simulation using the model to "predict" past migration movements demonstrated that it is more accurate than its predecessors. Despite these promising results, the instrument is regarded as "work in progress" within the EUAA, and too unreliable to share the concrete forecasts with the EU Commission or the member states.[53] Instead the reports produced by the model are restricted to the relative significance of individual drivers of migration over time — which is essential for medium-term strategic planning.[54]

The EUAA's multi-annual programming for 2022 to 2024 proposed expanding the use of big data and new data sources to develop meaningful indicators and forecasting models. The decision to double the number of Country Intelligence Reports produced annually suggests that great importance continues to be placed on qualitative data.[55] It is also planned to involve partner organisations and the member states more closely in strategic foresight and scenario development.[56]

Frontex

The European Border and Coast Guard Regulation requires Frontex to "prepare general and tailored risk analyses based on a common integrated risk analysis model, to be applied by the Agency itself and by Member States".[57] The Common Integrated Risk Analysis Model (CIRAM) was introduced in the mid-2000s to promote information exchange and cooperation in the field of border security and to assist in the preparation of risk analyses.[58] Frontex discusses issues with experts from the EU member states in the Frontex Risk Analysis Network (FRAN), while third states participate in four regional networks.[59]

50 See The GDELT Project, "A Global Database for Society", https://www.gdeltproject.org/ (accessed 5 June 2023).

51 Constantinos Melachrinos et al., "Using Big Data to Estimate Migration 'Push Factors' from Africa", in *Migration in West and North Africa and across the Mediterranean: Trends, Risks, Development and Governance*, ed. International Organization for Migration (Geneva, 2020), 98—116, https://euaa.europa.eu/sites/default/files/ch08-using-big-data-to-estimate-migration.pdf (accessed 16 November 2022).

52 Marcello Carammia et al., "Forecasting Asylum-Related Migration Flows with Machine Learning and Data at Scale", *Scientific Reports* 12, no. 1457 (2022).

53 Background conversation with representatives of the EUAA, November 2022.

54 Anthony Albertinelli et al., "Forecasting Asylum-related Migration to the European Union, and Bridging the Gap between Evidence and Policy", *Migration Policy Practice* 10, no. 4 (2020): 35—41 (37).

55 EASO, *Single Programming Document* (see note 49), 117.

56 Ibid., 26.

57 "Regulation (EU) 2019/1896 of the European Parliament and of the Council of 13 November 2019 on the European Border and Coast Guard and repealing Regulations (EU) No 1052/2013 and (EU) 2016/1624", *Official Journal of the European Union*, L 295, 14 November 2019, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R1896.

58 Frontex, *Common Integrated Risk Analysis Model. Summary Booklet* (Warsaw, 2013), 3ff., https://frontex.europa.eu/assets/CIRAM/en_CIRAM_brochure_2013.pdf.

59 See Frontex, "Risk Analysis", https://frontex.europa.eu/what-we-do/monitoring-and-risk-analysis/risk-analysis/risk-analysis/ (accessed 5 June 2023).

Frontex conducts risk analysis, which is closely tied to scenario development.

Risk analysis is thus an important aspect of the work of Frontex, and is closely tied to scenario development. In Frontex's Risk Analysis Unit, which is a subdivision of its Situational Awareness and Monitoring Division, about seventy staff work on different formats of risk analysis and strategic foresight.[60] Frontex conducts early warning "impact level assessments" through the European border surveillance system EUROSUR.[61] The EU's external land and sea borders are divided into sections whose risk of irregular border crossing or cross-border crime is classed as critical, high, medium or low.[62] Warnings are shared with the members of Frontex's Management Board, the member states and the EU Commission, in order to enable the affected states to respond quickly, for example by increasing border personnel (with support from Frontex if required).

As well as this early warning function, which is tailored to rapid response, Frontex also prepares analyses to support one- to two-year planning cycles for material and human resources for border surveillance. Since 2020 Frontex has published biennial strategic risk analyses with a time horizon of ten years. Employing qualitative foresight methods in consultation with experts from the member states, the reports analyse the megatrends that appear relevant for European border surveillance in the coming years and develop scenarios for future developments. These biennial reports are shared with the EU Commission, which uses them to shape Frontex's strategic orientation. Frontex has been pursuing an interest in quantitative migration prediction for some years now,[63] and is developing an IT-supported model to forecast migration movements on relevant routes with a time horizon of roughly three months. There is, however, no publicly available information about the details of this instrument. One motivation for the project is that the immense amounts of data that Frontex accumulates through its border management functions increasingly exceed its capacity for human analysis.[64]

EU Commission

The Pact on Migration and Asylum published by the EU Commission in September 2020 contains a proposal for a Regulation addressing situations of crisis and force majeure in the field of migration and asylum (the Force Majeure Regulation) and a recommendation on an EU mechanism for preparedness and management of crises related to migration (the Migration Preparedness and Crisis Blueprint).[65] In both documents the Commission calls for efforts to improve forecasting to be stepped up. The Migration Preparedness and Crisis Blueprint contains concrete suggestions for improving information exchange between relevant EU actors, which also includes the areas of early warning and prediction.[66]

Almost simultaneously with these proposals, the EU Commission published a feasibility study on an AI-based tool to forecast the direction and intensity of irregular migration into and within the EU with a short (one to four weeks) to medium-term (one to three months) time horizon. The study identifies creating an adequate governance architecture as the greatest challenge. That will require investment in a coordination mechanism for the AI tool, including new working agreements between the relevant EU agencies and a central coordination point for data exchange.[67] However, there are rivalries between the

60 Background conversation with a representative of Frontex, February 2022.

61 Art. 34 Regulation (EU) 2019/1896.

62 See Frontex, "Monitoring and Risk Analysis", https://frontex.europa.eu/what-we-do/monitoring-and-risk-analysis/monitoring-and-risk-analysis/ (accessed 5 June 2023).

63 See Frontex, "Announcements. Invitation to Industry — Forecasting Changes in the Migration Flows Using Open Sources" (Warsaw, 8 August 2018), https://frontex.europa.eu/innovation/announcements/invitation-to-industry-forecasting-changes-in-the-migration-flows-using-open-sources-7uzal2 (accessed 5 June 2023).

64 Background conversation with a representative of Frontex, February 2022.

65 European Commission, *Proposal for a Regulation of the European Parliament and of the Council addressing situations of crisis and* force majeure *in the field of migration and asylum*, 2020/0277 (COD) (Brussels, 23 September 2020), https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020PC0613&from=de (accessed 22 November 2022).

66 "Commission Recommendation (EU) 2020/1366 of 23 September 2020 on an EU mechanism for preparedness and management of crises related to migration (Migration Preparedness and Crisis Blueprint)", *Official Journal of the European Union*, L 317, 1 October 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020H1366&from=de (accessed 15 August 2023).

