Portable Interactive Atlases for Political Science Research

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Abstract

Political scientists increasingly work with data that capture relationships among countries across time, yet these patterns can be difficult to explore and communicate through static figures and tables. This article presents a practical workflow for building portable interactive atlases that allow researchers to examine longitudinal networks through a single HTML file. Combining maps, temporal navigation, inspectable observations, and data and image exports, the approach makes visualization choices and underlying evidence accessible to readers without requiring specialized software or website maintenance. An application to international trade around economic sanctions illustrates how researchers can examine shifts in trading partners, compare relationships over time, and assess patterns consistent with potential sanctions busting. The discussion emphasizes transparent measurement choices and distinguishes descriptive trade changes from evidence of intentional circumvention. By connecting an adaptable mapping workflow to concrete analytical tasks, the article offers political scientists a practical approach to exploring and sharing relational data while preserving the information needed to scrutinize their interpretations.

Keywords: visualizations, maps, longitudinal data, economic sanctions, sanctions busting

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Introduction

Please download the online supplement to this paper, an interactive HTML file. This file requires only a browser, and it can be downloaded here:

https://www.dropbox.com/scl/fo/sgxtiheqlygg8r5uztgi5/AIp4q9cc5JRlEeciZbX9h8o?rlkey=0xtziw1522dze0tulb99b3sbh&dl=0

Political relationships unfold across time and connect actors whose choices depend partly on the relationships around them, especially in international relations (but not only). International relations is inherently relational (as the name indicates) (Lazer 2011), and the subdiscipline frequently examines political behavior as a function of trade (Ward et al. 2013), foreign aid (Swiss 2017; Oishi et al. 2022), overseas development assistance (ODA) (Roodman 2005), alliances (Leeds et al. 2002), sanctions circumvention and evasion (Early 2015; Preble and Willis 2024; Preble and Willis Ward 2024), econonomic interdependence (Farrell and Newman 2019), conflict (Maoz 2009), nonproliferation (Onderco 2021), and many other forms of political behavior in international relations.

Many political science datasets describe relationships among geographically situated actors over time. Foreign aid links donors and recipients; migration connects places of origin and destination; diplomatic representation records ties between sending and host states; and arms transfers connect suppliers with recipients. Across these settings, researchers confront related questions. Which relationships persist, which emerge or disappear, and how does the geographic distribution of connections change? Longitudinal network atlases provide a way to explore these questions while retaining access to the observations behind the display. Their usefulness depends on adapting the visual encodings and documentation to the substantive meaning of each relationship. I demonstrate this approach through trade relationships surrounding three sanctions targets - Libya, Lebanon, and Belarus using Hufbauer et al. (Hufbauer et al. 2009). This application illustrates how an atlas can connect temporal exploration with scrutiny of alternative measures, reference periods, and coding decisions. A simplified example in the supplement provides an entry point for researchers adapting the workflow to their own data.

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These *international relations* generate data that are simultaneously relational but also temporal and geographic: that is spanning across time and space. Presenting these dimensions together poses a practical challenge for published research where interactive maps and models do not render easily in portable document formats (PDFs), Word documents, or other types of files, which frequently require proprietary software to view and interact. A static map can show the distribution of relationships in a particular year, while a time-series figure can trace changes in selected relationships. Researchers must decide those countries, years, and observations readers will encounter visually in articles (or must interact with the data themselves). Those decisions shape how readers understand the evidence and which patterns they can examine for themselves.

Interactive maps offer opportunities to make these choices more accessible while opening large data sets to exploration. *Visualizing* networks can reveal patterns and relationships that are difficult to discern in statistical tables or among thousands of observations (Willis and Preble, n.d.). Within a discipline that places considerable emphasis on quantitative inference, systematic description helps researchers identify relational patterns alongside variation in those relations, and help with the interpretation of statistical findings. Interactive maps support this work by allowing readers to move between years, inspect individual relationships, and examine the data set observations underlying a visual pattern that confirm (and disconfirm) our findings. Their usefulness depends on whether their design helps readers connect what they see to the data and analytical choices that produced it.

