Representing Freedom and Force:
How Data Visualisations Convey the Complex Realities of Migration

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Across many spheres—policymaking, media, civil society—the means and modes of communicating information are changing. Digital platforms, as well as free or low-cost tools and apps, enable people to create and share different kinds of outputs that go beyond traditional texts and audiences. Moreover, as organisations (both public and private) increasingly make data available for wider use and reuse, there are clear opportunities for identifying new insights about society, holding governments to account, or raising awareness of issues that demand attention.

The medium of data visualisation, or the visual representation and presentation of data,[1] aims to help users make sense of potentially large sets of information that often appear in quantitative forms. These can be as everyday as weather maps—which are actually based on multiple, complex calculations of different kinds of meteorological data—or highly specialised dashboards that aim to inform decisions in businesses or government by aggregating a range of key indicators.

Although pioneering visualisation experts emphasised the value and effectiveness of simplicity in design,[2] newer research shows how the creation, spread, and reception of data visualisations is anything but simple. Politics, sociocultural norms and practices, and power run through visualisations just as they do in other mediated forms of communication.[3] Instead of being self-evident and objective windows onto data, and by implication the phenomena they are meant to represent, visualisations are 'multitruthed'[4] in form and function.

Launching from this premise, I aim to address how visualisations represent particular assumptions about the nature of migration, an issue that remains high on international public and policy agendas. Specifically, I am interested in asking (1) how visualisations convey different dimensions of human mobility, (2) whether they exhibit tendencies towards certain features over others, and (3) how these relate to notions of 'freedom' and 'force'.

Why migration? For some time, social scientists have come to understand human behaviours and organisation as increasingly characterised by networks and transnational movement.[5] But others have argued that this 'mobility turn' actually reinforces particular values associated with migration instead of critically engaging with them. Indeed, sociologist Thomas Faist urges us to consider 'what is this new norm normalizing?'[6]

One of these norms, I argue, is the idea of 'freedom of movement'. It can be viewed in either general terms, as in the ability to choose where one goes, or in more specific legal terms such as the rights conferred to workers who are EU citizens. Notions of freedom prominently feature in political discussion about migration policies, rights afforded to citizens and migrants, and the roles of states to intervene.

Ralf Dahrendorf thought of freedom as 'the absence of coercion. Human beings are free to the extent to which they are able to take their own decisions'.[7] Extending from his work, as

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[1] Kirk (2016)
[2] Frankel (2002); Tufte (1983)
[3] Hill (2017); Kennedy et al. (2016); Kennedy and Allen (2017)
[4] Welles and Meirelles (2015: 37)
[5] Castells (2000); Ernste et al. (2009)
[6] Faist (2013: 1644)
[7] Dahrendorf (2007: 125)

well as other philosophers such as Isaiah Berlin and Karl Popper, scholars have linked this concept of freedom to other areas including expression and trade.

Human mobility can also be considered on a spectrum of freedom, or the extent to which people are able to decide to move for a variety of reasons. Some people, owing to their skills, education, citizenship, or financial capital, might be very free to move. Others may not have such choices available to them, particularly asylum seekers or those displaced by conflict.

The complexity of migration—its multidimensional character, as well as the heterogeneity of migrants themselves—presents challenges for data visualisation that require decisions about what to include, exclude, or simplify. These choices, and how they relate to ideas about freedom and force, are the subject of this essay.

Consider the image in Figure 1, reproduced from a recent article in *Science* that reported findings about international migration.[8] It depicts a static (non-interactive) image taken from a dynamic (interactive) data visualisation titled 'The Global Flow of People'.[9]

Figure 1. Circular plot of migration flows between and within world regions during 2005 to 2010

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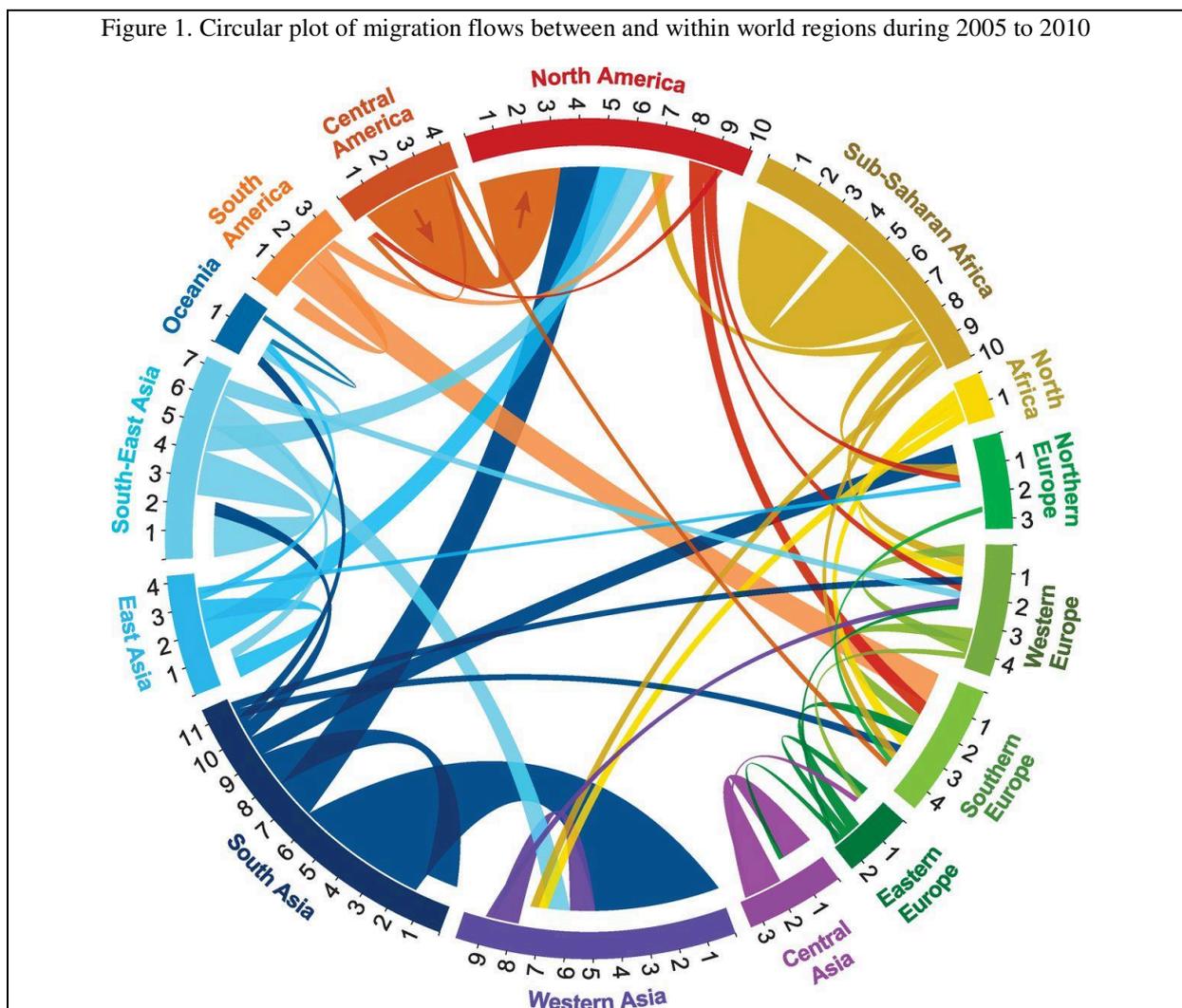
[8] Abel and Sander (2014)