67 Ecorys, *Feasibility Study on a Forecasting and Early Warning Tool for Migration Based on Artificial Intelligence Technology: Execu-*

EU Commission's directorates-general when it comes to migration prediction: the Directorate-General for Migration and Home Affairs has its own Situational Awareness Unit and leads the Blueprint Network; the Directorate-General for European Civil Protection and Humanitarian Aid Operations organises the Emergency Response Coordination Centre (ERCC) and maintains its own forecasting capacity; and the European External Action Service (EEAS) also prepares its own migration predictions.

At this juncture, more than two years after publication of the feasibility study, a collective European migration forecasting instrument is yet to be developed. One possible reason for the delay is that the instrument's added value in comparison to those developed by the EUAA and Frontex is unclear; another is the aforementioned rivalry between various directorates-general.[68] According to the Commission it is not currently possible to reliably quantify the resources that would be required to create a fully functioning AI-based prediction tool. A further study is therefore planned to concretise the needs. While such an instrument is not expected to be operational for several years, an instrument limited to predicting irregular migration on a single route will be trialled in a pilot project.

EU research funding

The European Commission promotes research on migration and demographics through its Joint Research Centre (JRC). In this context it has also been pursuing the potential of new data sources and machine learning for forecasting migration. The growing interest in methods and instruments for quantitative migration forecasting is reflected in the EU's research funding choices. Several major consortiums working in exactly this field were funded under the Horizon 2020 programme (2014 to 2020). DeepCube (January 2021 to December 2023) uses AI to analyse migration-related data from the satellite-based Copernicus Earth observation programme.[69] QuantMig (February 2020 to July 2023) uses quantitative analysis to develop migration scenarios and offers interactive applications and simulations for testing migration policy options.[70] HumMingBird (December 2019 to May 2024) investigates the causes of migration by linking qualitative and quantitative methods and tests big data methods of quantitative forecasting.[71]

The ITFlows consortium (September 2020 to August 2023) seeks to forecast crisis-driven immigration to the EU and to support integration.[72] Its EUMigraTool is designed to supply relevant information to civil society and local government actors involved in receiving and integrating asylum-seekers. The tool has two components, which are currently in the test phase. One predicts the numbers of asylum-seekers expected to arrive in the EU, while the other seeks to identify social tensions related to migration and asylum in EU member states. The first component is based on the ABM tool "Flee" developed at Brunel University; the second employs machine learning to analyse sources including Twitter data.[73] Civil society organisations have criticised ITFlows for ignoring the potential for abuse of EUMigraTool and potentially facilitating human rights violations and illegal practices like push-backs.[74] The members of the consortium reject the criticism and point to the clearly defined purpose of EUMigraTool. Nevertheless, their financial dependency on EU funding does create pressure to make the instrument available to relevant EU agencies.[75]

tive Summary (Brussels, November 2020), 2, https://op.europa.eu/en/publication-detail/-/publication/5afa29f0-700a-11eb-9ac9-01aa75ed71a1.

68 Helena Hahn, *Keeping a Cool Head: How to Improve the EU Migration Crisis Response*, Discussion Paper (Brussels: European Policy Centre [EPC], 20 October 2022), https://www.epc.eu/content/PDF/2022/Crisis_management_DP_v2.pdf (accessed 22 November 2022).

69 Deep Cube, "Climate Induced Migration in Africa", https://deepcube-h2020.eu/use-cases/climate-induced-migration-in-africa/ (accessed 5 June 2023).

70 Website of QuantMig, http://www.quantmig.eu/ (accessed 5 June 2023).

71 Website of HumMingBird, https://hummingbird-h2020.eu/ (accessed 5 June 2023).

72 Website of ITFlows, https://www.itflows.eu/ (accessed 5 June 2023).

73 See "FabFlee Tutorial for Multiscale Migration Prediction", https://github.com/djgroen/FabFlee/blob/master/doc/FabFlee.md (accessed 5 June 2023).

74 "Open Letter to the ITFlows Consortium: Stop Tech Tools for Predicting Migration That Can Be Repurposed to Violate Fundamental Rights", *accessnow*, 27 September 2022 (updated 7 March 2023), https://www.accessnow.org/open-letter-itflows-consortium/ (accessed 5 June 2023).

75 Background conversation with a member of the ITFlows consortium, January 2023.

European Space Agency

The European Space Agency (ESA) has been working since 2015/16 to develop quantitative instruments for predicting migration movements. Between 2017 and 2019 it funded three feasibility studies on the use of satellite data in migration prediction. These were prepared by private-sector contractors working in collaboration with state actors.[76]

International actors

The sudden and significant increase in immigration into the EU in 2015/16 led to an increase in investment in quantitative forecasting of forced displacement and migration at the international level. The Global Compact on Refugees of December 2018 also called for migration predictions to be improved. UNHCR, IOM and the World Bank are positioning themselves in this field, and a number of international NGOs are developing their own prediction tools.

UNHCR

Project Jetson, launched in 2017, is UNHCR's first machine-learning-based application for forecasting internal and cross-border displacement.[77] This initiative was initially motivated by signs of looming famine in Somalia and the legacy of the famine of 2011, when humanitarian aid organisations were inadequately equipped to house and feed Somalis fleeing to neighbouring countries. The main purpose of the model is not operational application but to test the performance of AI-based prediction approaches. Two years after work began it was able to accurately predict arrivals in eleven of Somalia's eighteen regions.[78]

The latest prediction initiative of the UNHCR Innovation Service also came in response to an acute crisis. After the Covid-related border closures of 2020 interrupted migration between Venezuela and Brazil, the Brazilian government needed to know how many Venezuelan arrivals to expect when the border was reopened, and what scale of humanitarian need this would involve. In order to generate viable predictions, UNHCR collaborated with UN Global Pulse (the UN Secretary-General's initiative on big data and AI) to create a machine-learning-based forecasting instrument and an interactive model for simulating housing and other needs under different scenarios.[79] While UNHCR has access to enormous quantities of relevant data, it often lacks the capacity to analyse it in depth or to utilise it for forward planning. The partnership with UN Global Pulse is intended to enable such uses and, according to UNHCR, will be a model for application in other geographical contexts.[80]

IOM

With its Big Data for Migration Alliance (BD4M), IOM has positioned itself as an influential actor developing new sources of data on forced displacement and migration. BD4M was founded in 2018 by IOM's Global Migration Data Analysis Centre (GMDAC) and the EU's Joint Research Centre (JRC). In this context IOM is also working on the use of artificial intelligence and machine learning to forecast migration movements.[81]

76 See ESA, "Migration Radar 2.0", https://business.esa.int/projects/migration-radar-20, ESA, "BigMig", https://business.esa.int/projects/bigmig, and ESA, "Big Data Applications to Boost Preparedness and Response to Migration", https://business.esa.int/projects/big-data-applications-to-boost-preparedness-and-response-to-migration (accessed 5 June 2023).

77 UNHCR Innovation Service, "Project Jetson", https://jetson.unhcr.org/ (accessed 5 June 2023).

78 UNHCR Innovation Service, "Is It Possible to Predict Forced Displacement?" (Geneva, 13 May 2019), https://medium.com/unhcr-innovation-service/is-it-possible-to-predict-forced-displacement-58960afe0ba1 (accessed 5 June 2023).