This article asks how political scientists can make longitudinal network data easier to explore, scrutinize, and share through portable interactive maps using simple web-based technologies that already exist on browsers and that do not involve advanced programming skills. It develops a workflow for packaging geographic context, annual relationship data, measurement rules, and export functions into a single HTML file that readers can open in a web browser without the need for additional proprietary software that even work on portable smartphone devices. The software to run these figures exists on nearly every personal computer, tablet, or smart phone, which highlights how portability is central to the approach presented here. Distributing the interface together with its data offers a practical way to share an interactive research artifact without requiring readers to install specialized software or for researchers to maintain a separate website. Because the data use HTML, the page that is created to profile the data can be placed

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easily on web sites for others to utilize and share. More critically, updating such tools can be automated using R and Python, tools that many social science researchers already use.

The application presented here examines the trade networks of Libya, Lebanon, and Belarus, using selected sanctions episodes identified in Hufbauer et al (Hufbauer et al. 2009) using Standard International Trade Classification Data (SITC, rev. 2) (Growth Lab at Harvard University 2026). Each country profile displays all available trade years, placing the selected episode within a longer commercial history. A measure selector allows readers to examine relationships using a relational trajectory classification or alternative dichotomous sanctions-busting measures present in the literature. This feature makes measurement choices part of the reader's encounter with the evidence. Readers can inspect how a relationship's classification changes while its underlying trade values remain the same, they can download the underlying data, and generated visuals that can be used in slide presentations and papers.

The contribution of this article is a practical framework for connecting interactive visualization to transparent research practices but also developing tools that aid in the descriptive exploration of data sets so that the *relations* of *international relations* is more apparent and accessible. The sanctions application presented illustrates how readers can examine variables that are common in trade and sanctions research, notably partner composition, commercial dependence, and changes relative to an explicit historical baseline. The online supplement presents code using fictitious foreign aid data to give uses a less complex example with which to adapt. More critically, the tool presented here highlights how trade does not by itself demonstrate intentional sanctions circumvention nor do they identify the causal effects of sanctions. By making the underlying values and comparison rules that determines the extent to which sanctions busters are busting, the proposed workflow aims to support more informed exploration and interpretation of relational evidence while presenting an accessible and affordable tool for exploring and examining complex relational data.

The article proceeds in six sections. I begin by identifying the design principles that guide the atlas, emphasizing transparency, accessibility, and portability. I then explain the workflow for converting longitudinal relational data into interactive maps. Next, I illustrate this approach through trade networks involving Libya, Lebanon, and Belarus, showing how alternative measures reveal different patterns of trade under sanctions. I evaluate the atlas's usefulness and

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limitations, including data coverage, measurement choices, and the boundaries of visual interpretation, before concluding with its implications for research practice. In two appendices, I provide data preparation guidance and a worked tutorial using fictional aid networks that readers can adapt with either R or Python.

Design Principles

I designed the atlas to help readers explore relationships over time and examine the data behind the patterns they see. The aim is to make it straightforward to move from a broad view of a network to a particular relationship, year, or measurement choice, espescially when working with trade data sets over several decades (which can mean hundreds of thousands of data set observations). I develop five principles guide the design of this interactive tool.

First, readers should be able to follow relationships over time. The atlas includes all available trade years, including those before and after the selected sanctions episode. Countries remain in the same geographic positions as the year changes, making individual partners easier to follow. Marker sizes represent bilateral trade and use a fixed scale across years within each target profile. A change in marker size thus reflects a change in trade rather than a rescaled display. Scales differ across targets, and the smallest relationships receive a minimum marker size so they remain visible. A "play" button is built into the feature so users can see how networks and their respective properties change and adapt over time, as well. Second, readers should be able to see how measurement choices affect the map. The atlas allows them to switch among three measures while keeping the country and year unchanged. Selecting a partner reveals its trade values, shares, reference values, and classifications under each measure. Readers can then examine why a relationship receives a particular classification or why the available information does not support one.

