From the Adriatic to the Alps

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Transport and Trade Networks in Roman and Late Antique Northern Italy

James Page

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Cover: View over Verona (photograph by Caitlin McMenamin).
Dressel 6A amphorae.

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List of Abbreviations

AMINI – Amphora in Northern Italy
ARS – African Red Slip
CBM – Ceramic Building Materials
CITS – Central Italic Terra Sigillata
DESTINI – Decorative Stone in Northern Italy
ETS – Eastern Terra Sigillata
GTS – Gallic Terra Sigillata
LRA – Late Roman Amphora
MADINI – Material Data in Northern Italy
MATS – Middle Adriatic Terra Sigillata
MNI – Minimum Number of Individuals
NITS – Northern Italic Terra Sigillata
OCK – Oxé, Comfort, and Kenrick 2000
RBH – Rims, Bases, and Handles
REFINI – Red-Slipped Finewares in Northern Italy

Introduction

The eleventh region receives from the river the name of Transpadana; it is situated entirely inland, but the river carries to it on its bounteous channel the products of all the seas.
Pliny the Elder, *Natural History* 3.123.1*

The waterways of Northern Italy were a busy sight during the 1st century AD. Laden with traffic, the rivers and canals of the Po-Veneto Plain formed the main transport arteries of the region. Slow-moving barges, towed by panting men and loaded with produce from the Adriatic and Eastern Mediterranean dwarfed smaller, faster craft, ferrying passengers to their destination. Fishermen plied their trade along the banks and on the water, while the land around the rivers, recently reclaimed from marsh, hosted herds of cattle and other livestock. Within the great cities that lay along the rivers' path, cargoes were loaded and unloaded from bustling wharves and well-stocked *horrea*. Imported wine amphorae from Crete and coloured marble from Asia Minor competed for space with locally produced terra sigillata, oil, and wine destined for the great ports of Ravenna, Altinum, and Aquileia. This vista represents the culmination of over two centuries of development and investment in Northern Italy's economy, creating the circumstances where the Po truly did carry upon it all the products of the seas.

Despite being located hundreds of kilometres from the nearest seaport, the upper reaches of the Po Valley were integrated into the wider Roman economy. The Po, also known as the Padus or the Eridanus in Antiquity, is the largest river in Italy, host to dozens of tributaries, and was said to be navigable as far as Turin in the Roman period.[1] The wide, flat plain of its valley consisted of an urbanised landscape that included the great cities of Milan, Turin, and Bologna, and contained extensive agricultural wealth. Ancient writers unanimously agree on the prosperity of the region. Tacitus called it 'the richest district of Italy', while Polybius claimed the Po Plain, 'surpassed in fertility any other in Europe'.[2] Yet the Po Valley, and Northern Italy more widely, have at times been written off in modern scholarship as 'marginal' or 'isolated', a border zone between Italy proper and the northern provinces that was economically insignificant.[3] Although there have been moves to challenge perceptions of Northern Italy's isolation, this important region remains severely neglected within economic scholarship.[4]

Inland areas made significant contributions to the Roman economy, yet inland regions, such as Northern Italy, have not seen the same focused attention as coastal areas when it comes to studying ancient trade networks.[5] The large production centres of Gallic sigillata at La Graufesenque and Lezoux, and African Red Slip (ARS) production sites between Kairouan and Sbeitla in Tunisia, were all located inland.[6] Great quantities of *pavonazzetto* marble were extracted from Dokimion in central Anatolia and exported across the Roman world.[7] Many less archaeologically visible products, such as perishable foodstuffs, livestock, timber, charcoal, and textiles, were also cultivated and extracted from inland areas.[8] However, inland regions were not solely producers; they also consumed significant quantities of imported goods. The Rhenish Limes imported large sums of Baetican olive oil, Gallic wine, and terra sigillata.[9] The Ebro Valley consumed large quantities of wine produced along the Iberian Coast, and the discovery of Iberian Dressel 20 and Dressel 2-4 amphorae at the Temple of Jupiter atop the summit of the Gran San Bernardo Pass in the Alps demonstrates that imported goods could reach even the most remote parts of the Roman world.[10]

Although their distance from the sea did not exclude them from wider markets, inland regions faced additional obstacles to trade when compared with

* See bibliography for translations used.
1 Plin. *HN* 3.123; Polyb. 2.16.
2 Polyb. 2.15; Tac. *Hist.,* 2.17.
3 Chilver 1941; Brunt 1971; Harris 1985; 2011; Häussler 2007; 2013; Patterson 2006; Scheidel 2014.
4 Broadhead 2000; Campbell 2012: 302-7; Roncaglia 2013; 2018. These studies take a more positive view of the region's economy and connectivity during the Roman period.
5 Major studies of maritime trade and coastal regions include: Brandon *et al.* 2014; Horden and Purcell 2000, in particular chapters IV and V; Keay 2012; Leidwanger *et al.* 2014; Morley 2007; Rice 2012; 2016; Tchernia 2011; 2016; Wilson 2009a; 2011a; 2011b; Wilson and Bowman 2018; Wilson, Rice, and Schorle 2011.
6 Bonifay 2003; 2016; Lewit 2015; Mackensen and Schneider 2002.
7 Russell 2013: 170-75; 2018: 140. See also the extraction of *giallo antico* at Chemtou in North Africa.
8 Diosono 2009: 258-76; Liu 2009: 29-31, 75-77; Lavan 2015; Meiggs 1982; Roncaglia 2018: 89-95.
9 Remesal-Rodriguez 1986; 1997; 2002. Although it might be argued that these imports were driven by state action to feed the frontier armies, Franconi (2014: 103-06) argues that there was also significant civilian demand for foreign goods which would eventually outstrip that of military. Indeed, civilian sites often show a greater diversity of imports than military ones.
10 Beltrán Lloris 1987: 51–74; 2008: 271–318; Castillo 2016: 132-33; Paccolat, Joris, and Cusanelli-Bressenel 2008: 149.

those on the coast. Maritime transport was the cheapest and the fastest way of moving goods across the Roman world, but costs could rapidly increase as goods began to move inland.[11] River transport, although more expensive than maritime, provided a cheaper alternative to overland travel.[12] However, not every town was located on a navigable river, necessitating the completion of most journeys via overland transport.[13] The transhipment of cargo between maritime, fluvial, and overland transport also incurred additional costs.[14] The low cost of fluvial transport, when compared with overland travel, means river valleys have often played an important role in the development and functioning of inland trade networks, forming corridors of commerce and communication between the coast and the interior.