79 UN Global Pulse, "Understanding Population Movement from Venezuela to Brazil Related to COVID-19 Border Closures: Pulse Lab New York" (New York, 2020), https://www.unglobalpulse.org/project/understanding-population-movement-from-venezuela-to-brazil-related-to-covid-19-border-closures/ (accessed 5 June 2023).

80 Amy Lynn Smith, "Predicting the Unpredictable: Preparing for Potential Future Scenarios" (Geneva: UNHCR Innovation Service, 29 September 2021), https://medium.com/unhcr-innovation-service/predicting-the-unpredictable-preparing-for-potential-future-scenarios-1b22cd7f8da2 (accessed 5 June 2023).

81 Jasper Tjaden et al., *Using "Big Data" to Forecast Migration: A Tale of High Expectations, Promising Results and a Long Road Ahead* (Geneva: IOM — UN Migration, 27 January 2021), https://medium.com/@UNmigration/using-big-data-to-forecast-migration-8c8e64703559.

Technical experts express ethical reservations about quantitative prediction tools.

In 2022 GMDAC was subsumed into the IOM's new Global Data Institute, which is intended to become the central hub for all migration-related data needs. But the IOM's project-based funding structure leaves it lacking human and financial resources dedicated primarily to research and development of new instruments.[82] There is also a latent discrepancy between management and working levels, which is reminiscent of the discussions within UNHCR. IOM's leadership stresses the potential of quantitative prediction as a new field of activity for the organisation, while the technical experts point to the limited practical use of the instruments and express ethical reservations about data protection and the danger of the findings being used for migration control and deterrence.

Those concerns point yet again to the fundamentally ambivalent nature of migration predictions, which can be used both to support humanitarian reception and to design measures to prevent migration. The IOM is currently in the process of clarifying its position on and role in migration prediction, as well as the internal distribution of related tasks. The conclusions of these consultations are expected in the course of 2023.

World Bank

Although the World Bank is not developing AI-based instruments in the narrow sense, it does produce important quantitative forecasts of possible future human mobility, in particular in the context of climate change. As a development actor the World Bank has traditionally had only tangential dealings with forced displacement and migration. However, its two widely received Groundswell Reports published in 2018 and 2021 made a crucial contribution to the debate on future climate-related migration.[83] Both reports contain scenarios based on gravity models for climate-related migration and displacement within countries in the so-called Global South. Groundswell I concentrates on Sub-Saharan Africa, South Asia and Latin America, while Groundswell II also includes East Asia, North Africa and Eastern Europe/Central Asia. What is unique about these contributions is their focus on migration in response to gradual environmental change and the potential of development interventions to enable people to stay.

Africa Climate Mobility Initiative

The Africa Climate Mobility Initiative (ACMI) was founded in 2021 by the AU Commission, the UN and the World Bank, and has developed its own model for predicting intra-African migration movements. It builds on the gravity model of the World Bank's Groundswell Reports but differentiates further by including additional aspects such as armed conflicts. Using a combination of data from different development paths (strong versus weak) and different emissions trajectories (high versus low) the model can be used to create four plausible quantitative mobility scenarios for Africa that address both internal and cross-border migration. The time horizon of the scenarios extends through 2050. The results resemble those of the Groundswell Reports in the sense that under all four scenarios the bulk of the migration movements will occur within countries. Interestingly the scenarios with lower emissions indicate greater mobility than those with higher emissions, suggesting that the negative consequences of climate change may have an immobilising effect.[84]

Internal Displacement Monitoring Centre

The Internal Displacement Monitoring Centre (IDMC) was founded in 1998 under the auspices of the Norwegian Refugee Council (NRC). It supplies data and analyses on internal displacement, prepares analyses of specific displacement situations and publishes the annual Global Report on Internal Displacement (GRID), which has become the acknowledged reference work in the field. Some years ago the IDMC developed a model for calculating the displacement risk associated with natural hazards as a function of hazard type, exposure risk and vulnerability. The IDMC calculates

82 Background conversations with a representative of IOM, January 2023.

83 Kanta Kumari Rigaud et al., *Groundswell: Preparing for Internal Climate Migration* (Washington, D.C.: The World Bank, 2018), https://openknowledge.worldbank.org/bitstreams/0804521a-3318-565e-ad8a-5924f75c3cf2/download; Viviane Clement et al., *Groundswell, Part II: Acting on Internal Climate Migration* (Washington, D.C.: The World Bank, 2021), https://openknowledge.worldbank.org/bitstreams/158b2f56-a4db-5a2d-93b9-0070068fa084/download.

84 Africa Climate Mobility Initiative, *African Shifts: The Africa Climate Mobility Report: Addressing Climate-Forced Migration and& Displacement* (February 2023), 76ff., https://cdn.sanity.io/files/pd7x7lde/production/2a4ad38091846247068faf2d2493413f88b607d8.pdf?dl= (accessed 17 May 2023).

the probability and scope of disaster-related displacement by country for different time periods on the basis of data on historical and predicted natural disasters and the expected level of damage to buildings. This information can help to ensure that measures are adopted to reduce the risk of displacement, that early warning systems are established and that preventive evacuations are set in motion.[85] In the EU-funded project Habitable the IDMC contributes its experience to a larger research consortium whose goals include developing models of future migration movements occurring in response to both acute natural disasters and gradual environmental changes.[86]

Danish Refugee Council

With technical support from IBM and funding from the Swedish Foreign Ministry, the humanitarian and development NGO Danish Refugee Council (DRC) has created its so-called Foresight Model. This is an AI-based tool designed to predict conflict-related internal and cross-border displacement in currently twenty-six countries. More than 120 social, economic, political, conflict-related and environmental factors and mediating variables gathered from public sources flow into the calculations.[87] The instrument is designed to make country-specific forecasts with a time horizon of one to three years. The chosen period is comparatively long because the results are intended for the DRC's internal annual planning and for coordinating the work of different actors in the context of the Humanitarian Programme Cycle (HPC). The DRC has published annual Forecast Reports since 2021, providing a global overview and more detailed case studies on particular countries.[88]

The DRC has also developed another prediction instrument, the West Africa Context Analysis and Foresight Initiative Model (WACAFI), which serves specifically to forecast internal displacement in fifteen selected regions in Burkina Faso, Mali and Niger. WACAFI generates quarterly predictions with a time horizon of three or four months to support the operational work of humanitarian actors in those countries.[89]

Save the Children

Another NGO engaged in forecasting displacement in order to support its own programming and to identify future needs is Save the Children. With support from Boston Consulting Group (BCG), Save the Children developed a machine-learning-based instrument to predict the scope and duration of displacement. Since its introduction in 2018 it has been continuously improved. Central lessons from this process include the realisation that localised, context-specific models are more useful than a generalised global model and that certain missing data can be interpolated using agent-based modelling.[90] For the latter Save the Children collaborates with the Migration and Simulation Group at Brunel University, whose algorithm, named Flee, is one of the most advanced for forecasting forced displacement.[91] Versions of the instrument have been tested in Burundi, Ethiopia, South Sudan and Mali.[92]

Potentials and limitations

As described above, many different actors are involved in quantitative forecasting of irregular migration, and there are already many different prediction instruments in service or development. Two groups can be distinguished: those that are designed to predict arrivals in the EU for purposes of asylum and

85 International Displacement Monitoring Centre, "Disaster Displacement Risk Model", https://www.internal-displacement.org/disaster-risk-model (accessed 6 June 2023).