Third, readers should have some control over how much detail they see. I place the map and its main controls at the center of the interface. Explanations of the legend, data coverage, and measures remain available, but readers can open them when needed so that it reduces real estate on the screen or does not occupy too much space on small portable devices. Legend toggles also allow readers to focus on particular categories of relationships to decouple complexity in large networks and to aid in the comparison of key network dynamics over time. These controls

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change what appears on the map without removing observations from the underlying data. Fourth, the map should communicate through more than color and accessibility should be seriously considered as these interactive features are developed. I use different shapes to identify categories, including opposing triangles for expanding and contracting relationships, a plus symbol for new trade, and a hexagon for reentry. Labels and the partner inspector explain these categories in words. This combination gives readers several ways to identify a relationship and interpret its classification, and future updates and adaptations should include alt text and other accommodations support.

Finally, the atlas should be easy to share and possible to rebuild without requiring expensive proprietary software. The HTML file contains the data, map, styling, and explanatory text needed to view it offline and uses apps and applets already present on most computers (PC or Mac) and mobile devices. The interactive map also permits users to export a map or download annual observations for further examination, although researchers should take care that the data they are sharing have the requisite licenses for doing so. The accompanying source files and documentation explain how to rebuild the atlas and adapt it to another project. Together, these materials support its use as a research tool, a manuscript supplement, a teaching resource, and a starting point for further research.

Atlas Workflow

Building an atlas begins with deciding what relationships to display and what readers should be able to explore. The actors might be states, organizations, or individuals, while the relationships might represent trade, aid, alliances, or other connections. Researchers also need to identify the available time periods and decide what a connection means. In the sanctions application, I display annual bilateral trade and allow readers to compare different ways of classifying those relationships.

The next step is to prepare the relationship data. Each observation needs identifiers for the actors involved, a time period, and the value or type of relationship. These identifiers must remain consistent across the files used to build the atlas. Researchers also need to distinguish a recorded zero from an unavailable observation and decide how to handle absent records. Any measures or categories should be calculated at this stage and documented alongside the data. Keeping these

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decisions separate from the interface makes it easier to revise a measure or adapt the atlas to another application.

The prepared observations are then connected to geographic information. Coordinates locate the actors, while boundary files provide geographic context. This step requires checking that identifiers match and that the locations make sense for the period being studied. Historical changes can complicate these matches, so researchers should explain whether the map uses contemporary boundaries or reconstructs geography for each period. Once the data are prepared, they can support several connected views. In my implementation, the map displays relationships, the timeline places them in a longer time frame, the partner inspector provides details about a selected relationship, and the table lets readers examine the values directly. Changing the year or measure updates these views together. Readers can begin with a broad pattern and then examine the observations that contribute to it.

The final step is to check the atlas and prepare it for distribution. I compare displayed values with the prepared data and check that selections, filters, and exports work as intended. The completed HTML file contains the materials needed to view the atlas, allowing readers to open it without running the code that built it. Sharing the source files and documentation also allows others to rebuild or adapt the example. The appendices provide a worked tutorial using fictional aid data, with equivalent workflows in R and Python.

Trade and Trade-Based Sanctions Busting

This article demonstrates a practical case using trade data coupled with economic sanctions episodes and the coding of trade-based sanctions busting. I present three cases of economic sanctions that are prominent examples of how visualizations can help examine *relational* dynamics of trade, trade-based sanctions busting, and the imposition of economic sanctions. Using Hufbauer et al. (Hufbauer et al. 2009) and their coding of economic sanctions events, I choose three cases as a demonstration from their book: Libya (1978-2004), Lebanon (1984-1997), and Belarus (2006-2024) (Hufbauer et al. 2009, 25; 27; 36). I select these cases because they offer a range of sanctions busting opportunities as well as examples of sanctions termination (Attia and Grauvogel 2023), which can help us see how trade adapts post-sanctions. I compare a

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relational classification (Preble 2026) with two dichotomous indicators (Early 2015; Preble 2023). I document their implementation in the online appendix.