Beyond transportation and connectivity, river valleys form important economic zones. Valley floors offer flat, fertile land for settlement and agriculture, with the rivers that flow through them presenting a source of water and, if they are navigable, a method of transportation. Even in the absence of a navigable river, a valley floor offers a level or gently sloping path inland, far easier, cheaper, and faster than traversing hills or mountains. The optimum conditions presented by river valleys would result in the development of several major productive landscapes across the Roman world. The Tiber Valley produced food, oil, wine, and building materials for the city of Rome, resulting in an intensively cultivated landscape stretching from the city's hinterland to the river's torrential upper course.[15] The Guadalquivir Valley saw the creation of a landscape orientated around the production of olive oil for export. This included both the olive oil itself and the transport apparatus in the form of Dressel 20 amphorae.[16] The Nile Valley formed one of the most important agricultural landscapes in the Roman world, with its produce responsible for supplying the *annona* in Rome.[17] The river also formed an artery for the transport of stone from the Imperial quarries in the Eastern Desert and goods arriving at Red Sea ports to the Mediterranean coast.[18] The economic impact of rivers has received increasing attention in Roman archaeology, however, not all rivers have been given equal consideration.[19] Italy itself contained several major river valleys, most notably the Tiber Valley which has been researched extensively. The Tiber Valley has been the subject of intensive study for the past seventy years, beginning with the South Etruria Survey and most recently the Tiber Valley Project, which resulted in a series of major publications that significantly changed understanding of the region.[20] In comparison, the lack of investigation into the Po and its impact on Northern Italy's economic development stands out.

Northern Italy's location and unique geography make it a perfect case study to explore questions related to inland trade during the Roman period. The region forms a transitional zone, a meeting point between the Eastern and Western Mediterranean, and the Italian Peninsula and Northern Europe. How did goods and people move through the region between these places? How did the valley's geography aid or hinder the distribution of goods and people? What was being produced in this fertile region and where was it being consumed? Examining the zones of production from which Northern Italy was importing goods, how they entered the region, and how they circulated, has the potential to shed light on the factors governing inland trade and consumption.

At first glance, Northern Italy appears difficult to access via overland routes. To the south of the Po Valley, the Apennines form a physical separation between the region and the rest of the Italian Peninsula. Bordering the north and west, the Alps create a formidable barrier to movement, beyond which lay the north-western provinces of the Empire. These mountains presented a significantly larger obstacle than the Apennines to overland trade but one that was not necessarily insurmountable. Despite the assumption that the cost of overland transport, particularly over steep gradients, would have been too great for any meaningful trade to have occurred through mountains, in some circumstances the opposite appears to have been true.[21] The potential of the Alps and the Apennines as connective spaces, rather than barriers to movement, warrants investigation.

[11] Russell 2018a: 140.

[12] DeLaine 1992; de Soto 2019; Erim and Reynolds 1970; Fernández 2021; Scheidel 2014. Upstream river travel was more expensive than downstream, although still significantly cheaper than overland travel. It is worth noting that many factors, such as weather, seasonality, terrain, and competition between traders would have affected prices.

[13] While it is easy to view terrestrial and fluvial transport networks as independent from one another, Laurence (2005: 138), emphasises that 'to discuss water and land transport as competing systems ... is to misunderstand the economics of transport in the Roman world'. See also Fernández 2021.

[14] Franconi 2014: 58; Russell 2013: 137.

[15] Braconi 2009b; DeLaine 1997; Diosono 2009; Graham 2002; McCallum 2004; Patterson, Di Giuseppe, and Witcher 2020; Vidal 2009.

[16] Ponsich 1974; Remesal Rodríguez 1980; 1997; 1998.

[17] Adams 2018; Erdkamp 2012.

[18] Adams 2001; 2007; Peña 1989.

[19] Campbell's (2012) *Rivers and the Power of Ancient Rome* was the first book to synthesise much of the evidence on ancient rivers. While an essential study, its wide coverage led to a lack of depth in some areas. It has also been criticised for its predominantly western focus, reliance on literary evidence, and dismissal of the role that palaeoclimatological and palaeohydrological data can play in the analysis of ancient rivers. On these points, see Franconi 2013.

[20] Coarelli and Patterson 2009; Patterson 2004; Patterson, Giuseppe, and Witcher 2020. It should be noted, however, that the majority of research has taken place in the lower and middle Tiber Valley. The economy, population, and settlement in the upper valley is understood to a far lesser extent.

[21] Bell, Wilson, and Wickham 2002; Bruno 1998; Carreras, de Soto, and Mũnoz 2019; Gabucci 2017.

Looking to maritime routes, Northern Italy's two coastlines on the Adriatic and the Ligurian seas offered competing entry points for extra-regional imports. The Adriatic Coast offered access to the Eastern Mediterranean, while the Ligurian Coast was integrated into Western Mediterranean markets. The Po Valley's connection to the Adriatic and its proximity to the Ligurian Sea allows the opportunity to examine the potential effect that two alternate maritime entry points, located at opposite ends of the region, had on material distribution. Indeed, ports on the Adriatic and Ligurian Coasts were not equally accessible from inland areas. Although the Ligurian ports were in close vicinity to sites in the south-west of the Po Valley, their goods had to cross the Apennines to enter the region. Conversely, goods arriving via the Adriatic ports had a greater distance to travel to reach the west of the valley, yet the flatter terrain and fluvial connections may have resulted in an easier and cheaper journey compared to the goods crossing the Apennines.

The Po Valley itself comprises a great alluvial plain through which flowed one of the largest navigable rivers in the Roman world. The dense network of waterways meant that one was rarely more than fifteen kilometres from a navigable river, the extents of which were further expanded and enhanced through ambitious engineering projects. In tandem with the region's rivers, an extensive network of roads criss-crossed the valley and climbed into foothills and mountains ringing it. Investment in significant infrastructure allowed goods to efficiently move between terrestrial and fluvial transportation, leading to an expansive, interconnected transport network. This provided the means of conveying large quantities of goods from the coast inland and vice versa.

Transport networks and the costs associated with moving cargo have heavily shaped the thinking behind the mechanics of inland trade. It has been hypothesised that there would be a steep drop-off in the distribution of imported goods as one moved further inland due to the high cost of terrestrial transport.[22] This would contrast with the far more extensive distribution of imports in coastal areas due to the low cost of maritime transport. However, this model is somewhat simplistic. For example, Fulford highlights the sustained inland distribution of Dressel 20 amphorae across inland regions, from their production and filling in the Iberian Peninsula to the Empire's northern frontier.[23] State actors may have formed an important driving force behind this pattern, leading to differences in distribution between trade facilitated by the state and that conducted by private individuals. Fentress further discusses the impact of political and economic geography on inland economies in North Africa, where she highlights how the dual economic systems of the inland city of Sétif allowed some of its produce to be traded over long distances, while other produce remained uncompetitive outside of local markets.[24] Indeed, not all goods would have been traded inland in the same way. African cookwares were widely distributed in coastal regions yet had very little penetration inland.[25] This is in stark contrast to fine African Red Slip ware (ARS) which had far greater inland distribution.[26] The relatively cheap cookware was less able to absorb transport costs in comparison to the more expensive ARS. Stone and marble cargoes could also move in an atypical way. Imported stone, in the form of revetment, sarcophagi, sculpture, or architectural elements, was able to travel great distances inland in some circumstances.[27] The expense and financing behind stone and marble items (especially for monumental architecture and sarcophagi) might mean that transport costs were something the commissioner could readily afford. The picture that emerges of inland trade is far more complex than a simple drop-off of imported goods as distance from the coast increased, with myriad factors besides transport costs affecting material distribution.