86 Maria Teresa Miranda Espinosa and Sylvain Ponserre, "Estimating Displacement Risk in a Changing Climate", *Habitable* (blog), 19 April 2022, https://habitableproject.org/news/estimating-displacement-risk-in-a-changing-climate/ (accessed 6 June 2023).

87 Today the Foresight Model is also funded by the Swedish development agency SIDA and the European Commission's Directorate-General for European Civil Protection and Humanitarian Aid Operations (ECHO).

88 International Displacement Monitoring Centre, "Disaster Displacement Risk Model" (see note 85).

89 Danish Refugee Council, "West Africa Context Analyses and Foresight Initiative (WACAFI)", https://pro.drc.ngo/what-we-do/innovation-and-climate-action/predictive-analysis/wacafi/ (accessed 6 June 2023).

90 Save the Children, *Predictive Displacement. Harnessing the Power of Data to Transform Support to Displaced Children* (Save the Children, Migration and Displacement Initiative, 2021), 2, https://resourcecentre.savethechildren.net/pdf/pd_brief_on_phase_iii.pdf/.

91 Suleimenova et al., "A Generalized Simulation Development Approach" (see note 20).

92 Stuart Campo and Nathaniel Raymond, *Displaced Children and Emerging Technologies: Save the Children's Opportunities for Investment and Impact* (London, 2019), 19, https://resourcecentre.savethechildren.net/pdf/stc_tech_innovation_study_v7_digital.pdf/ (accessed 6 June 2023).

Figure 2

AI-supported migration forecasting: Actors and existing/planned instruments

German and European migration policy

Actor	Instrument	Field	Time horizon
BAMF	Vorausschauende Migrationsanalyse	Irregular migration to Germany	6–12 months
EUAA	DynENet algorithm	Number of new asylum applications in the EU	1 month
Frontex	n. a.	Irregular migration to the EU	3 months
ITFLOWS	EUMigraTool	Number of new asylum applications in Greece, Italy and Spain (potentially also other EU member states)	1 month
EU Commission	Forecasting and early warning tool	Irregular migration to the EU	1–4 weeks 1–3 months

Humanitarian aid and development cooperation

Actor	Instrument	Field	Time horizon
UNHCR	Project Jetson	Involuntary migration within Somalia	1–3 months
	Venezuela-Brazil Border Scenarios	Venezuelan migration to Brazil and associated humanitarian needs	Flexible
DRC	Foresight Model	Conflict-driven forced migration, currently covers 26 countries	1–3 years
	WACAFI	Internal displacement in Burkina Faso, Mali and Niger	3–4 months
Save the Children	Predictive Displacement Project	Duration and scope of conflict-driven (and potentially also environmental) displacement in selected countries	Flexible

Source: Research and representation SWP 2023; DOI: 10.18449/2023RP11

migration policy, and those intended to serve humanitarian and/or development objectives in third states (see Figure 2).

While sharing a general interest in improving preparedness for future challenges, the two spheres pursue different objectives. The primary concern in the realm of asylum and migration policy is to better steer and manage migratory movements towards the EU, while the core interest in humanitarian aid and development cooperation is to support people affected by forced displacement. As the overview demonstrates, the practical benefit of innovative, AI-based instruments — under the current state of the art — differs significantly between the two areas.

In the European Union, multiple forecasting tools with similar time horizons are currently under development. The fact that none of them is yet ready for application points to the existence of challenges that

resist even the methods of machine learning. The ambition of developing a comprehensive forecasting and early warning system for irregular migration into the EU (or in the case of BAMF to Germany) — which is broadly shared by Frontex, EUAA, BAMF, ITFlows and essentially also the EU Commission — encounters technical limits in two respects. Firstly, as the example of the EUAA demonstrates, even the most advanced AI-based instruments cannot yet adequately grasp the complex interaction of the numerous factors that influence migration decisions (especially when the respective instrument is required to be universally applicable to all countries and all migration routes to Europe). Secondly, the reliability of any forecast is limited by the aleatoric uncertainty of migration processes (see "Methodologies", p. 9). Many of the most relevant recent migration movements towards Europe were caused by disruptive events that influenced forced displacement and migration in unpredictable ways.

The picture is rather different when it comes to the application of migration predictions in humanitarian contexts outside the EU. Various prediction tools are already in practical use: UNHCR's for Somalia and the Venezuelan-Brazilian border, and those developed by Save the Children and the Danish Refugee Council. The technical challenges are significant here too, but the prediction objectives are generally spatially and temporally more limited because of the concrete operational needs, and the learning curve more tangible than in the more comprehensive Eurocentric approaches mentioned above. Additionally, refugee movements caused by sudden events like natural disasters or outbreaks of armed conflict tend to be easier to model using machine learning than other migration movements that are influenced by a much larger number of factors.[93] Nevertheless, developing context-specific prediction instruments is time-consuming, requiring about one year according to the UNHCR Innovation Unit. Existing quantitative migration prediction approaches are therefore especially suitable for longer-term observation of fragile contexts, which is also relevant for development cooperation.[94]

Even if the practical benefit of quantitative migration predictions varies strongly from one policy field to another, similar obstacles to feeding them into political decision-making processes exist in all areas. Despite the strong need for more foresight expressed at all levels, national administrations lack the resources and structures required to fully exploit the findings of quantitative prediction instruments. One reason for this is a shortage of personnel in the relevant ministries. Especially in the fast-moving world of foreign policy there is rarely the time to digest the findings of crisis early warning or migration forecasts, to integrate them into planning and decision-making processes, and to validate and improve the instruments.[95] Another reason is that the inevitable uncertainty of predictions diminishes their value for the political process, which is best suited to dealing with clear and simple facts. And finally there is a lack of established processes to feed forecasts into political decision-making processes.[96]

93 Background conversation with a representative of the ITFlows consortium, January 2023.

94 Background conversation with representatives of the UNHCR, January 2023.

95 Background conversations with representatives of the German Foreign Office, February 2022, und der EUAA, March 2022.

96 Background conversations with representatives of the German Foreign Office, March 2022.

Political Functions and Risks of Quantitative Migration Predictions

As laid out in the section on "Predicting Irregular Migration in Practice" (p. 15), the practical utility of quantitative migration prediction for anticipatory planning and effective implementation in the European context remains limited. Given these limitations, the persistent political demand for AI-based forecasting tools in particular, and the ongoing investment in related instruments both in EU member states and at the European level requires explanation. What, aside from practical utility, are the most important reasons and motives for developing such instruments?