[9] Sander, Abel, and Bauer (2014)

The visualisation relies on a dataset containing information about the number of people who changed their country of residence over five-year periods. To illustrate these changes, the image uses a variety of visual techniques. Which of these is most striking? There are number of possibilities: the rainbow of colours; the curved, semi-transparent lines sweeping across the centre; the circular, symmetrical layout.

One the one hand, these techniques arguably succeed in capturing attention and inviting viewers to spend some time looking more closely at the relationships, trends, and directions of movement contained within the visualisation. For example, regional trends are made especially visible this way: movement from South Asia to Western Asia, or from Central America to North America.

One the other hand, the visualisation misses—or at least does not readily depict—some of the features of migration that other research shows to be important. As I have argued with colleagues elsewhere, this image suggests neat and clean journeys among regions that do not necessarily correspond with the realities of migrants' sometimes-recursive travel back and forth.[10] Moreover, by symbolising aggregate measures of migrants through the width of each coloured ribbon's starting- and end-point, the visualisation collapses individual migrants and their unique experiences into streams, flows, or masses.

The reason for raising these observations is not to claim this visualisation is 'bad', or that there are alternative 'good' ways of showing human movement. Instead, these illustrate how visualisations are both the products of decision-making that prioritises some aspects over others, and also objects that communicate these ideas in explicit and implicit ways. Visualisations, and the resources they draw upon, 'do' ideological work.[11]

This essay explores how this work happens in the context of visualisations about migration, with specific reference to the recent refugee 'crisis' of 2015-16. Examining how 'forced' migration is visualised is especially revealing of the assumptions about what constitutes 'free' movement. My argument is that visualising migration necessarily conveys some aspects of mobility while concealing (or outrightly missing) others. This occurs partly because of the nature of the underlying data—their limitations, assumptions, and gaps—and partly because of the norms and conventions within visualisation practice, as well as the visual resources available to support and enact that practice.

Visualising Migration
Visualisations represent and present data in visual ways to aid understanding. They are different from infographics, which contain visual elements but possibly no data. Migration is a particularly ripe topic for visualisation because it is not only politically and publicly relevant, but also contains several aspects that can be expressed visually.[12]

Table 1 outlines eight dimensions of migration, as well as example features of each dimension that could be visualised.[13] These dimensions can simultaneously exist within a single visualisation: for example, a map showing the number of migrants moving between two countries would have quantitative as well as spatial elements. If this map were animated to show trends over several decades, and further included an option to differentiate between

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[10] Kennedy et al. (2016)
[11] Kennedy et al. (2016)
[12] Dennett (2015)
[13] This is not a comprehensive list: I readily acknowledge there are other aspects of migration missed out.

economic migrant and refugees, then it could communicate temporal and migrant type dimensions as well.

Table 1. Dimensions of migration and corresponding features

Dimension	Description	Example Features
Quantitative	Numerical data showing quantities of migrants	• migrant stocks • migrant flows
Type	Different reasons or main motivations for migrating	• labour/economic • forced • study • family
Spatial	Geographic origins, destinations, or transiting areas	• direction • locations • internal movement • international movement
Temporal	Changes in characteristics relating to individuals or migration processes over time	• dynamics/trends • histories • shocks
Political	Governance of migration or migrants via expressions of power	• public opinion • state activities • differences in policies
Social	Interpersonal and cultural aspects	• lived experiences • community impacts
Economic	Impacts and drivers of migration relating to labour markets or fiscal performance	• access to employment • impacts on public services
Ethical	Trade-offs, norms, values, or moral dilemmas	• availability of rights • available freedoms

The following sections use published visualisations about migration to discuss how and to what extent they convey these eight aspects. Many of them were made in response to the 'refugee crisis' in 2015-16, although several cover time periods beyond that particular window. They were chosen either on the basis of being widely shared, publicised, or being produced by an especially relevant body or source. All details about where to access these visualisations appear in the Appendix.

'The Flow towards Europe': Emphasising the Scale of Migration
The first visualisation, titled 'The Flow towards Europe', uses data from the United Nations High Commissioner for Refugees (UNHCR) since 2012. Figure 2 shows the opening splash page as a static image. Although this is not a data visualisation, it still is part of the overall package that viewers would encounter.

Figure 2. Opening image of 'The Flow towards Europe'