A study of inland trade in Northern Italy, one that is grounded in the archaeological evidence, is long overdue. To this end, published assemblages of amphorae, finewares, and decorative stone and marble from across the region have been compiled together in a series of databases. Together they form the Material Data in Northern Italy (MADINI) dataset, a powerful tool to answer chronological and spatial questions on the nature of trade and the economy within Northern Italy during the Roman and Late Antique periods. Containing over 50,000 individual entries, MADINI forms one of the largest quantified datasets applied to the study of the Roman economy, and the largest body of Roman material data compiled for Northern Italy. The analysis presented in this book reappraises prior assumptions about the region's isolation and explores the mechanisms governing the movement and consumption of goods within Northern Italy. Archaeological data forms the heart of the investigation. Utilising the MADINI dataset, long-term chronological and geographic trends in the circulation and consumption of locally produced and imported materials are charted. The patterns exposed by the

[22] Bonifay 2018; Fulford 2009: 253; Laven 2016: 3; Vaccaro and MacKinnon 2014.

[23] Fulford 2009: 254. See also Carreras 1994. Gallic terra sigillata would see a similar sustained inland distribution across the northern provinces (Mees and Polak 2013).

[24] Fentress 1990. See also Fentress 2015 on inland textile production in North Africa, alongside Fentress 1979 for inland military supply.

[25] Leitch 2011; 2013.

[26] Bonifay 2003; 2004; 2018.

[27] It is important to note, however, that the long-distance trade of stone and marble constituted an exceptional phenomenon. The majority of stone in the Roman world travelled over very short distances, (Russell 2013: 143; 2018b: 240-42).

material analysis are used to examine the interplay and co-dependency of terrestrial and fluvial transport and demonstrate that, despite their distance from the coast, inland sites were strongly connected to Mediterranean markets through long-distance trade. While transport costs played an important part in the distribution of goods and materials in inland regions, they did not remove choice. The consumer played a significant role in the provenance and type of imports consumed across the region. The study's conclusions have wider applications to the study of inland economies and trade and provides a methodology for future analyses.

Past Research on Trade in Northern Italy

Although Northern Italy holds significant promise as a case study of inland trade, most prior regional scholarship has focused on examining social exchanges and connections, rather than economic ones. Roman expansion into Cisalpina and Transpadana during the mid-Republic, and their eventual incorporation into Italy in 42 BC, has seen significant engagement.[28] Far less attention has been given to the Imperial and Late Antique history of the region.[29] As a result, the Po Valley is often viewed as a frontier region, a border between the Roman south and the barbarian north rather than an area strongly interconnected with the wider Roman world.

As Northern Italy contains Italy's border with the rest of Europe, it has always been the point of entry for land invasions of the Italian Peninsula, with the region being no stranger to conflict during the Roman period. The Po Valley would serve as the theatre for the opening engagements of the Second Punic War, with the major battles of Trebia and Insubria taking place alongside dozens of minor actions.[30] Marius, at the Battle of Vercellae, would defeat the Cimbri and Teutones in 101 BC and the Emilian Plain hosted the first major engagements of the civil war that followed Caesar's death.[31] Beyond that, Augustus would campaign against the Salassi in the Alps, who revolted in 34 BC, and again in 25 BC.[32] Northern Italy would see further conflict throughout the Imperial and Late Antique Periods. The Po Valley would be the location of several battles in the Year of the Four Emperors in AD 69, most notably that of Cremona but also actions at Piacenza and along the Po itself.[33] Northern Italy would also be invaded during the Marcomannic Wars of the 2nd century AD, with Aquileia besieged and Oderzo razed to the ground.[34] Further conflict would follow during the civil wars of the 3rd century, and the region would see repeated incursions from the Alemanni, Juthungi and Marcomanni during this time.[35] This unrest would see the increasing militarisation of Northern Italy, culminating with the stationing of permanent military garrisons at Milan and Pavia, and the movement of an imperial capital to Milan in AD 286 to allow the emperor to be closer to the frontier.[36] After the fall of the Western Empire, the Po Valley would form a major battleground in the Gothic Wars of the 6th century.[37] The perception of Northern Italy as a buffer zone between Northern Europe and the Italian Peninsula has served to promote narratives of assimilation, either through conquest or 'Romanisation', which in turn reinforces the idea of the region as geographically and socially distinct from Central Italy.

The view of Northern Italy as separate or cut off from the rest of the Italian Peninsula has helped to foster concepts of isolation amongst some scholars, proving an especially common theme amongst the limited discussions of the region's geography and economy.[38] This perception of isolation, both social and geographic, can be traced back as far as the middle of the 20th century when the first regional studies were undertaken. The first to examine the valley in detail was that of Chilver in 1941. Chilver covered the entirety of the Cisalpine Gaul from the enfranchisement of the Transpadani in 49 BC up to the death of Trajan in AD 117, specifically concentrating on the social and economic development of the region. Writing at a time before any large-scale archaeological investigation had taken place, he concluded that the Cisalpine economy could have been of little more than regional significance due

[28] See Brunt 1971; David 1997; Dyson 1985; Harris 1985; Häussler 2007; 2013; Lomas 2017; Purcell 1990; Peyre 1979; Roncaglia 2018: Part I; Salmon 1982; Williams 2001. Caesar would grant the inhabitants of Gallia Cisalpina Roman citizenship in 49 BC via the *lex Roscia*, but it would not be until 42 BC that the province was incorporated administratively into Italy.

[29] Chevallier's influential 1983 work *La Romanisation de la Celtique du Pô. Essai d'histoire provincial* remains the most comprehensive history of Northern Italy during the Imperial period, although Roncaglia 2018: Part II provides several important reassessments.

[30] The major Roman defeat at Trebia near Parma was preceded by several skirmishes, notably around Pavia and Piacenza (Livy 21.47-58.).

[31] These were the battles of Forum Gallorum and Mutina in 43 BC (App. *B. Civ.* 3.67-72; Dio Cass. 46.37-39).

[32] On the 35 BC campaign see Dio Cass. 49.34, 49.38. For the 25 BC campaign, see Dio Cass. 53.25. Aosta would be founded on territory confiscated from the Salassi. Campaigns were also undertaken between 17 and 14 BC against the Cammuni, the Vennii, and the Rhaetians in the area of Trentino (Dio. Cass. 54.20-22; Suet. *Aug*. 21; *Tib*. 7; Velleius Paterculus, 2.95). Their subjugation, along with other Alpine peoples, is recorded on the Tropaeum Alpinum at La Turbie (*CIL* V 7817) and commemorated by triumphal arches at Aosta and Susa. Client kingdoms, such as that of that of the Cottiae in the Western Alps in the territory of Susa, would also survive into the latter half of the 1st century AD (Roncaglia 2013: 334-35).