One significant factor is without doubt the high expectations associated with quantitative forecasting of migration movements, especially in the context of European asylum and migration policy. While the technical experts involved in developing prediction tools are well aware of their technical limitations, the same cannot be said of higher-level decision-makers.

More broadly, our discussions with decision-makers in Germany and at the European level reveal that quantitative migration predictions fulfil a series of political functions over and above supplying numbers and expanding empirical knowledge. These political functions are associated with risks and complex normative questions.

Political functions of quantitative migration predictions

So what expectations are associated with quantitative migration predictions — aside from knowledge for its own sake — and what are their uses in the political process? Apart from hopes of improving inter-departmental cooperation, these include individual ministries gaining a competitive edge through the additional knowledge gained from predictions, legitimation of decisions already made, and the use of forecasts to advance political interests and to acquire funding.

Improving governmental coherence and cooperation

Decision-makers in Germany and at the European level report that the exchange of data on forced displacement and migration between different actors remains relatively unstructured and unsystematic. In Germany the comparison and consolidation of migration-related data between different line ministries is largely situative and often depends on the personal initiative of individuals.[97]

In the case of crisis early warning an institutionalised process involving the German Foreign Office, the Federal Ministry of Defence, the Federal Ministry of the Interior and the Chancellery exists for creating a broad situational picture (Ressortkreis Krisenfrüherkennung). Coordination on forced displacement and migration, on the other hand, is generally restricted to mapping the activities of the different ministries.[98] Broader situational pictures that bring together the knowledge of the ministries and their subordinate agencies, and join them up with the knowledge of other disciplinary or regional institutions, are lacking.

97 Background conversations with representatives of BAMF, March 2022, and the Chancellery, February 2022.
98 Background conversations with representatives of the Federal Defence Ministry, February 2022, and BAMF, March 2022.

Exchange of data on forced displacement and migration remains relatively unstructured and unsystematic.

The German government is aware of the problem and there have been growing efforts — in particular by the Foreign Office, the Federal Ministry of the Interior and the Federal Ministry of Defence — to expand coordination on issues of forced displacement and migration.[99]

To a certain extent these inadequate information flows are attributable to data protection and security classification (under which analyses by the Foreign Office and the Federal Ministry of Defence may fall for example). Altogether the pooling of knowledge is unsystematic.[100] The patchiness of the information on forced displacement and migration hinders joint decision-making and therefore constitutes a problem, especially in crisis situations where there is little time for coordination. Political decision-makers hope for two things from the AI-based prediction tools under development: They should contribute to a system for preparing a shared situational picture, which clearly assigns responsibilities and is accepted as a basis for decision-making by all relevant actors. And they should mitigate the time pressure that is inherent to crises by enabling discussion and consensus-building early on.[101] Gaining that kind of time would be of immense benefit in many acute crises — especially where human rights obligations have to be weighed against security concerns, as in the case of the evacuation of local staff from Afghanistan in summer 2021.

The same applies at the European level, where structures for joining up the diverse migration data from different countries are notably lacking.[102] EUAA staff emphasise the value of joint analyses, which they say lead to better outcomes and enhance ownership by the participating states and organisations, thus potentially strengthening engagement in data gathering and processing.[103] The European Commission also attaches importance to a collaborative approach involving the member states and the relevant EU agencies, and its Migration Blueprint mechanism is crucial for preparing for forced displacement situations.[104] AI-based quantitative predictions could expedite timely coordination between the countries of first arrival, the Commission and EU agencies in the event of a rapid increase in numbers along individual migration routes. This would in turn facilitate the timely adaption of accommodation and other capacities needed to provide for for large numbers of displaced persons — and to reduce capacity when it is no longer needed as numbers fall again (as occurred when the wars in former Yugoslavia ended in the 1990s and again after the heightened immigration of 2015/16).[105]

Knowledge as a competitive advantage

Although all our interlocutors emphasised the need for greater cooperation in the development of AI-based instruments for predicting migration, there were also countervailing tendencies. Despite sharing the goal of improving predictions, the behaviour of German and European actors is also characterised by competition for influence over asylum and migration decisions. In this situation of ongoing rivalry additional knowledge can represent a significant competitive advantage. Quantitative instruments are of particular value because they are regarded as especially exact and reliable.[106] Accordingly, representatives of various ministries reported competitive rather than cooperative behaviour by other ministries in the area of migration prediction.

A similar phenomenon can also be observed at the European level, where Frontex and EUAA are the most important producers of migration predictions and of the data and information required to prepare

99 Background conversations with representatives of the German Foreign Office, Interior Ministry and Defence Ministry, February and March 2022.

100 Background conversations with representatives of BAMF, March 2022, and the Federal Defence Ministry, February 2022.

101 Background conversation with representatives of BAMF, February 2022.

102 Background conversation with a representative of the EUAA, March 2022.

103 Background conversations with representatives of the EUAA, March and November 2022.

104 Background conversation with a representative of the Directorate-General for Migration and Home Affairs (DG Home), March 2022.

105 Background conversation with a representative of the Chancellery, February 2022.

106 Andrea Mennicken and Robert Salais, "The New Politics of Numbers: An Introduction", in *The New Politics of Numbers: Utopia, Evidence and Democracy*, ed. Mennicken and Salais (Cham: Palgrave Macmillan; Springer Nature Switzerland AG, 2022), 1—42.

them. Both these organisations employ qualitative as well as quantitative approaches to expand their knowledge. They also work to encourage contact and exchange between member states. Here again, there is plainly competition for political attention for the respective migration predictions, the agencies are pursuing diverging interests and priorities (as per their mandates), and they are leveraging their predictive abilities for their own benefit. Frontex for example primarily collects information about trends in irregular migration and uses this to generate support for its own expansion. The EUAA focusses on building reception capacity for asylum-seekers in the member states and on expanding its own capacity, and gathers information about current migration trends in various countries — including returnees and secondary migration. Although synergies between the two areas would be possible there is little joint analysis. Instead cooperation generally extends no further than sharing research findings.[107] Ultimately, work on developing quantitative migration predictions often serves the organisation's own political goals. This kind of "silo mentality" also creates obstacles to the development of a quantitative prediction tool by the EU Commission.

Political communication and legitimisation of political choices

In the field of migration and asylum, calls for a more evidence-based politics and more investment in data gathering and analysis are ubiquitous. The argument is that this would help objectify the frequently emotionally charged and highly polarised debates, present decision-makers with evidence-based options, and thus help to counteract populist rhetoric.[108] At the same time figures and statistics fulfil important communicative and legitimising functions in politics. Instead of serving an impartial exploration of different policy options their primary purpose often is to legitimise or substantiate decisions that have already been taken.[109] Quantitative predictions have yet another function: investments in migration forecasting can create an impression of control in a policy area characterised by uncertainty and periodic shocks and therefore signalise efforts to realise forward planning.