For the relational classification (Preble 2026), I compare each partner's share of the target's total trade with its minimum and maximum shares during the five years before sanctions onset. Continuing relationships are expanding when their shares rise above that range, contracting when they fall below it, and stable when they remain within it. I distinguish these changes from new trade, interruptions, durable exits, and reentry (these are described in detail in the sample interactive map in the online supplement). This approach captures changes in a partner's relative importance within the target's trading network, which captures more variation that the dichotomous measures of trade-based sanctions busting.

I use these sanctions cases (Libya, Lebanon, and Belarus) to illustrate three ways that interactive visualization supports the interpretation of longitudinal network data. First, I examine how alternative operationalizations change which trading partners receive a sanctions-busting classification. Second, I consider relationships that emerge against a baseline of no observed trade and the difficulties they present for percentage-growth measures. Third, I distinguish the magnitude of a trading relationship from changes in its relative importance. By moving between maps, years, and underlying observations, I show how the atlas makes these analytical distinctions available for inspection that might not be evident or apparent if examining tabular data or regression results alone. Figure 1 shows the case, measure, and year controls used to make these comparisons and an overall view of the interface of the html page. Readers can use the HTML atlas in the online supplement to explore the relationships illustrated in Figures 2–4.

Figure 2 shows Libya's trade network in 1986 with Bulgaria selected. Bulgaria accounts for approximately 4.93% of Libya's trade. It is classified as expanding by the relational measure and positively classified under the Preble binary measure, but falls below the Early-style benchmark's 5% share threshold. Switching measures makes that consequential threshold visible. The insight is that readers can inspect why a country changes its trade-based sanctions busting classification, rather than treating the displayed network as independent of measurement choices. Lebanon illustrates relationships that growth-based measures struggle to classify. Figure 3 shows its trade network in 1990 with Romania selected. Romania accounts for approximately 3.61% of Lebanon's trade in 1990 and appears as "New" in the relational view, while its zero

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onset-year baseline leaves the percentage-growth condition undefined under the implemented dichotomous measure (Preble 2023). The atlas makes these differences visible. “New” identifies positive observed trade during the selected episode following five baseline years coded as no observed trade. Figure 4 shows Belarus’s trade network in 2010 with Russia selected, illustrating why a large trading relationship is not necessarily an expanding relationship. In 2010, Russia accounts for approximately 53.94% of Belarus’s trade, yet the relational measure classifies it as contracting because its share falls below its pre-sanctions baseline range while both binary measures classify it as a positive case of trade-based sanctions busting. This is a particularly useful example because marker size and classification communicate different properties. A dominant partner can lose relative importance while still satisfying a growth-based indicator.