[33] Suet. *Vit*. 10; *Vesp*. 7; Tac. *Hist*. 2.1-51; 3.1-25.

[34] SHA. *Marc. Aur.* 14.

[35] Aur. Vic. *Caes.* 28.10; 33.1-18; Zos. 1.22. The emperors Philip the Arab, Decius, Gallienus, all fought in Northern Italy. Roncaglia (2018: Chapter 8) contains a good summary of the history of the region between the 3rd and 6th centuries AD.

[36] Aur. Vic. *Caes*, 33; *Epit.* 34.

[37] Procop. *Goth.* 5.

[38] See Chilver 1941; Brunt 1971; Harris 2011; Millar 1995; Patterson 2006; Purcell 2012; Scheidel 2014.

to its inability to export its produce.[39] Brunt, in his *Italian Manpower 225 B.C.-A.D. 14*, would reach a similar conclusion, describing Northern Italy as 'largely cut off from trade with other parts of Italy, Gaul, or the Mediterranean at large'.[40] One of the main issues that both Chilver and Brunt highlighted as an obstacle to the economic development of the Po Valley was the perceived absence of a large port at the mouth of the Po Delta, an argument that would be further developed by Harris in his 1989 paper, *Trade and the River Po: A Problem in the Economic History of the Roman Empire*.[41] Harris believed this to be a result of the Po's regime being too difficult to navigate, the valley having nowhere to trade a surplus to, and the region's cities having little interest in importing large quantities of foreign goods.[42] Notions of the region's geographic isolation have persisted well into the 21st century. To give an example, Scheidel, in his 2014 article on modelling connectivity across the Roman Empire, singles out the 'isolation' of Northern Italy from the rest of the Italian Peninsula.[43] However, Scheidel's model maps connectivity specifically from Rome across the Empire. Does this also mean that the Po Valley was isolated from markets in Germany, Gaul, Illyria, or the Eastern Mediterranean? Taking a Rome-centric viewpoint is unhelpful when discussing regional connectivity. Nevertheless, it has proved surprisingly common in Anglophone scholarship concerned with the Po Valley. In fact, a growing body of evidence suggests Northern Italy formed an important zone of supply for the Danubian *Limes*, providing consumables and commodities to communities on and around the frontier.[44]

The most recent regional study, Roncaglia's 2018 book *Northern Italy in the Roman World*, forcefully challenges perceptions of the social, geographic, and economic isolation of Northern Italy from the rest of the Italian Peninsula and the wider Roman world.[45] Roncaglia's work contains the most complete synthesis of information on the development of the region's economy to date, including information on agricultural production, more specialised economic activity, and trade.[46] Whereas prior studies have tended to concentrate solely on the early Roman history of the valley, specifically during the Republic, Roncaglia integrates the region's pre-Roman and Late Antique history into her analysis, giving a far more comprehensive overview of the area's development than has been previously available. While Roncaglia's study is a welcome addition to the body of literature on Northern Italy, a considerable amount of work on the region's economy remains to be done. Crucially, engagement with the archaeological evidence in most regional studies often remains superficial.[47] The Adriatic ports, especially Aquileia, are often the main focus, with evidence for inland trade often reduced to distribution maps of amphorae and other goods.[48]

Although the majority of regional scholarship available for the economy of Northern Italy remains grounded in literary and epigraphic evidence, a half-century of archaeological investigation has provided a wealth of new data.[49] At site level, there has been extensive investigation by Italian archaeologists working under the jurisdiction of the *soprintendenze* or academic institutions. Under their guidance, hundreds of excavations have been carried out in the region, including major investigations at important Roman cities such as Aquileia, Brescia, Milan, and Verona.[50] While not every excavation has been published, many have been studied to a high standard. Material specialists have produced catalogues of quantified data for individual excavations, offering detailed insight into the sites under investigation. Unfortunately, this material is rarely analysed in a wider context. There have been some attempts to compare material from sites located within the same *soprintendenza* jurisdiction, alongside several discussions surrounding individual artefact types at a regional level, (for example the distribution of Dressel 6A and Lamboglia 2 amphorae across Northern Italy), but these are seldom integrated into wider discussions on the Roman economy.[51] Analysis of both short and long-distance

[39] Chilver 1941: 29-35, 135.
[40] Brunt 1971: 180-81.
[41] Harris 2011: 115. The essay would be edited and republished as part of the 2011 volume, *Rome's Imperial Economy: Twelve Essays*. Harris and his predecessors were writing at a time before the advent of widespread geomorphological investigations. These would later show that the main mouth of the Po during the Roman period was located close to the port of Ravenna.
[42] Harris 2011: 196-97. Harris' analysis was principally based on literary, artistic, and epigraphic evidence and whilst the ideas are well presented, its argument was weakened by a lack of access to archaeological evidence.
[43] Scheidel 2014: 21.
[44] Assirelli 2023; Bekljanov Zidanšek, Vojaković, and Žerjal 2022; Duch 2017: 195-97; Egri 2007; Ehmig 2010: 155-156.
[45] Roncaglia 2018. Her study is primarily focused on the eastern and central valley, specifically the areas to the east of Lake Como and Milan, and the route of the via Aemilia. Whilst this area has produced some of the most detailed scholarship in the region, the western valley, specifically the territory of Piedmont, warrants further attention.
[46] See, in particular, textile production (Roncaglia 2018: 90-94).
[47] Studies that have included archaeological evidence (e.g. Broadhead 2000; Chevallier 1983; Garnsey 1998; Garnsey and Sallar 1987; Roncaglia 2018), have taken a far more positive view of trade within the region.
[48] Broadhead 2000: 156-57; Garnsey 1998: 53-58; Roncaglia 2018: 101-15.
[49] A lack of engagement with archaeological evidence when discussing economic history is not something unique to Northern Italy. The inaccessibility of many material studies and their lack of engagement with broader economic questions, has often led to them being side-lined in wider economic discussions. See, for example, Bang 2009; 2012; Finley 1973; Lo Cascio 2009; Morley 2007; 2012; Morris, Saller, and Scheidel 2007; Whittaker 1993; 1994.
[50] See Brogiolo 1999; Caporusso 1991; Cavalieri Manasse 2008; Filippi 1997; Fontana 2017; Maggi *et al.* 2017.
[51] Betori, Gomez Serito, and Pensabene's (2009) analysis of stone and marble types used in Roman monuments in the western Alps or Bruno (1998) and Melli's (2004) studies on trans-Apennine trade. For examples of studies focusing on single artefact types, see Bruno's (2005) gazetteer of amphora types found within Northern

trade within Northern Italy has seldom passed beyond the use of distribution maps of material. While these are useful for observing the spread of artefacts, they fail to map the intensity of trade by distinguishing between what might be termed 'one-off' imports and more sustained trade.[52] Furthermore, few studies adopt a long-term approach when examining trade networks, choosing instead to focus on a single chronological period.[53] The majority of quantified material analysis remains limited to a site-by-site basis, resulting in a huge amount of excavated material that has never been studied outside of its find context. Only rarely has this body of evidence been applied to broader regional and economic questions.