If they are to play a role in political decision-making processes, forecasting results need to be presented in an easily digestible format. This form of communication demands brevity, simplification and an attractive visual presentation that makes the central points clear at a glance.[110] However, such simplified representations can convey a false sense of certainty because it tends to sideline the uncertainty that is inherent to all predictions (and especially salient in the sphere of migration). At the same time quantitative findings need to be embedded in narratives that lay out possible courses of action.[111] These narratives necessarily involve interpretation — for example the decision to describe a particular migration movements as a "crisis".

Political lobbying and funding acquisition

In the humanitarian sector in particular, quantitative predictions of forced displacement fulfil the important additional function of generating political attention for emerging crises and mobilising the required funding. The NGOs DRC and Save the Children for example explicitly name funding as one of their motives for developing prediction tools,[112] while at the same time trying to avoid perpetuating the narrative of a growing threat to affluent states through large-scale refugee movements from the so-called Global South.

Migration predictions can also assist state actors in allocating funding and resources. Funding invested before a crisis has broken out is a great deal more efficient than emergency relief after the event. This has long been recognised in humanitarian aid, and would warrant greater use of forecast-based financing instruments:[113] For example it costs much less to save livestock from dying of thirst than to compensate farmers

107 Background conversation with a representative of the EUAA, March 2022.

108 Background conversation with representatives of the German Foreign Office, February 2022.

109 Christina Boswell, *The Political Uses of Expert Knowledge: Immigration Policy and Social Research* (Cambridge: Cambridge University Press, 2009); Background conversations with representatives of the German Foreign Office, February 2022.

110 Background conversations with representatives of the Federal Defence Ministry and the Federal Interior Ministry, February 2022.

111 Background conversations with representatives of the German Foreign Office and the Chancellery, February 2022.

112 Save the Children, *Predictive Displacement* (see note 90), 2; Background conversation with representatives of the DRC, February 2022.

113 IFRC/German Red Cross, "What Is Forecast-based Financing?", https://www.forecast-based-financing.org/about/ (accessed 6 June 2023).

for losses afterwards. The likelihood of greater efficacy of employed funds is an important argument in the competition for public resources.

Humanitarian aid practitioners also emphasise that reliable predictions could facilitate unearmarked and "soft earmarked" aid funding. This would be helpful for the aid organisations, which would gain greater freedom of action and be able to offer responses that are better tailored to the specific emergency.[114]

The political functions of quantitative migration prediction outlined here underline the diverse, sometimes contradictory motives that drive interest in forecasting migration and displacement and thus supplement the practical applications described in the section on "Predicting Irregular Migration in Practice" (p. 15). The interaction of the two dimensions explains the coexistence of cooperation and competition in the development of new instruments. While coordination and exploitation of synergies increase knowledge, the wish for competitive advantage and the legitimisation of existing policies mitigate towards unilateralism. Overall these political functions of quantitative migration prediction (especially the legitimisation of existing policies) can contribute to the outcome being merely a politically motivated — and therefore potentially selective — collection of empirical evidence, rather than the widely demanded evidence-based politics.[115]

Risks and normative considerations

The preparation and use of quantitative migration predictions, in particular those based on machine learning, is associated with risks and raises a number of normative questions. These include the danger of political instrumentalisation, data privacy issues and the unintentional creation of new pressures to act. The decision-makers we spoke with were aware of these risks and trade-offs, and tried their best to take them into account in the preparation and utilisation of migration predictions.

Political instrumentalisation

Irregular migration towards Europe is frequently perceived as a threat. In the past populist actors in Germany and other EU member states have exploited periods of heightened immigration to stoke fears and propagate an often xenophobic agenda.[116] This is supported by the typical visual presentation of quantitative data on migration, for example in the form of big arrows pointing to Europe suggesting a hostile invasion.[117] When new quantitative instruments to predict migration are developed, there is a danger that the resulting forecasts could also be instrumentalised for populist purposes. This can occur for example if statistical and methodological uncertainties are not communicated and predictions are instead presented as evidence of an imminent threat that demands action to strengthen border protections and to deter potential migrants.

Unlike IT specialists focusing on the technical development of forecasting tools, migration experts are usually aware of the dangers of instrumentalisation.[118] In view of these risks the DRC for example took the rather far-reaching decision to restrict its model to forecasting the numbers of refugees and internally displaced persons who leave their home regions — but not as originally planned to predict where they were likely to go.[119] In other cases the risk of instrumentalisation was reason enough to choose not to publish data at all.[120]

EU-funded research projects on quantitative migration prediction face similar questions. For example

114 Background conversation with representatives of the German Foreign Office, February 2022.

115 Holger Straßheim and Pekka Kettunen, "When Does Evidence-based Policy Turn into Policy-based Evidence? Configurations, Contexts and Mechanisms", *Evidence and Policy* 10, no. 2 (2014): 259—77.

116 Frank Decker, "The 'Alternative for Germany': Factors Behind Its Emergence and Profile of a New Right-wing Populist Party", *German Politics and Society* 34, no. 2 (2016): 1—16; Francesco Campo et al., "The Refugee Crisis and Right-wing Populism: Evidence from the Italian Dispersal Policy", *IZA*, no. 14084 (2021), https://repec.iza.org/dp14084.pdf (accessed 3 May 2023).

117 Elsa C. Gomis, "Cartographies of Migration and Mobility as Levers of Deferral Policies", *Convergence: The International Journal of Research into Media Technologies* 28, no. 1 (2022): 52—69; Henk van Houtum and Rodrigo Bueno Lacy, "The Migration Map Trap: On the Invasion Arrows in the Cartography of Migration", *Mobilities* 15, no. 2 (2020): 196—219.

118 Background conversation with representatives of the IOM, January 2023.

119 Background conversations with representatives of the DRC, February 2022.

120 Background conversations with representatives of the EUAA, November 2022, and BAMF, January 2023.

the AI-based forecasting instrument EUMigraTool, developed by the research consortium ITFlows, is funded under an EU research programme dedicated to security. While the project is geared towards humanitarian purposes, and to help civil society actors and local authorities to prepare in good time to receive and support asylum-seekers, both the European Commission and Frontex have expressed interest in a broader application of the instrument. The ITFlows consortium rejects this, but at the same time stands under pressure to secure follow-on funding.[121] In September 2022 a group of individuals and civil society organisations signed an open letter calling for the EUMigraTool to be withdrawn with immediate effect. They argued that developing migration prediction technologies without adequate legal protections was fundamentally irresponsible, because it created an infrastructure that can lead to human rights violations such as illegal push-backs.[122] To date however no independent national or European institution possesses any mandate to evaluate and regulate such endeavours.

Data privacy and security risks

The power differential between state authorities seeking total surveillance and control and the individuals affected by these efforts is especially stark in the area of irregular migration. The collection of personal data in this area is therefore associated with special data privacy challenges and possible additional risks for migrants.[123]

Awareness of the human rights risks inherent to the gathering and utilisation of group-based data is lacking.