The flow towards Europe

Europe is experiencing the biggest refugee crisis since World War II. Based on data from the United Nations, we clarify the scale of the crisis.
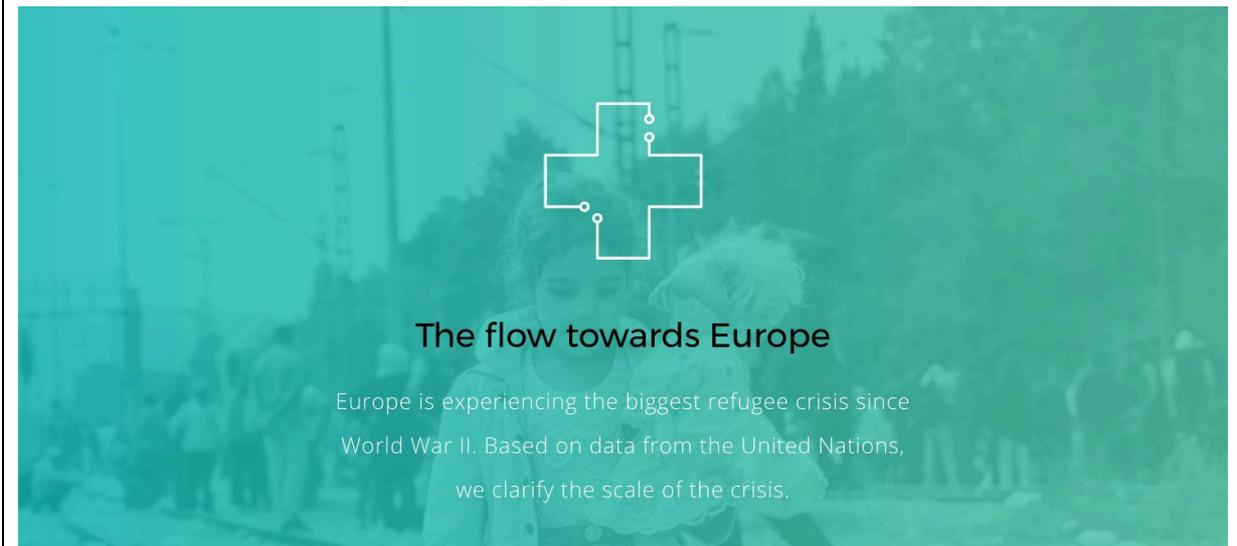
There are several visual and textual elements that help set up the subsequent visualisation and its purpose for the user. The text itself mentions 'crisis' twice, as well as 'Europe' (once in in the bolded title, and once as the first word of the description). These clearly indicate the motivation and scope of the visualisation to follow.

Meanwhile, the stylised cross is composed of two lines with circular endpoints, signaling some kind of movement from one point to another. Combined with the green background, this image takes on similarities to the well-known pharmacy symbol. Finally, the face of a young girl looking downwards appears between the cross and the title, while a larger group— possibly a queue—makes up the background.

This starting point aims to capture attention and encourage the viewer to continue scrolling downwards to the main visualisation, a portion of which is seen in Figure 3. It displays a map of Europe and the surrounding areas—north Africa, central Asia, the Middle East—with individual states outlined in light green on a dark blue background. Above the image (not pictured) is a timeline of asylum applications that initially scrolls through the monthly data while enabling the user to jump to particular moments.

Arguably the most striking visual features are the white lines formed by moving dots. In the full version, which animates each dot as it moves from countries of origin to arrival across Europe, explanatory text preceding the map explains that 'each moving point…represents 25 people. That corresponds to approximately one busload with every other seat taken'. The visual effect is akin to swarming, dust, or some kind of particle movement along currents. As some pathways become more established, more dots appear, and the link grows in visual strength.

Figure 3. Screenshot of 'The Flow towards Europe'
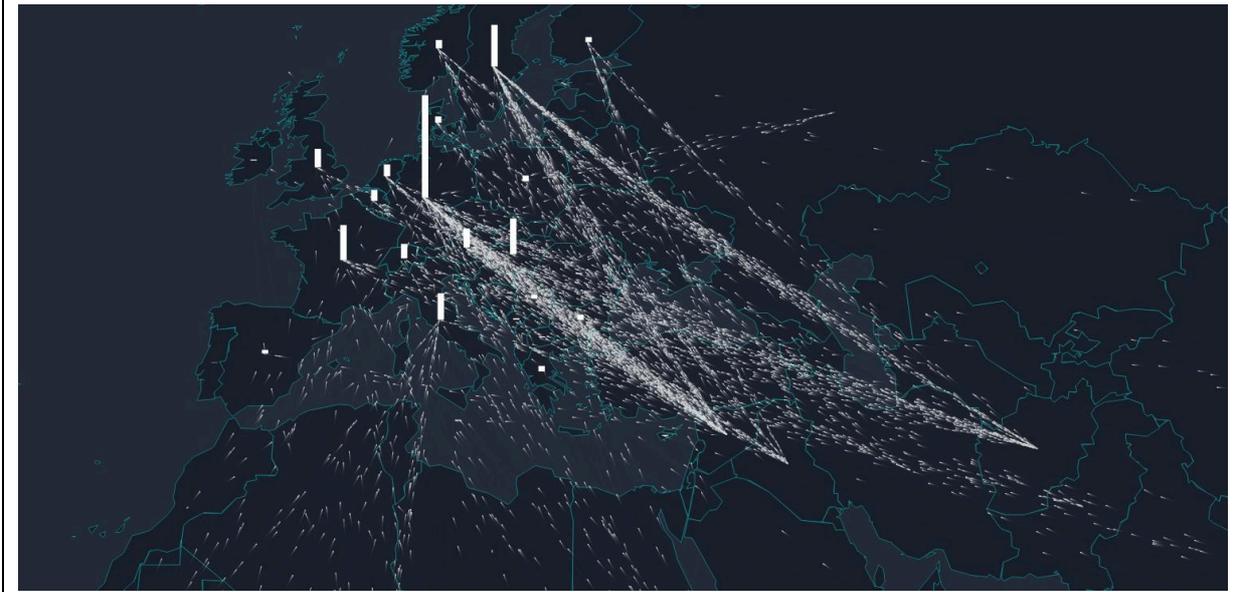
What does the visualisation aim to do? Ostensibly, it tries to 'clarify the scale of the crisis'. By allowing users to pan through over a decade of UNHRC asylum data, it places the 2015-16 period in context. In this way, it does convey the relative size of asylum flows across time.

But it introduces other potential issues for users. The sheer number of dots, especially as they cross each other, obscures the lines demarcating state boundaries, making it difficult to see where asylum applicants are either coming from or going. This problem is partly alleviated by hovering over a selected country: as seen in Figure 4, which separates out the flows to the UK, sending countries are depicted in increasingly brighter shades of purple.