Towards a Quantitative Approach

One of the key objectives of Roman economic scholarship over the past 20 years has been to promote a more rigorous analysis of existing archaeological data, with an emphasis on moving towards quantified studies of economic activity.[54] Over a century of excavation across the Mediterranean world has produced a vast quantity of Roman material, yet only recently have the technology and methodologies to host and analyse these data become available.[55] An increasing number of studies have used quantified material evidence to analyse and reconstruct economic activity, challenging prior perceptions and drawing new conclusions about the Roman economy and trade.[56] A study that unites individual, quantified material datasets from across Northern Italy has the potential to answer complex questions about the region's economy.[57] By comparing and contrasting the quantity and concentration of material from different sites, geographical and chronological patterns and trends in trade and consumption can be brought to light. An analysis of material distribution across the entirety of Northern Italy will provide new insight into the relationship between the coastal regions and inland zones which have been previously assumed as marginal and difficult to access.[58]

The analysis performed here goes beyond that carried out by pre-existing quantified studies, which traditionally only examine a single material type. Mapping the spread and provenance of different materials serves to highlight the multiple levels and directions of trade occurring within Northern Italy, exposing the role that cost and choice played in the selection of goods within assemblages. Therefore, this study compares and contrasts three separate material types: amphorae, finewares, and decorative stone (marble and stone flooring and revetment). These materials represent three distinct types of consumption within the Roman world, being traded through different mechanisms and consumed in different ways. Amphorae primarily carried consumables, items such as oil and wine that were essential to the day-to-day diet and would be purchased repeatedly. In contrast, finewares, though widely represented across the strata of Roman society, were a non-essential item rather than a necessity. Decorative stone and marble were luxury items, bulky and expensive one-off purchases that were the preserve of the wealthy or civic projects. The different patterns in the geographic and chronological distribution of these goods serve to contrast the varying levels of trade within Northern Italy and the different supply mechanisms behind them.

Before the analysis could take place, the data, taken from a diverse range of publications, had to be synthesised and prepared for study. To accomplish this, a series of databases were created, one for each of the material types. The result is MADINI, one of the largest and most diverse corpora of material evidence gathered in Roman archaeology, a powerful resource for the analysis undertaken in this book and for future studies.

The MADINI Dataset

The Material Data in Northern Italy (MADINI) dataset consists of three relational databases, one for each of the material types discussed in the analysis: amphorae, finewares, and decorative stone. In total, 58,743 individual entries are recorded across the dataset from 39 urban sites within the region (see Figure 1).[59] The design of the MADINI databases was influenced by other

Italy; Zara's (2018) study of the quarrying, distribution, and use of Euganean trachyte; or Cipriano and Mazzocchin's (2018) analysis of the development of Dressel 6A amphorae.

[52] For example, Kenrick 2000; Lindhagen 2009; Mazzocchin 2009.

[53] Notable exceptions include Auriemma and Quiri 2004; Auriemma, Degrassi, and Quiri 2012; Quiri 2009.

[54] Brughmans 2022; Bowman and Wilson 2009a; Peña 2007; Wilson 2022.

[55] Brughmans 2022; Wilson 2022. See also the work of Project MERCURY, which aims to equip scholars with the skills needed to undertake computational analysis by supplying tutorials, datasets, and a model library, has been instrumental in raising the profile of network and statistical modelling as an analytical tool amongst classical archaeologists (Brughmans 2020).

[56] Bes 2015; Brughmans, Poblome, and Pots 2016; De Callataÿ 2014; Franconi *et al.* 2023; Rubio-Campillo *et al.* 2017; Rubio-Campillo and Coto-Sarimento 2022; Romanowska *et al.* 2021; Taelman 2022.

[57] An array of proxy data has been applied to the study of the Roman economy, some more successfully than others. For a discussion of proxies, their potential, and their shortcomings, see Scheidel 2009; Verboven 2021; Wilson 2009a; 2009b; 2014.

[58] Horden and Purcell's (2000) *The Corrupting Sea* helped to establish a movement of thought that emphasised the role of ports and coasts in connecting the disparate regions of the Mediterranean, with Rice describing ports as the 'pinnacle of market connectivity' in the Roman world, (Rice 2012: 60, n. 187). See also, Bonifay 2004: 451-2; Leitch 2011: 185-86; Morley 2007: 27-29; Russell 2013: Chapter 5; Tchernia 2016: 90-94.

[59] In Version 1 of the MADINI databases, only urban and suburban sites are included, with rural sites such as farms and villas to be added in future iterations.