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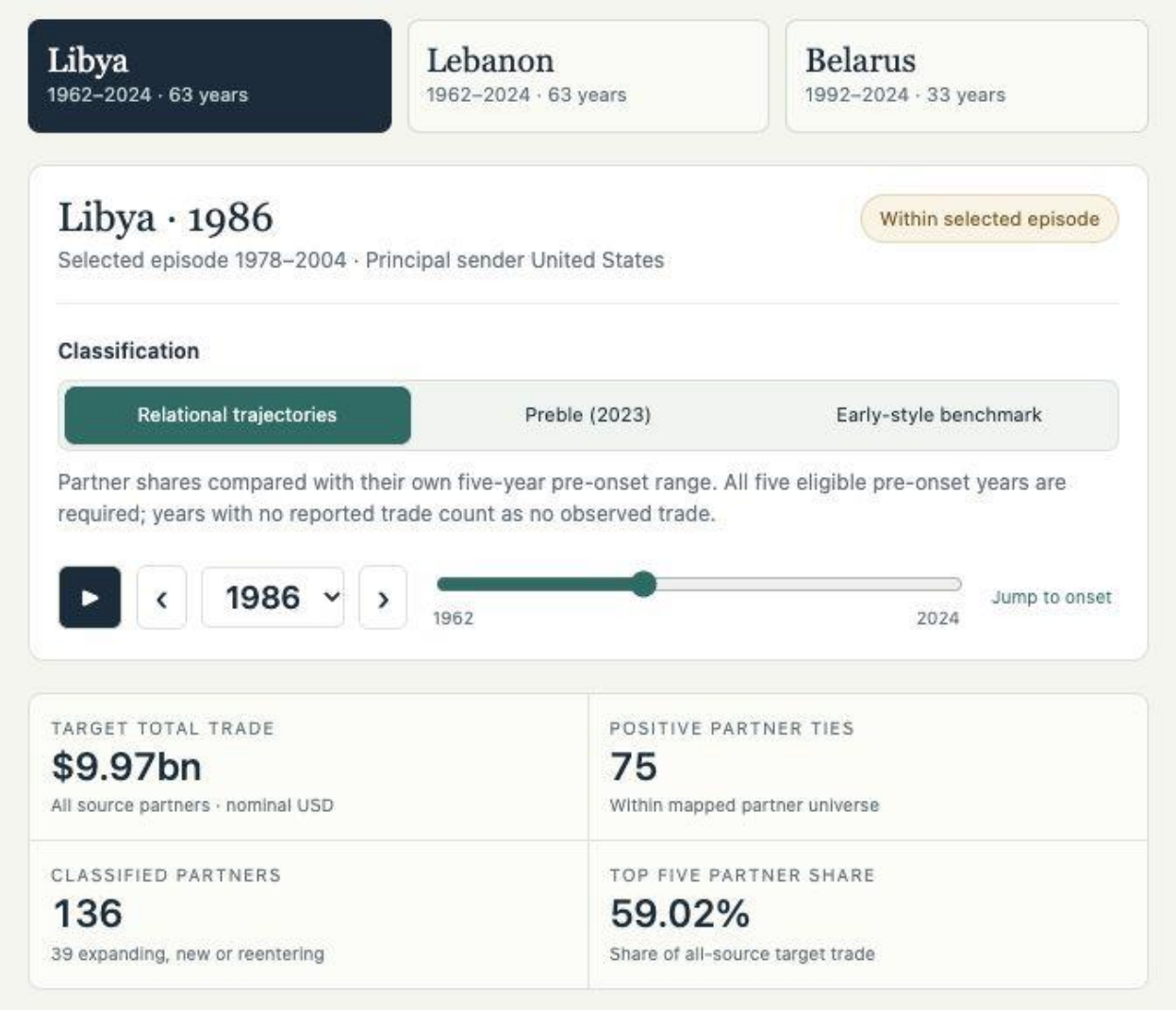


Figure 1. Selecting cases, measures, and years in the interactive atlas interface. The interface combines case selection, classification toggles, a year selector, and summary statistics. Libya in 1986 is shown with the relational classification selected. Readers can hold the case and year constant while comparing measures or move through time within a case.