Here it is useful to distinguish between personal data (such as biometric data) and group-based data (of the kind on which the forecast instruments discussed in this study are based).[124] Data gathering occurs in both spheres, but with different levels of regulation. Today the EU extends comparatively far-reaching statutory protections to personal data, but not to group-based data.[125] The issue has also been largely ignored in the current negotiations over an EU Artificial Intelligence Act (AIA).[126] This underlines the lack of awareness of the human rights risks inherent to the gathering and utilisation of group-based data. The risks include the preventive closure of border crossings to asylum-seekers, the growing danger of physical attack and exploitation in the context of people trafficking, and encouragement of racism against particular nationalities or ethnicities.[127] The use of social media data for migration predictions can also be problematic from a data privacy perspective, as the European Data Protection Supervisor told the EASO in September 2021.[128]

There is somewhat more awareness of these dangers in the humanitarian sphere, where there may also be additional risks such as deliberate attacks on aid convoys. Organisations like OCHA, IOM, UNICEF and WFP participate in the development of ethical standards for new data gathering and analysis methods in humanitarian aid.[129] Save the Children founded

121 Background conversation with representatives of the ITFlows consortium, January 2023.

122 "Open Letter to the ITFlows Consortium" (see note 74).

123 Petra Molnar, "Technology on the Margins: AI and Global Migration Management from a Human Rights Perspective", *Cambridge International Law Journal* 8, no. 2 (2019): 305–30.

124 Bruno Oliveira Martins and Maria Gabrielsen Jumbert, "EU Border Technologies and the Co-production of Security 'Problems' and 'Solutions'", *Journal of Ethnic and Migration Studies* 48, no. 6 (2022): 1430–47 (1431).

125 Linnet Taylor, "No Place to Hide? The Ethics and Analytics of Tracking Mobility Using Mobile Phone Data", *Environment and Planning D: Society and Space* 34, no. 2 (2016): 319–36 (321).

126 European Commission, "A European Approach to Artificial Intelligence", https://digital-strategy.ec.europa.eu/en/policies/european-approach-artificial-intelligence (accessed 6 June 2023).

127 Ana Beduschi, "The Big Data of International Migration: Opportunities and Challenges for States under International Human Rights Law", *Georgetown Journal of International Law* 49, no. 4 (2018): 981–1017 (1009).

128 See European Data Protection Supervisor, "Formal Consultation on EASO's Social Media Monitoring Reports (Case 2018-1083)", https://edps.europa.eu/sites/default/files/publication/19-11-12_reply_easo_ssm_final_reply_en.pdf (accessed 5 June 2023).

129 See among others 510 — An Initiative of the Netherlands Red Cross, *Data Responsibility Policy*, November 2018, https://www.510.global/wp-content/uploads/2018/12/510-Data-Responsibility-policy-V2.2-20181211-PUBLIC-USE.pdf; Kate Dodgson et al., *A Framework for the Ethical Use of Advanced Data Science Methods in the Humanitarian Sector* (Data Science and Ethics Group, April 2020), https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/

the Migration and Displacement Initiative (MDI) as a multidisciplinary team to promote research, programming and innovation in the area of child migration and displacement — and to examine the ethical risks associated with digital technologies.[130] IOM has also been working for some time on ethical standards for migration prediction, both for data processing and for open-source solutions. Nevertheless, at the working level in major institutions like EUAA, IOM and UNHCR there are worries that technical concerns about privacy risks associated with forecasting tools will not be heard at the executive level because political considerations come first and priority is given to serving the strong demand for quantitative migration predictions.[131]

There is also a lack of clarity about the rights of displaced persons and refugees to prevent their data being used in training sets for modelling migration or to receive redress if they suffer unintentional harm through the use of prediction models or if their data is misused for other purposes.

Commercialisation of data gathering and lack of democratic control

The "datafication" of migration is a much-discussed phenomenon, in the course of which migration data has become a growth market.[132] First and foremost the use of machine learning demands deep technical expertise, which those working in public administration frequently simply do not possess. This can lead to important decisions about the configuration of new prediction instruments being outsourced to commercial IT providers. As well as offerings operational benefits, involving private-sector actors also creates additional risks. Firstly, it makes decision-making processes less transparent by reducing the influence of democratic control mechanisms on the development of new quantitative prediction instruments. Secondly, IT experts without specific migration expertise may be unaware of the human rights sensitivity of related data, which can exacerbate data privacy risks (see "Data privacy and security risks", p. 32). Additionally, models that use digital data, for example from Google Search, X or Facebook, may potentially create dependencies on the respective platform — which can unilaterally restrict access to the data or alter its quality. And finally market mechanisms can create a situation where an increasingly differentiated supply of migration predictions increases the political demand, and the expanded supply generates greater attention to migration-related security problems.[133]

Aside from the ethical problems of presenting migration simply a as threat that needs to be controlled and ideally prevented, questions also arise concerning the best use of scarce human and financial resources — given the practical limits to what AI-based migration forecasting tools can actually achieve (see "Potentials and limitations", p. 25).

New pressures to act

The usual justification for investing in developing new prediction instruments is the hope of being able to prepare in good time for migration movements and thus shifting from a largely reactive mode of migration and asylum policy to an anticipatory approach. But little attention has been paid to the fact that knowledge about the future can also create new pressures to take action in anticipation of likely developments. In that sense predictions can be problematic for a government if public expectations of anticipatory action are encouraged but cannot be fulfilled on account of the multitude of other priorities and the uncertainty inherent to all predictions. Legal scholars also discuss whether predictions about movements across the Mediterranean could have implications under international law, for example concerning search and rescue.[134]

documents/files/dseg_ethical_framework_april_2020.pdf (accessed 7 June 2023).

130 Campo and Raymond, *Displaced Children and Emerging Technologies* (see note 92).

131 Background conversations with representatives of the UNHCR, January 2023, IOM, January 2023, and the EUAA, November 2022.

132 Dennis Broeders and Huub Dijstelbloem, "The Datafication of Mobility and Migration Management: The Mediating State and Its Consequences", in *Digitizing Identities: Doing Identity in a Networked World*, ed. Irma van der Ploeg and Jason Pridmore (London: Routledge, 2016), 242—60; Linnet Taylor and Fran Meissner, "A Crisis of Opportunity: Market-making, Big Data, and the Consolidation of Migration as Risk", *Antipode* 52, no. 1 (2020): 270—90.

133 Oliveira Martins and Gabrielsen Jumbert, "EU Border Technologies and the Co-production of Security 'Problems' and 'Solutions'" (see note 124).

134 Beduschi, "Big Data of International Migration" (see note 127).

Conclusion and Recommendations

The heightened immigration of 2015/16 in Germany and the EU and the widespread public impression that the state had lost control left many political decision-makers concerned not to be taken by surprise next time. Interest in new approaches to quantitative forecasting of irregular migration has increased noticeably, with national and European actors driving the development of AI-based instruments in particular.

The present study identifies three central findings on the preparation and use of migration predictions.