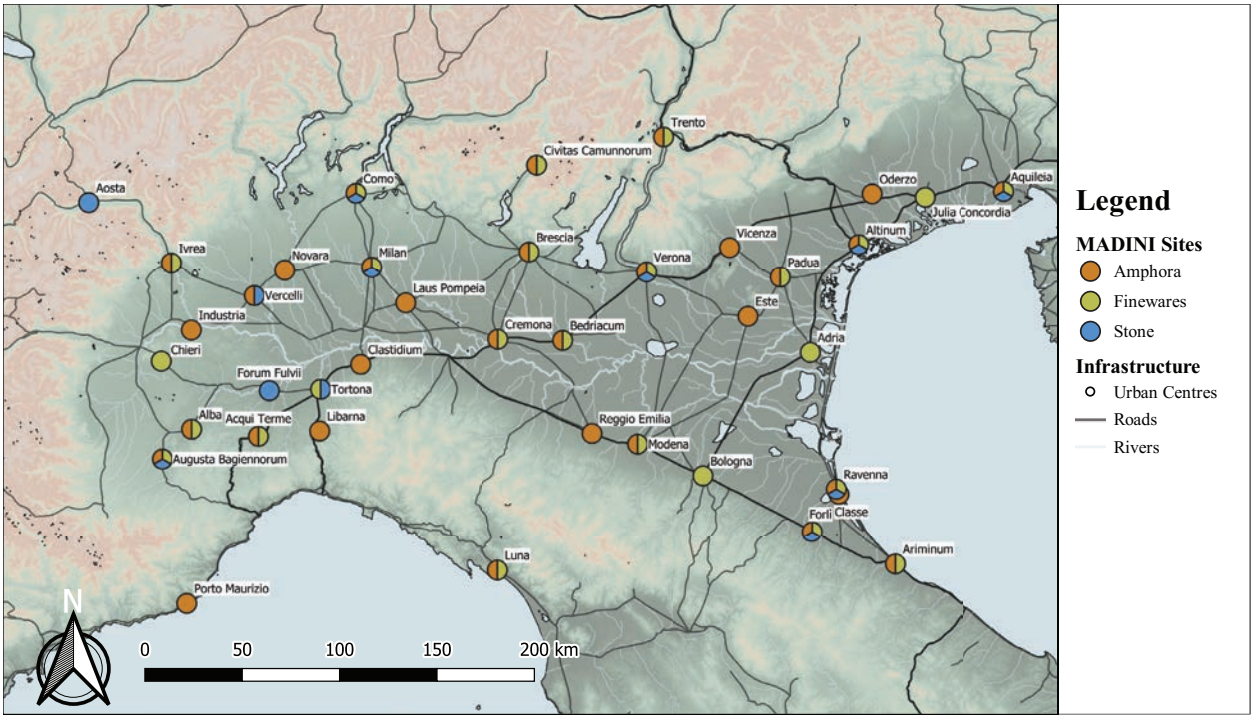

Figure 1. A map of sites within the MADINI dataset and the material assemblages originating from them.

synthetic databases of Roman material, particularly the RAAD (Roman Amphora Assemblage Database) and ICRATES (Inventory of Crafts and Trade in the Roman East) datasets.[60] The incorporation of overlapping design elements ensures a level of compatibility, promoting comparison and the application of pre-existing research methodologies to the data. Each database within MADINI, alongside a full layout and metadata, is hosted online and available to end users.

Although the rise of quantified studies has improved understanding of the Roman economy, they are not without their problems. The survival and publication of the ceramic data are not uniform across the Roman era, with some artefact types and periods better preserved or favoured for study over others. Data from the 1st and 2nd centuries AD are the best studied and published, and were available across all 39 sites within MADINI. Unfortunately, intact Republican deposits of ceramics are rare, with most assemblages returning under ten fragments. The situation is similar for data from Late Antiquity. Assemblages from the 3rd century AD onwards are far less comprehensively studied, with most of the data being described in only a tokenistic manner, if at all. A greater focus is typically given to the earlier Republican and Imperial periods. Where material specialists with Late Antique or Early Medieval experience have examined assemblages, the Late Antique data is presented in greater detail, but such cases are rare.[61] Consequently, data from the Republican period and the Late Antique are absent for several sites within MADINI. Furthermore, archaeological data contains biases, either inherent (such as survivability) or acquired (such as through excavation practice), and it is important to acknowledge these weaknesses in the data.[62] The MADINI databases are synthetic datasets, combining data from dozens of research publications across Northern Italy. These published assemblages varied in their quality and quantity across the study area. With little to no standardisation, they often reflect the publishing styles and practices of the region and the times in which they were compiled, presenting substantial challenges for synthesisation.[63]

A lack of uniformity amongst the values used to quantify excavation data often forms a significant hurdle to comparing datasets from multiple sites. The unit of quantification is something which often varies from publication to publication, with common methods including minimum number of individuals (MNI), the number of rims, bases, and handles (RBH), sherd weight, and number of sherds (also known as maximum number of individuals). MNI offers the most accurate measure of the quantity of vessels within a

[60] Bes 2015: 3-5; Franconi *et al.* 2023.

[61] For example, Bruno 2008; 2002; Bruno and Bocchio 1991; 1999; Massa 1999; 2002; Morandini 2008a; 2008b.

[62] Heilen and Manney 2023; Orton 2009; Peña 2007b; Wilson 2009a: 229-38; 2009b; 2014.

[63] A summary of the challenges and difficulties in synthesising archaeological data for analysis can be found in Franconi *et al.* 2023: 3-6.

site and would have been the preferential unit to use within MADINI. Unfortunately, while this measurement was present in some publications from Northern Italy, it was absent from the majority. In a significant number of assemblages, the data for specific fragment types (i.e. walls, handles, bases, and rims) was also missing, meaning that it was not possible to calculate the MNI retrospectively for these sites. The number of sherds per vessel was the only measurement available across the entire range of publications and, consequently, this was the measurement selected for analysis.

As with ceramics, there are several possible units of quantification for decorative stone. The preferable comparative unit would be the total weight of each lithotype present in each assemblage, as this offers a more accurate indication of the quantity of material at each site. Unfortunately, weight was only recorded for one assemblage within the study area, that of the *Domus* of 'Bestie Ferite' and 'Titus Macro' at Aquileia.[64] Another possible quantitative measurement available was the total volume of each lithotype. This unit is not without its own problems (namely the difficulty of achieving an accurate volumetric measurement for highly irregular objects) and forms an uncommon method of quantification.[65] For assemblages that solely contained wall revetment or floor panelling, the total surface area of a lithotype might be included in cm^2, but this measurement was also absent from many sites.[66] The final quantitative measurement for stone was the total number of fragments of each lithotype. While providing a starting point for analysis, using the number of fragments as an indication of the total quantities of stone present at a site is problematic. The uneven nature of fragmentation means that two pieces of stone that are vastly different in size are given equal weight in the analysis. As the number of fragments was the only measurement available across all datasets, this was selected as the unit of comparison despite its flaws. However, the possibility of over and underrepresentation of some lithotypes caused by comparing fragments of different sizes remains.

The MADINI dataset of amphorae, finewares, and decorative stone forms a complex, yet powerful tool to analyse trade networks and the economy in Northern Italy. With careful attention to both their strengths and limitations, the material databases will allow a far greater scope of quantified analysis to be achieved than has previously been possible in the region. The following sections provide details on the component MADINI databases (AMINI, REFINI, and DESTINI) and the structure of the data within them.

AMINI: Amphorae in Northern Italy

The first database, AMINI, contains 28,323 sherds of amphora from 32 urban sites across Northern Italy.[67] It comprises five interconnected tables, the contents of which are outlined as follows. The main AMINI Catalogue table contains information on each sherd, including epigraphic data. Where available, the type of sherd (rim, base, handle etc.) was recorded. The AMINI Standard Forms table provides information on the different vessel forms present in the database. This includes details on form name, start and end date of production, provenance, contents, and capacity in litres. Where available, a URL link to the relevant entry on the Southampton University Amphora Project Database is provided.[68] The AMINI Deposits table contains information on the excavation context of the sherds. This includes details on the nature of the deposit and the proposed date of the context. The AMINI Locations table provides information on the site from which the sherd was recovered, including name, coordinates, geography, and topography. Where available, a link to the relevant entry on the Pleiades Database is provided. Finally, the AMINI Publications table supplies information relating to the publications containing the amphora sherds, including author, date, and full bibliographic entry.