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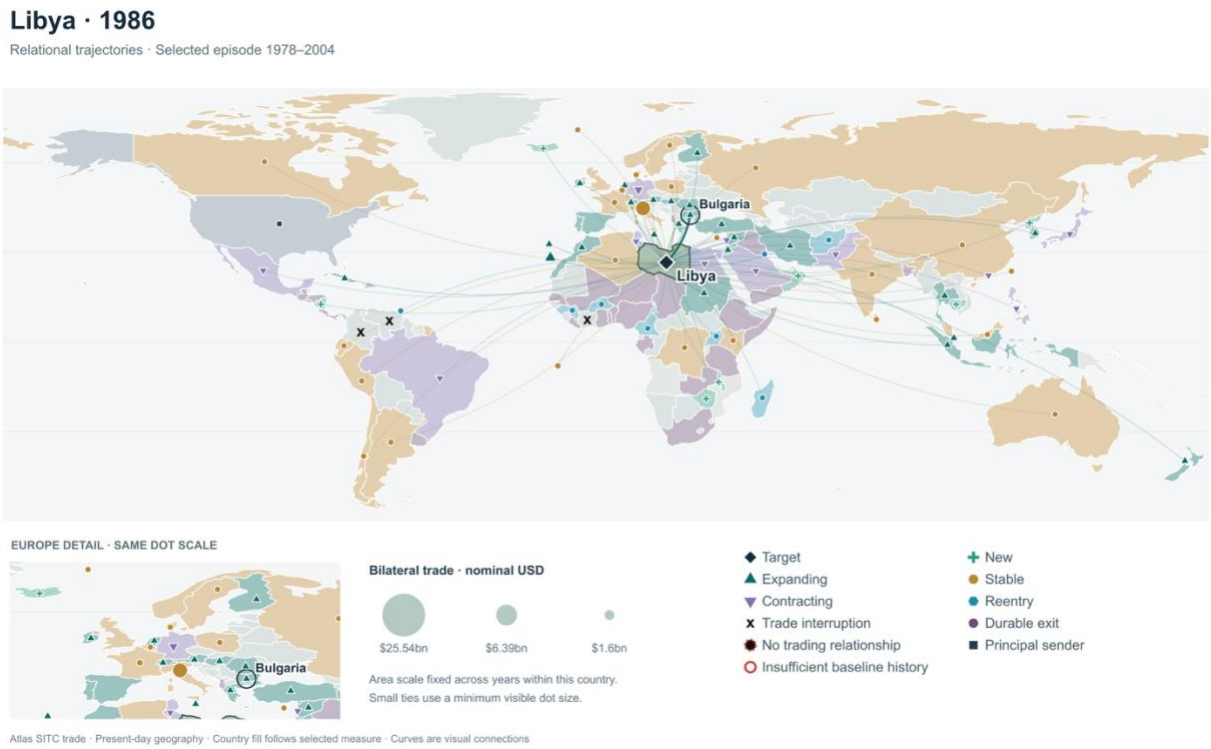


Figure 2. Measurement choices in Libya's trade network, 1986. The relational map highlights Bulgaria, which accounts for 4.93% of Libya's trade and is classified as expanding. The same relationship meets the Preble binary rule but falls below the Early-style benchmark's 5% trade-share threshold. These alternative classifications can be compared in the interactive supplement.

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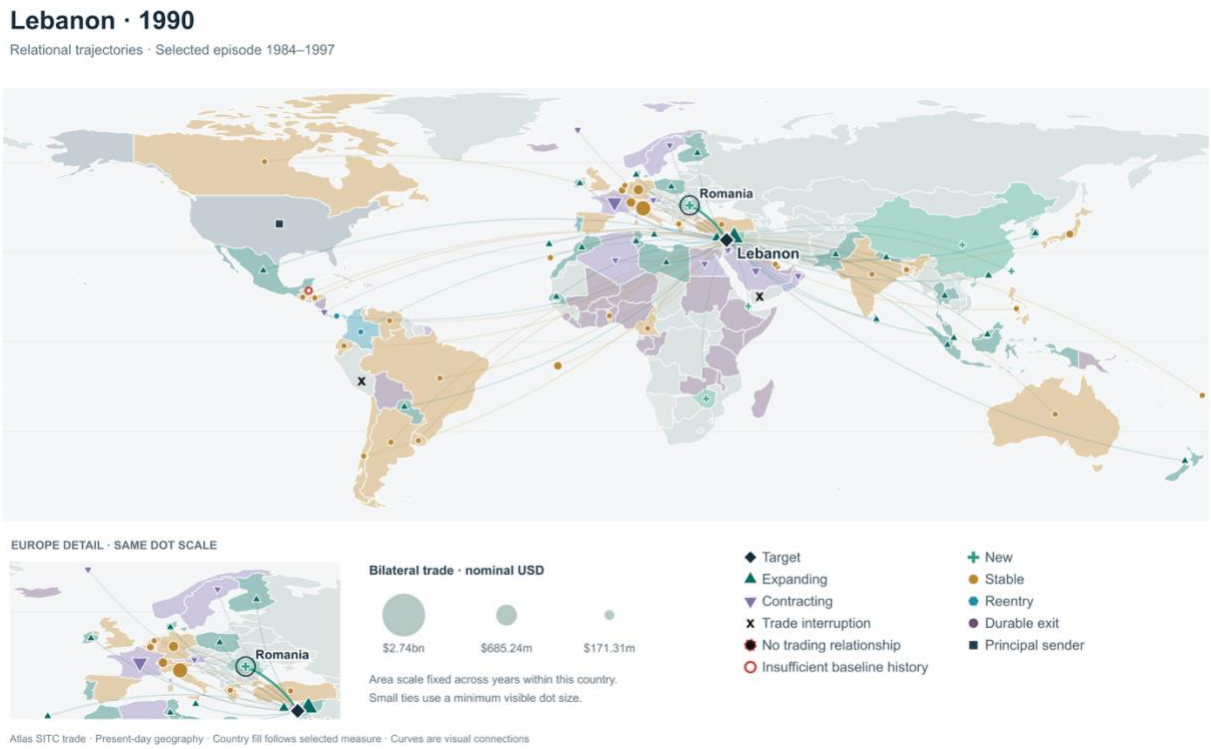