Figure 4. Asylum applications, UK highlighted
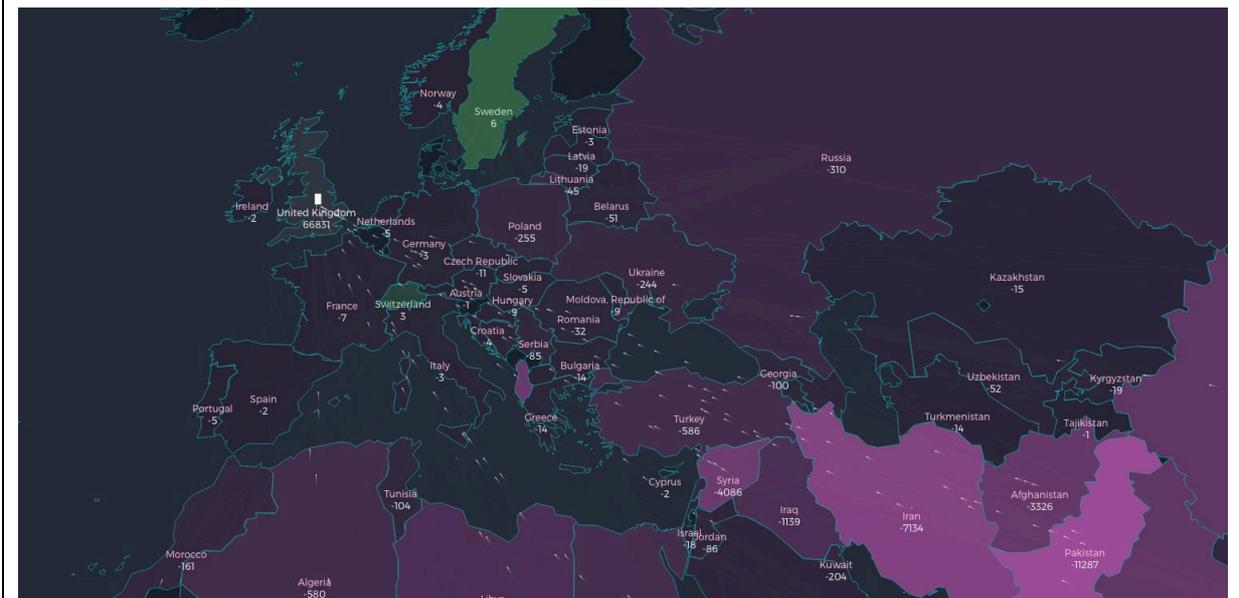
Another problem relates to the way that origin and destination locations are represented. Each dot moves towards the centre of the destination country. This gives an impression of

precision that is simply not present in the data: the units of analysis are states, but the presence and movement of dots suggests they are moving to specific locations within states. Moreover, the lines created by these flows are straight and cross boundaries with ease. This does not reflect many asylum seekers' journeys, which can be recursive, iterative, or multi-staged through several countries.[14]

There are several assumptions made about migration in this piece, expressed across several visual and textual elements. Framing movement in terms of flows, and its importance in terms of crises, reasserts a European perspective: *other* people are coming to Europe, and this is a problem for *us*.[15] Although the choice of geographical scope is understandable for the purposes of the project, it nevertheless contributes to a potentially myopic and limited view of global migration.

Also, the very nature of these dots—each uniform in speed, size, and colour—imparts subtle messages about asylum seekers in numerical terms. What is more, the explanation that translates their aggregation through the visual image of partially-filled buses contributes to an overall sense that the scale and pace of the crisis is what really matters.

'The Refugee Project': Force and Spread

The second visualisation, called 'The Refugee Project', also uses UNHCR data about refugee stocks from 1975 to 2016. It differs from 'The Flow Towards Europe' in its global scope: instead of focusing on asylum seekers entering Europe, this visualisation paints a world-wide picture. In its opening splash page (not pictured), it states its objective as 'allow[ing] for map-based exploration of refugee migrations over time'.

This visualisation uses the sizes of red circles to indicate the number of each country's citizens who are living abroad as refugees, while blue circles indicate the number of refugees in destination countries. Figure 5 demonstrates what this looks like when the user clicks on a given country, in this case Syria. These circles grow and shrink with each year of data. Lines emanating from red circles indicate where refugees are hosted, while lines pointing to blue circles indicate the origins of refugees in that country.


Figure 5. Screenshot of 'The Refugee Project'

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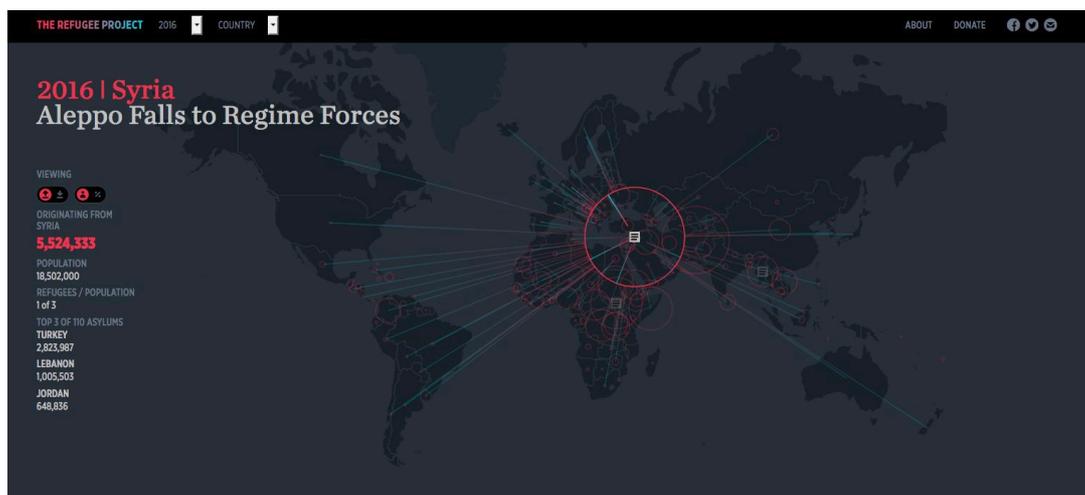
[14] Griffiths (2014)
[15] Anderson (2017)

In addition to these graphics, the visualisation provides descriptive text about pre-specified cases in each year of the dataset. These appear as headlines in the initial exploratory view that can be expanded to reveal much longer explanatory text with links to other related news stories. Figure 6 shows what these features look like.