Each sherd in the database was assigned a standard vessel form based on the typology of the amphora. The dataset from the Southampton University Amphora Project formed the starting point for standardisation. Vessels were cross-referenced with the Southampton database, with concordances in typologies equated. Across the publications synthesised by AMINI, 127 amphora forms overlapped with the Southampton database. A further 25 amphora forms present in the region were not recorded in the Southampton database and were added to the AMINI dataset. Fragments for which the vessel form was unknown, but whose zone of production could be traced through fabric analysis were grouped together by their origin. This resulted in a total of 165 unique vessel forms.

Each sherd within the database was assigned a zone of production. In total, there were six broad provenances

[64] Previato and Mareso 2015. A total weight for the stone assemblage from the Capitolium of Verona was also available, however the weights for individual stone and marble types was not provided (Bocconcello 2008).

[65] The only assemblage to include a measurement of stone and marble volume was the MM3 excavations in Milan (Terraccina 1991). Minato 2018 also included the measurements necessary to work out volume for the architectural elements and sculpture recovered from the Altinum survey.

[66] The stone and marble assemblage from the theatre at Augusta Bagiennorum included these measurements (Gomez Serito and Rulli 2014).

[67] The AMINI dataset is available at https://doi.org/10.5281/zenodo.13745898.

[68] Southampton University Amphora Project, viewed 23 January 2024, http://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/.

for the amphorae circulating in Northern Italy during the Roman period. The first was the 'Adriatic Littoral', encompassing vessels produced in the coastal hinterland of the Adriatic Sea. The second was the 'Eastern Mediterranean', containing vessels from the Aegean, Asia Minor, and Palestine. The third was the 'Iberian Peninsula', encompassing vessels from the provinces of Baetica, Lusitania, and Tarraconensis. The final three origins were for vessels from Southern Gaul, the coast of North Africa, and the Tyrrhenian Littoral. In some cases, a more specific provenance was available for the vessels. Although using these would have obscured the overarching patterns in the data, they are recorded in the database where present.

Two sets of dates were assigned to each fragment. The first were the start and end dates of production for its vessel form. These were taken from each vessel form's typology. The second was the opening and closing dates of the context in which the fragment was deposited. These dates theoretically give a better indication of when a vessel was consumed, rather than simply when it was in circulation. While deposition data were available for many of the sherds in the AMINI database, a large number of publications did not present their material stratigraphically, meaning more refined dating than the overall site chronology (at times covering hundreds of years) was not possible.[69]

Each vessel form was also assigned a broad chronological period reflecting their most prominent era of production and circulation. The longevity of some amphora forms, coupled with uncertainty over the start and end dates of their production, meant that it was necessary to maintain broad dates for these periods. These were the Late Republic (vessels whose main period of production lay between 150 BC and 28 BC), the Imperial period (vessels whose main period of production lay between 27 BC and AD 250), and Late Antiquity (vessels whose main production lay between AD 251 and AD 700). Each vessel was assigned the period which encompassed either the entirety or majority of its production lifespan. While some vessel forms might have seen production outside these parameters, these are exceptional cases.[70]

Finally, a probable content was assigned to each amphora, covering the most likely product to have been transported within the vessel. Possible commodities consisted of, wine, oil, fish products, olives, fruit, *defrutum*, and alum. However, expanding evidence for reuse, both within Northern Italy and across the Roman world, means this data should be approached with caution.[71]

REFINI: Red-Slipped Finewares in Northern Italy

The second database, REFINI, contains 12,112 sherds of red-slipped finewares (terra sigillata and ARS) from 25 urban sites across Northern Italy.[72] As with AMINI, it comprises five interconnected tables. The main REFINI Catalogue table contains information on each sherd. If a stamp was present on a sherd, epigraphic information and its OCK number, if identified, was noted. Where available, the type of sherd (rim, base, handle etc.) was recorded, alongside fabric type (mostly applicable for ARS and ETS sherds). The zone of production of the sherd was also noted. The REFINI Standard Forms table provides information on the different vessel forms present in the database. This includes details on form name, start and end date of production, and vessel type (plate, bowl, cup etc.). The REFINI Deposits, Locations, and Publications tables follow the same format as those in the AMINI database.

Each sherd in the database was assigned a standard vessel form based on the typology of the fineware. Where possible, the vessel form assigned by the publication was used for each fragment. However, some excavations were conducted before updated typologies were available. For example, the MM3 excavations in Milan mainly utilise Goudineau's and Pucci's typologies, rather than the more recent Conspectus series that has become the dominant typology used to identify terra sigillata.[73] Concordances between typologies listed within the Conspectus Series were used to standardise the vessel forms within the REFINI dataset.[74] Fragments for which the vessel form was unknown, but whose zone of production could be traced through fabric analysis were grouped together by provenance. In total 630 unique vessel forms were attested across the publications making up the REFINI database.

Each sherd within the database was assigned a zone of production. In total, there were six broad provenances for red-slipped finewares circulating in Northern Italy during the Roman period. The first was the 'Adriatic Littoral', encompassing finewares produced in the coastal hinterland of the Adriatic Sea. The second was 'Central Italy', applied to terra sigillata produced in workshops located at Arezzo, Pisa, and elsewhere south of the Apennines. The third was the 'Eastern

[69] For example, Biondani 2008; Bruno 2008; Cipolato 2018; Pettirossi and Pistarino 2008; Zanda 2011.

[70] For example, there are rare cases of the Dressel 6B being produced in the 3rd century AD, when the majority of production took place during the 1st and 2nd centuries AD (Cipriano 2009: 175).

[71] On amphora reuse more generally, see Abdelhamid 2013; Brughmans and Pecci 2020; Pecci *et al.* 2017.

[72] The REFINI dataset is available at https://doi.org/10.5281/zenodo.13745898.

[73] The Conspectus typology (Ettlinger *et al.* 1990) was created from the analysis of the terra sigillata recovered from the closely dated stratigraphy present at Magdalensburg, Austria. See Jorio 1991 for the excavations at Milan.

[74] Ettlinger *et al.* 1990: 190-97.

Mediterranean', covering Eastern terra sigillata vessels. The fourth was 'Gaul', encompassing Gallic terra sigillata. ARS was assigned 'North Africa' as its zone of production. Finally, 'Northern Italy' was applied to terra sigillata produced in the Po Valley and Alpine foothills. As with the amphora data, often a more specific provenance was available for a sherd. In particular, sherds equipped with a stamp could often be traced to workshops operating in a limited geographic area. Where available, these more specific provenances have been recorded.

As with the AMINI dataset, each sherd has been provided with a set of production and deposition dates, alongside being assigned to a chronological period.

DESTINI: Decorative Stone in Northern Italy

The third database, DESTINI, contains 18,308 fragments of decorative stone from 13 urban sites in Northern Italy.[75] The stone recorded in DESTINI was primarily revetment, used as paving or cladding, but also contains other small architectural features such as cornices and wainscotting. The main DESTINI Catalogue table contains information on each fragment. Where available, the type of fragment (paving, cornicing, billet etc.) was recorded. The DESTINI Stone Types table provides information on the lithotypes present in the database. This includes name, provenance, and quarry site, alongside whether the stone was white, grey, or polychrome. Where available, a link to the relevant entry on the Corsi Database is provided. The DESTINI Deposits, Locations, and Publications tables follow the same format as those in the AMINI and REFINI databases.