Figure 3. New relationships in Lebanon's trade network, 1990. Romania accounts for 3.61% of Lebanon's trade and is classified as New relative to five baseline years coded as no observed trade. Its zero onset-year trade leaves the percentage-growth condition undefined under the implemented Preble's (2023) measure. The highlighted relationship illustrates how baseline choices affect classification.

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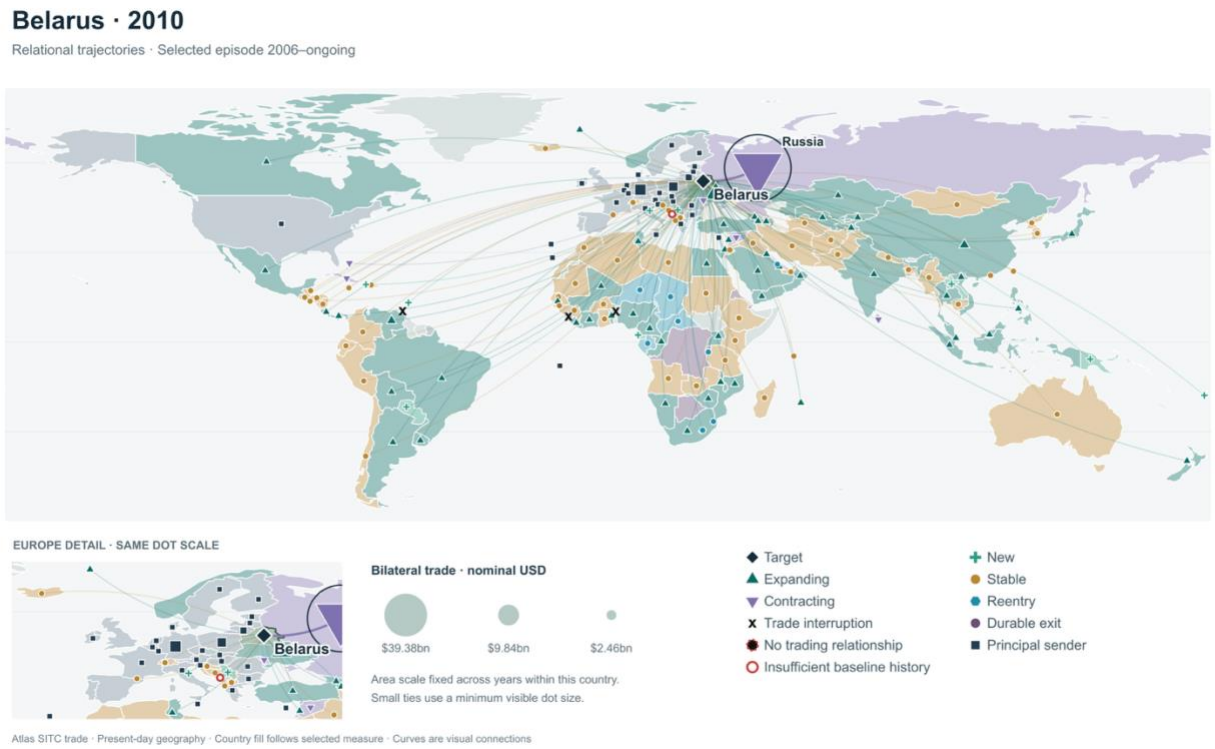


Figure 4. Trade magnitude and relative change in Belarus's network, 2010. Russia accounts for 53.94% of Belarus's trade but is classified as contracting because its share is below the 2001–2005 baseline range of 56.83%–66.12%. Both binary rules are met. The large downward triangle distinguishes a dominant relationship from an expanding one.