Figure 6. Detailed view of Syrian refugees in 2016
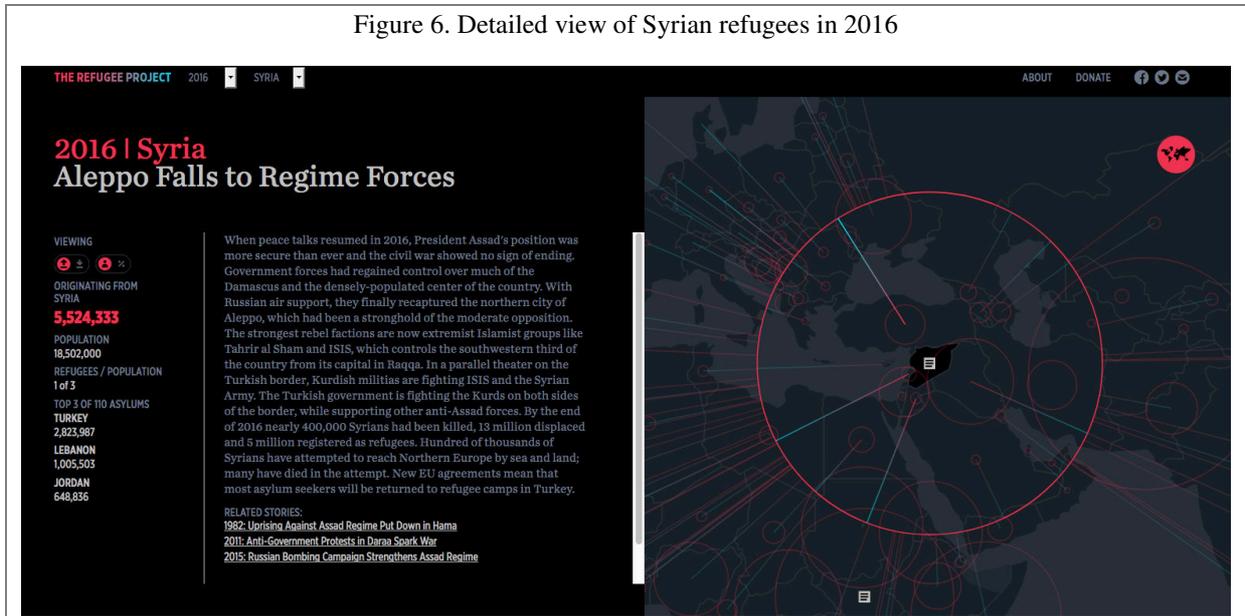
Visualisations about migration tend to feature—even priortise—spatial aspects of movement. Communicating where migrants are coming from, as well as where they are going, is important because these aspects define what being 'a migrant' means.[16] 'The Refugee Project', along with the previous two examples, focus on these end points: whether through stylised graphics (e.g., 'The Global Flow of People') or maps with starting and ending points (e.g., 'The Flow Towards Europe'), there is a clear sense that migrants' journeys begin and end in discrete locations.

Lines and Movement: Comparing Frontex and Reuters Visualisations of Migration Pathways
But what about the intermediate steps—the paths that people take en route? These, too, can be visualised in different ways for different purposes. Figure 7, for example, is an excerpt from a quarterly report produced by Frontex, the European agency in charge of border and coast guard security.

It contains two sets of visualisations. On the left, a series of bar charts indicating the number of 'illegal border-crossings' between 2014-16 across three different routes or known corridors. On the right, a map showing these three entry-points, and the nationalities of migrants intercepted in each border area during the second quarter of 2016.

Although the images state that they are concerned with quantitative data about trends and nationalities, they also do more subtle work in communicating the spatial dimension of migration. The choice of red, for example, raises alarm—especially when contrasted against the blue used to colour Europe (and frame the report itself). Ten red streams, each originating

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[16] The UN definition of a migrant is 'a person who moves to a country other than that of his or her usual residence for a period of at least a year [....] so that the country of destination effectively becomes his or her new country of usual residence' (Anderson and Blinder, 2017).

in a different country in Africa, combine to form one large arrowhead pointing to the Central Mediterranean route.

Meanwhile, in a similar fashion, six curved arrows indicate flows towards the western Balkan route. As was the case in 'The Flow Towards Europe', these lines know no borders. They flow gracefully and unaware of the lines they cross. Yet, in this representation of Destination Europe, there are no state boundaries. When combined with the colour design, this implies the existence of a homogeneous unit, towards which 'illegal border-crossers' gravitate.

Figure 7. Visualising irregular migration into Europe in a Frontex report
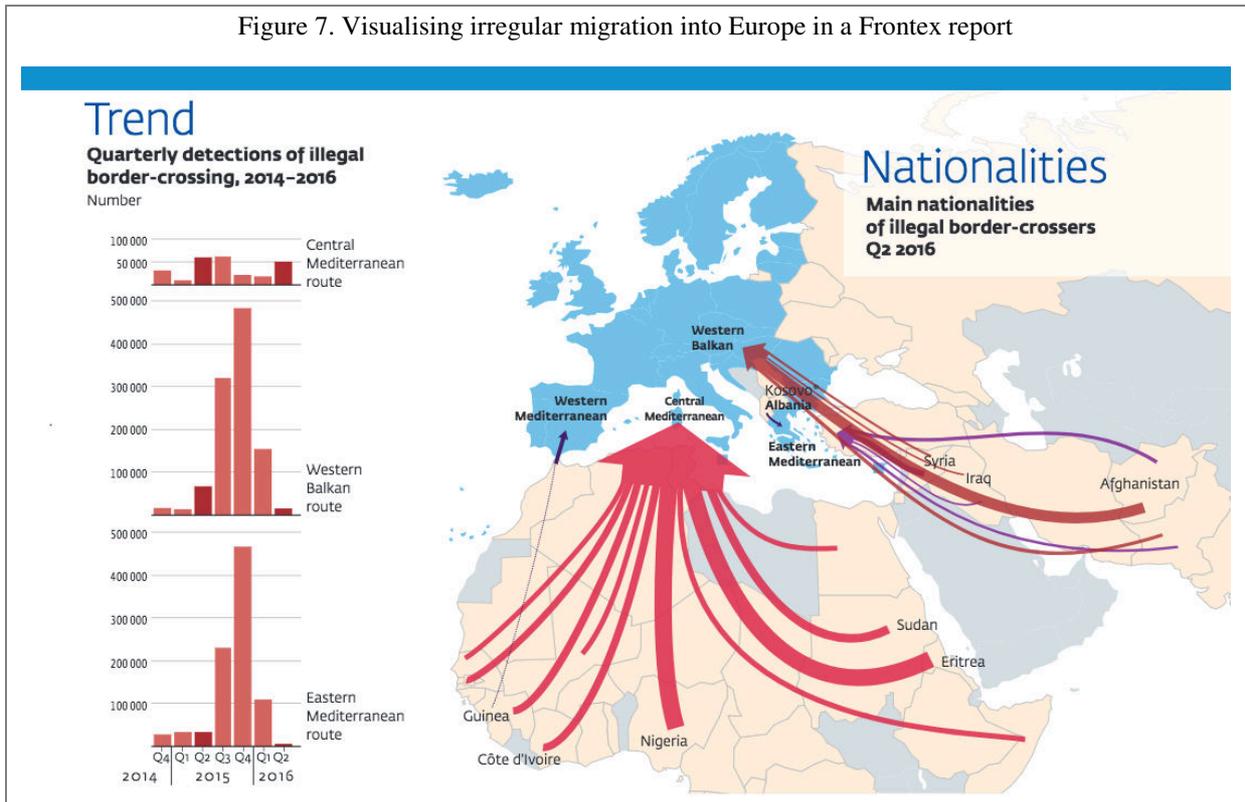
Compare this to the visualisation in Figure 8, produced by Reuters News Agency. Although it explicitly focuses on the pathways used by migrants, rather than migrants' nationalities, the image does exhibit several parallels to the one produced by Frontex. It divides the main routes by their regional origins, indicating specific cities within states through which these pathways go. Indeed, using language such as 'migration hub' and 'connecting or minor route' emphasises this visualisation's character as a network.