Firstly there is a significant discrepancy between the expectations placed in the new forecasting models and their actual practical utility. There are several reasons for this. Firstly, there are technical limits. The ability of algorithmic models to reliably identify correlations between migration movements and any number of other factors in huge amounts of data is constrained by the availability of training datasets. Forecasts generated in this way are ultimately still just highly complex extrapolations of existing trends, even if they do produce much more sophisticated results than if migration statistics are simply extrapolated in the conventional manner. Even AI-based forecasting models encounter their limits in disruptive events like the fall of Kabul, the Russian invasion of Ukraine or serious natural disasters. Secondly, institutional obstacles diminish the practical benefit of migration predictions. For example the relevant line ministries tend to lack the resources and structures that would be required to make productive use of quantitative prediction tools. In the rough and tumble of foreign policy there is often insufficient time to digest the output of crisis early warning and migration forecasting and to integrate it into planning and decision-making processes. Ultimately the inherent uncertainty of predictions diminishes their value for the political process, which is designed to make decisions on the basis of definite assessments that are as clear, simple and precise as possible.

The *second* central finding of the study concerns the question of why political decision-makers nevertheless show great interest in migration predictions and invest considerable funds in developing them. One explanation would be that migration predictions fulfil a series of political functions that can offer competitive advantages to political decision-makers — both vis-à-vis other actors and with respect to justifying and legitimising their own policies to their citizens. These political functions of migration predictions include asserting authority, mobilising financial resources and promoting inter-departmental cooperation.

The *third* finding is that the practical benefits of AI-based migration predictions depend on their objectives and differ in magnitude depending on the policy field. German and European hopes of forecasting arrivals in Europe can probably only be partly fulfilled, both because the causalities are too complex and because the crises that cause rapidly rising numbers of arrivals in Europe frequently fall in the realm of aleatoric uncertainty. Even here there is doubtless a gain from quantitative migration predictions, but the benefits of continuous monitoring of fragile contexts to improve humanitarian aid delivery are considerably larger. This is because the geographically limited nature of the forecasts required for operational planning of acute emergency relief (within countries or regions) can facilitate predictions. The same applies to development cooperation, where quantitative assessments of the medium-term conflict/climate-related risk of displacement in specific countries (of the kind prepared by NGOs like DRC and IDMC) have direct practical relevance for development planning.

In view of the above, we make the following recommendations for German and European policymakers:

1) Open communication of the potential and limits of migration predictions

In order to avoid creating false expectations and prevent misallocation of financial and other resources, the application of migration predictions should always go hand in hand with a realistic assessment of the potential benefits and a systematic risk assessment. That requires a clear understanding of the fields of application, the political objectives, and the practical and legitimatory functions of migration predictions. The financial and human resources that are available for migration predictions should be concentrated in the areas that promise the greatest practical effect. These include the planning and provision of acute emergency relief for refugees and displaced persons in crises caused by conflict and natural disaster, and the identification of areas at risk of climate-related displacement, in order to implement timely development measures to strengthen resilience, to set up early warning systems, or to resettle affected populations.

2) Promote exchange and networking

German and European migration policy should adopt a process-led approach to migration predictions rather than hoping for a "magic bullet" in the form of a spectacularly successful instrument. The large number of actors currently working on migration predictions in Germany and the EU suggests that better use should be made of possible synergies. More resources should be invested in better data exchange and closer inter-departmental cooperation on data gathering and processing. There is also a need for institutionalised structures such as the EU's Migration Preparedness and Crisis Blueprint, in order to feed the results of migration predictions into political decision-making processes in a systematic and differentiated form — without fudging the inevitable uncertainties.

3) Strengthen crisis early warning and risk analysis

Armed conflict and political persecution remain the most important causes of irregular migration. So when it comes to anticipating crisis-related migration, investment in general crisis early warning (at both the national and European levels) makes more sense than developing specific instruments to predict migration. In order to maximise the relevant knowledge gains, crisis early warning should be strengthened — especially in the German Foreign Office and the EU Commission — and should always also contain a migration scenario component. The technical expertise required for predictions needs to be expanded within line ministries and other relevant institutions.

4) Invest in context analysis and scenario development

Quantitative migration predictions are generally communicated not in the form of numbers alone but embedded in narratives. Such a contextualisation is always political. The producers of predictions therefore bear a share of responsibility for the ways their analyses are used politically. In order to ensure a real gain in knowledge and facilitate political action, quantitative predictions should be embedded in careful context analysis. The German government and the European Commission must ensure that this occurs as they work to develop migration predictions, and all actors should publish the premises and assumptions behind their models. Quantitative prediction models should always be supplemented by qualitative scenarios, in order to be better prepared for unpredictable crises.

5) Set normative standards and promote their control

Even if predictive tools are gradually improved, forced displacement and migration will remain areas where difficult political decisions have to be made and defended. Where quantitative migration predictions are used in practice, the risks to those directly affected must be considered and addressed. On the one hand, it must be ensured that predictions are not politically instrumentalised or used to present migration as nothing but a security risk. On the other, data protection must cover group-based data as well as personal data. In the European context this should be reflected in the Artificial Intelligence Act (AIA), which is currently under negotiation in the scope of the EU's Digital Strategy. In addition, a technical control organ should be established to evaluate and regulate new predictive tools. In the area of humanitarian aid and development cooperation, the principles of the responsible data movement should be developed and adapted to keep pace with the technological progress of the predictive models.

Abbreviations

ABM	Agent-based modelling
ACMI	Africa Climate Mobility Initiative
AI	Artificial Intelligence
AIA	Artificial Intelligence Act
AU	African Union
BAMF	Federal Office for Migration and Refugees (Bundesamt für Migration und Flüchtlinge)
BCG	Boston Consulting Group
BD4M	Big Data for Migration Alliance
BND	German Foreign Intelligence Service (Bundesnachrichtendienst)
CIRAM	Common Integrated Risk Analysis Model
DARS	Data Analysis and Research Sector (EUAA)
DRC	Danish Refugee Council
EASO	European Asylum Support Office
ECHO	European Civil Protection and Humanitarian Aid Operations
EMN	European Migration Network (EU)
EPC	European Policy Centre (Brussels)
EPS	Early Warning and Preparedness System
ERCC	Emergency Response Coordination Centre
ESA	European Space Agency
EUAA	European Union Agency for Asylum
FRAN	Frontex Risk Analysis Network
Frontex	European Border and Coast Guard Agency
GASIM	Joint Analysis and Strategy Centre for Illegal Migration (Germany, Gemeinsames Analyse- und Strategiezentrum illegale Migration)
GDELT	Global Database of Events, Language, and Tone
GMDAC	Global Migration Data Analysis Center
GRID	Global Report on Internal Displacement
HPC	Humanitarian Programme Cycle
IDMC	Internal Displacement Monitoring Centre
ILO	International Labour Organisation (Geneva)
IOM	International Organisation for Migration (Geneva)
JRC	Joint Research Centre
MDI	Save the Children's Migration and Displacement Initiative
ML	Machine learning
NRC	Norwegian Refugee Council
OCHA	UN Office for the Coordination of Humanitarian Affairs
PFI	Push Factor Index
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
WACAFI	West Africa Context Analysis and Foresight Initiative Model
WFP	UN World Food Programme