Shared note for Figures 2–4: Colors and shapes identify relational categories; marker size represents nominal bilateral trade, with a minimum visible size for small ties. Size scales are fixed across years within each target and differ across targets. The outlined marker identifies the selected partner. Boundaries are present-day Natural Earth geography; historical mappings follow the atlas.

Evaluation & Limitations

My evaluation focuses on whether the atlas allows readers to explore relationships and inspect the data behind them. I checked that the displayed values match the prepared data, that changing the year or measure updates the map, and that selecting a partner reveals the corresponding observations. I also checked that the legend controls show and hide the intended categories. These checks establish that the main features work as intended. Whether readers find them useful requires a separate evaluation.

Interactivity offers readers choices, but those choices can also complicate interpretation. A dense network may be difficult to read, particularly when several partners occupy a small geographic

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area. Filters can reduce this crowding, although readers must recognize that a filtered map displays only part of the network. The partner inspector, evidence table, and geographic inset provide additional ways to examine relationships that are difficult to distinguish on the main map. Accessibility also requires attention. I use shapes as well as colors to distinguish categories, but the usefulness of these features will depend on screen size, visual acuity, and familiarity with the interface. Readers must also learn what the symbols and controls mean, which may complicate interpretation. Alt text and other accessibility features can be built in to the existing tool to enhance usability. The accompanying explanations help with this task, but they do not substitute for testing with users.

Lastly, the portable HTML format makes the atlas straightforward to share, while the supplied code and documentation allow others to rebuild it. Adapting the example still requires preparing compatible data and explaining the relationships being displayed, and it is important to note that the data are the principal element that makes these descriptive tools function. Data that are not properly conceptualized or contain errors will transfer those errors to the visualizations. Also, larger networks or different geographic units may require changes to the layout and controls, but these adaptations are not insurmountable and a plethora of support online and through coding agents may facilitate the ease through which data can studied and explored. A useful next step would be to ask readers to complete tasks such as locating a relationship, tracking it over time, and explaining a change between measures. Such an evaluation could identify confusing features and establish where interactivity contributes most to research communication and teaching.

Conclusion: Implications for Research Practice

In this article, I have presented a practical workflow for making longitudinal relational data easier to explore, scrutinize, and share through portable interactive maps. The trade and sanctions examples illustrate how readers can distinguish the magnitude of a relationship from changes in its relative importance while also comparing classifications of events. I have also examined how one can inspect the observations behind a visual pattern to enhance inferential results. These capabilities give systematic description a more visible role in communicating research and pairing it with inferential quantitative social science methods.

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The implications extend beyond the presentation of completed findings. During analysis, researchers can use an atlas to identify unexpected relationships, investigate discontinuities, and examine how measurement choices shape the patterns they observe. The processes can also help highlight coding errors and inconsistencies, which may help researcher correct coding discrepancies and improve research workflows. During review and publication, the same interface can help readers connect an author's interpretation to particular observations as well as make those connections accessible by creating opportunities for closer scrutiny and generating questions that may warrant further investigation in current or future projects.

Realizing these benefits requires attention to design and documentation as well as clear definitions and consistent visual scales. Visualizations require that researchers pay attention to accessibility while also being explicit in issues that often occur with data, such as the treatment of missing observations. The accompanying fictional aid example provides an entry point for researchers who wish to adapt the workflow using R or Python. By distributing both a working atlas and the materials needed to rebuild it, I offer a practical means of making relational research more inspectable, reusable, and, more important, shareable to increase the transparency of research results that puts *relations* back into international relations.

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