Placing these images next to each other is not intended to suggest that one is necessarily 'better' or more 'effective' than the other. Instead, they are accomplishing different tasks for different audiences. For example, Frontex quarterly reports aren't aimed at informing the general public. Instead, they are directed towards border control authorities around Europe to improve their operational practices. Moreover, they are prepared 'to provide a clear summary of the situation at the external border of the EU',[17] signaling how the scope and focus of each report is not intra-European.

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[17] Frontex (2016: 3)

Figure 8. How Reuters visualises migration pathways into Europe
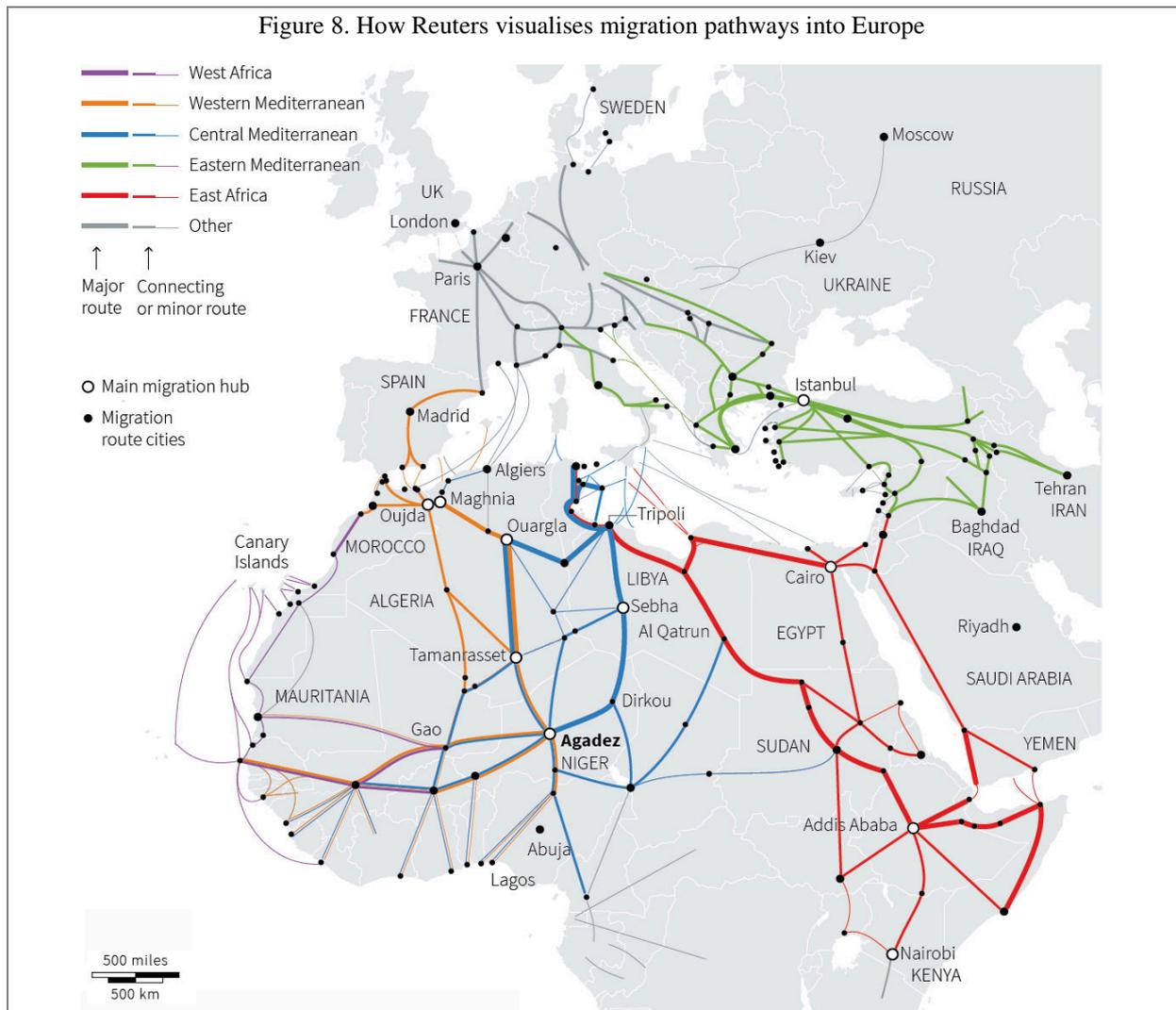
But they do convey different assumptions about how and where forced migration happens. Given its focus on protecting the external EU border, Frontex understandably directs its attention and limited resources towards major channels where it is doing its work. This is conveyed through large, sweeping, and relatively imprecise arrows: the concern is not necessarily about the routes prior to arriving at the threshold of Europe, but rather where along that imagined border people are arriving.

'Fortress Europe': Visualising Individual Journeys
The previous visualisations used lines in different ways to indicate movement—if not literally and accurately as in the Reuters example, then as a stylised way of distinguishing between 'here' and 'there' in the case of the Frontex report. Both instances, however, generalise from migrants' experiences to produce 'typical' or 'usual' channels and pathways.

Contrast this with the visualisation 'Fortress Europe', produced by Swedish Radio and seen in Figure 9. This public service broadcaster, in collaboration with other members of the European Broadcasting Union (EBU) in the UK, France, and Germany, collected stories of Syrian asylum seekers and refugees. These interviews—53 in all—form the qualitative data about each person's or family's movements from one place to another.

Figure 9. Screenshot of 'Fortress Europe'
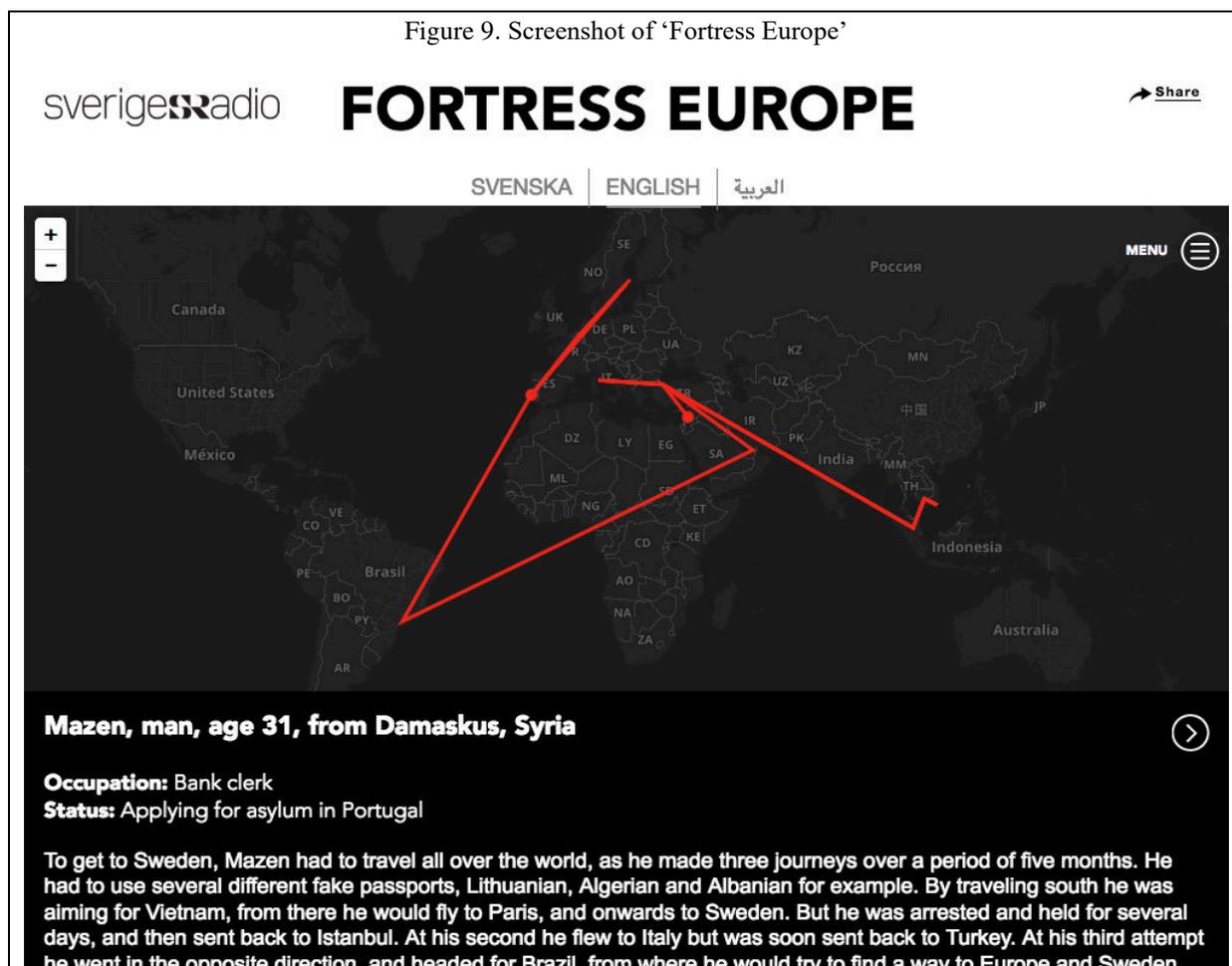
The dark grey and black colour scheme draws out the contrasting white text and thick red lines. These lines, with solid circles at each endpoint, represent the multi-staged journeys described in the text panels. Figure 9 shows the journey of Mazen, a 31-year-old man whose story is one of longest and most inter-continental examples contained in the visualisation. By clicking on the 'menu' icon in the upper right-hand corner, users can access another panel in the same red colour to choose among the other interviews. Each name is accompanied by the conventional symbols for each sex, Mars (male) or Venus (female), age, and city of origin.

On the one hand, the fact this visualisation is based on qualitative interview data allows it to depict more finely-grained journeys that occur in multiple stages. Instead of sweeping, unbroken lines such as those suggested in previous examples, these lines are jagged and often recursive: as seen in several panels, asylum seekers often try several applications in sequence. This element would not necessarily be captured in statistics that only report on migrants' countries of origin or eventual residence.

On the other hand, as a product generated by journalists in the reporting tradition, these stories still tend to follow formulaic templates—not only in the choice of which demographic traits to mention, but also in highlighting the interviewees' occupations and asylum status. They also priortise a narrative approach to each migrant's story, possibly missing out the long periods of waiting that increasingly characterise asylum seekers' experiences.[18]

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[18] Griffiths (2014); Hyndman and Giles (2011)

Visualising Freedom and Force

Although brief and necessarily selective, this survey of visualisations does reveal some key observations. First, the unit of analysis across these images tends to be the nation-state. There are some exceptions, notably the portrayal of Europe as a region in the Frontex report (Figure 7). But it is clear through the dominant use of maps that the nation-state is a major lens through which asylum and migration is viewed.

This is partly due to the nature of the underlying data, which is almost always collected and reported at the state level. Yet it is also arguably part of a wider interest in policymaking and public debate on the geographical aspects of migration: not only in terms of where people come from and go to, but also in terms of their impacts on destination countries.[19] This is at the expense of observing the implications and consequences of migration at other scales, including supranational regions, sub-regions, and cities.

Second, migrants themselves tend to be represented as groups or in masses. Through lines, arcs, or arrows, individual people become aggregated into larger flows and stocks. This 'massification' of migrants has links beyond the visual, even extending to the practices of modern border control.[20] As a result, an individual's characteristics and path are replaced with relatively blunt features, usually 'country of origin' and 'country of destination'.

While this kind of simplification does enable comparison of key aspects over time, it also can obscure the heterogeneity present in migrants' reasons for moving, as well as the conditions in which they move. Several visualisations such as those in Figure 6 and Figure 9 use additional text panels as a way of providing more detail about a given population or individual.

Third, the visualisations tend to more readily depict quantitative, spatial, and temporal aspects of migration over other dimensions offered in Table 1. To an extent, the visual techniques on display (e.g., bar charts, maps, timelines) lend themselves to these dimensions.[21] Moreover, the very notion of 'data visualisation' assumes some kind of numerical representation of reality.

The point offered here is more about the visual priority given to these aspects compared to the social, political, and ethical dimensions of mobility. To be sure, data for these areas may not be compiled or even available to the extent desired, either over time or across cases. This illustrates how critically analysing visualisations requires not only asking questions about what is represented and how, but also what is missing and potentially left out.[22]

It is this aspect of missing-ness that is particularly pronounced when thinking about the subject matter of these visualisations. There is relatively little suggestion or analysis of the conditions in which forced migration is happening, the reasons why it continues, or ways forward either in policy or civil society. Instead, viewers are possibly left with the impression that the sheer scale of the problem, combined with the inevitability of further migration, makes the whole situation intractable. The flood of dots, of half-full buses, of unbroken arrows, will continue.

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[19] Allen et al. (2017)
[20] Adey (2009)
[21] Dennett (2015)
[22] Kress and Van Leeuwen (2006)

In their attempts to represent migration and asylum, these examples demonstrate how there are multiple tensions present in every visualisation—between facilitating exploration and providing explanation, between simplification and detail, between the needs and expectations of audiences and the abilities and aims of visualisers.[23]

Therefore, the implication for visualisation practice is not to definitively resolve these tensions in favour of 'best practice' or a particular definition of 'effectiveness'. Rather, it is to acknowledge how the choices and decisions involved in conceiving, creating, and communicating data visualisations shape not only how they appear, but also how they are received.[24]

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[23] Alcíbar (2006); Kennedy et al. (2016)
[24] Allen (2017)

Appendix
The visualisations mentioned within this essay can be found at the following URLs (accurate as of 1 October 2017).

'The Global Flow of People'
http://www.global-migration.info/

'The Flow Towards Europe'
https://www.lucify.com/the-flow-towards-europe/

'The Refugee Project'
http://www.therefugeeproject.org/#/2016

'Quarterly Detections of Illegal Border-Crossing, 2014-2016' and 'Main Nationalities of Illegal Border-Crossers Q2 2016', Frontex, p.9
http://frontex.europa.eu/assets/Publications/Risk_Analysis/FRAN_2016_Q2.pdf

'Europe's Migration Crisis'
http://graphics.thomsonreuters.com/15/migrants/#section-network

'Fortress Europe'
http://sverigesradio.se/fortresseurope/

Works Cited

Abel GJ and Sander N (2014) Quantifying Global International Migration Flows. *Science* 343(6178): 1520.

Adey P (2009) Facing Airport Security: Affect, Biopolitics, and the Preemptive Securitisation of the Mobile Body. *Environment and Planning D: Society and Space* 27(2): 274–295.

Alcíbar M (2017) Information visualisation as a resource for popularising the technical-biomedical aspects of the last Ebola virus epidemic: The case of the Spanish reference press. *Public Understanding of Science*. Available from: http://dx.doi.org/10.1177/0963662517702047 (accessed 6 June 2017).

Allen W, Anderson B, Van Hear N, et al. (2017) Who Counts in Crises? The New Geopolitics of International Migration and Refugee Governance. *Geopolitics*.

Allen WL (2017) Making Corpus Data Visible: Visualising Text With Research Intermediaries. *Corpora* 12(3). Available from: http://www.compas.ox.ac.uk/media/Allen_Making_Corpus_Data_Visible_2018.pdf.

Anderson B (2017) Towards a new politics of migration? *Ethnic and Racial Studies* 40(9): 1527–1537.

Anderson B and Blinder S (2017) *Who Counts as a Migrant? Definitions and Their Consequences*. MIgration Observatory Briefing, Oxford: COMPAS, University of Oxford. Available from: http://www.migrationobservatory.ox.ac.uk/wp-content/uploads/2016/04/Briefing-Who_Counts_Migrant.pdf.

Castells M (2000) *The rise of the network society*. London: Wiley Blackwell.

Dahrendorf R (2007) Freedom. In: Randall E and Brack D (eds), *Dictionary of Liberal Thought*, London: Politico's Publishing, pp. 125–130.

Dennett A (2015) Visualising migration: Online tools for taking us beyond the static map. *Migration Studies* 3(1): 143–152.

Ernste H, Van Houtum H and Zoomers A (2009) Trans-world: debating the place and borders of places in the age of transnationalism. *Tijdschrift voor economische en sociale geografie* 100(5): 577–586.

Faist T (2013) The mobility turn: a new paradigm for the social sciences? *Ethnic and Racial Studies* 36(11): 1637–1646.

Frankel F (2002) *Envisioning science: The design and craft of the science image*. Cambridge, MA: MIT Press.

Frontex (2016) *Frontex Risk Analysis Network Quarterly: Quarter 2, April-June 2016*. Warsaw, Poland: Frontex Risk Analysis Unit.

Griffiths MBE (2014) Out of Time: The Temporal Uncertainties of Refused Asylum Seekers and Immigration Detainees. *Journal of Ethnic and Migration Studies* 40(12): 1991–2009.

Hill RL (2017) The political potential of numbers: data visualisation in the abortion debate. *Women, Gender and Research* (1). Available from: http://eprints.whiterose.ac.uk/118537/.

Hyndman J and Giles W (2011) Waiting for what? The feminization of asylum in protracted situations. *Gender, Place & Culture* 18(03): 361–379.

Kennedy H and Allen W (2017) Data Visualisation as an Emerging Tool for Online Research. 2nd Edition. In: Fielding NG, Lee RM, and Blank G (eds), *The SAGE Handbook of Online Research Methods*, London: SAGE Publications Ltd.

Kennedy H, Hill RL, Aiello G, et al. (2016) The work that visualisation conventions do. *Information, Communication & Society* 19(6): 715–735.

Kirk A (2016) *Data Visualisation: A Handbook for Data Driven Design*. London: SAGE.

Kress GR and Van Leeuwen T (2006) *Reading images: the grammar of visual design*. 2nd ed. London: Routledge.

Sander N, Abel GJ and Bauer R (2014) The Global Flow of People. Available from: http://www.global-migration.info/ (accessed 29 September 2017).

Tufte ER (1983) *The visual display of quantitative information*. Cheshire, CT: Graphics Press.

Welles B and Meirelles I (2015) Visualizing Computational Social Science. *Science Communication* 37(1): 34–58.