The most common nomenclature (such as *giallo antico*, *africano*, Proconnesian etc.) was used to define the stone or marble present, with a list of concordances found via the Oxford Corsi Collection of Decorative Stone.[76] Each fragment within the database was assigned a zone of production. While specific quarry sites are known for most stone quarried, broad provenances were used to highlight overarching patterns in the data.[77] Stone and marble quarried on mainland Turkey or in the Sea of Marmara was referred to as being extracted from 'Asia Minor'. Stone and marble extracted from south of the Apennines and coastal Liguria were termed as coming from 'Central Italy and Liguria'. Lithotypes from Egypt and North Africa were recorded as being extracted in 'Egypt and North Africa'. Marble from France was referred to as having a 'Gallic' provenance. Stone and marble extracted from the Aegean islands and Greek mainland was referred to as having originated from 'Greece and the Aegean'. Finally, stone and marble extracted from sites within the Po Valley and the Alps were referred to as having come from 'Northern Italy'. Where possible, the provenance of each fragment was taken from the assemblage publication, however, the exception to this was *greco scritto*. While previously thought to have been sourced from North Africa, recent research has shown that most *greco scritto* quarried in antiquity likely originated from Asia Minor.[78]

When it came to dating the material within the stone and marble assemblages, in some cases the chronology was highly specific. For some structures, especially public buildings, the construction date could be narrowed down to within a few decades or the reign of a specific emperor. Where available, the chronological data for the construction phase of the stone and marble revetment is given. However, in many other cases, chronological data was missing, or the material was predominantly from residual contexts. For example, the publication of the MM3 excavation's assemblage of Roman marble wall revetment and floor panelling did not include a chronological element and its exact origin could not be pinpointed.[79] Consequently, a chronological element is lacking for much of the decorative stone data.

Methods and Approaches

The study presented in this volume represents the largest geographic and chronological examination of trade within Northern Italy during the Roman period so far attempted, offering a unique opportunity to reassess prior thinking on the region's economy and wider connections in the Roman world. Although it hopes to provoke new discussions on the mechanics of inland economies more broadly, it does not seek to create a singular model of trade within inland areas, recognising that the unique geographic and commercial environments within each region resulted in highly individualised economic circumstances. These are circumstances that changed again depending on the materials being exchanged, leading to multiple levels of trade and consumption. The book's conclusions present inland economies and trade in their full breadth and complexity, challenging prior conceptions of isolation and marginality and providing a framework for future regional studies.

[75] The DESTINI dataset is available at https://doi.org/10.5281/zenodo.13745898.

[76] Corsi Database, viewed 2 January 2024, http://www.oum.ox.ac.uk/corsi/.

[77] A list of known quarries for each stone and marble type can be found via OXREP database of stone quarries, viewed 2 January 2024, http://www.romaneconomy.ox.ac.uk/databases/stone_quarries_database/.

[78] Attanasio *et al.* 2012. Previously, *greco scritto* was thought to have originated from quarries at Cap de Garde in Algeria. Isotopic and EPR analysis revealed that the quarries at Hasançavuslar, near Ephesus, were in fact the main source during the Roman period.

[79] Terracina 1991. The assemblages from Altinum (Minato 2018), Forum Fulvii, and Tortona (Gomez Serito 2007) also lacked a chronological element in their publication.

The analysis begins with an exploration of Northern Italy's transport infrastructure. Roads, rivers, and canals constituted the backbone of the region's economy, and without them, the complex networks of exchange discussed throughout the volume could not have formed. The development of terrestrial and fluvial transport systems across Northern Italy are charted, demonstrating the significant effort and capital that was expended in the creation of new infrastructure. This extended the transport network into new areas of the region and served to reduce the difficulty of traversing challenging terrains such as low-lying waterlogged ground and steep mountain passes. Evidence for fluvial navigation is also synthesised to create a new catalogue of navigable rivers, revealing many waterways in the region that are no longer navigable did, in fact, support rivercraft during the Roman period.

Although the majority of evidence for trade within Northern Italy comes from imported goods, the role of local production for regional supply and export markets forms an important part of the picture. Evidence for the production of foodstuffs and commodities in Northern Italy is examined, alongside the probable export destinations for these goods. Looking at Northern Italy's agricultural landscape, a wide range of food is shown to have been produced, with sites containing multiple wine or oil presses attested across the region, alongside examples of cereal cultivation, drying, and storage.[80] While exports of foodstuffs have proved hard to trace archaeologically, ceramics from Northern Italy have been found in significant quantities along the Adriatic Coast and the Danubian frontier.[81] It is unknown if Northern Italic ceramics piggy-backed on other goods exported from the region but the frontier and Danubian provinces offered an expansive market in close proximity.[82]

The majority of the volume is dedicated to the analysis of the amphora, fineware, and decorative stone data contained within the MADINI dataset. The MADINI databases present the opportunity to examine long-term patterns and geographic trends in trade across Northern Italy, tracing the evolution of demand and supply within the region. While some superficial patterns can be observed by simply comparing the quantified data, statistical methods form important tools, often revealing underlying patterns not immediately discernible. The potential of statistical studies is readily apparent as they offer ways to scientifically test theoretical models, study large datasets, and overcome flaws or limitations inherent within archaeological data.[83] Such methodologies are especially useful when examining large datasets, providing a way to locate underlying trends hidden by the volume of material contained within them.[84] To examine chronological and geographic patterns, two separate forms of analysis were used. Aoristic analysis was used to examine chronological trends in the data, while geographic changes in consumption and distribution were identified using hierarchical clustering. The code used to run the analysis is openly available to end users online in the form of R Scripts.[85]

Aoristic Analysis

For the ceramic assemblages, long-term chronological changes in the datasets were graphed using aoristic analysis, using the R package \datplot. Aoristic analysis uses a probabilistic approach, selected due to its ability to account for the chronological uncertainty inherent in ceramic data. Ceramic vessels were in production for an extended period of time, with some production timescales lasting for hundreds of years. A vessel may have been produced at any point during its production dates. Likewise, most archaeological contexts are dated to broad periods, often decades-long, and a ceramic vessel may have been deposited at any point within the context's life cycle. Aoristic analysis accounts for this by calculating the probability of an individual sherd being produced or deposited at any point across its production or deposition chronology, distributing it across these timescales.[86] The result is a graph that reflects the level of uncertainty in the archaeological record with greater accuracy than conventional data visualisation techniques.[87] While the advantages of this approach when analysing data with a temporal element are evident, its application remains rare within the field of Roman archaeology.[88]

The aoristic analysis consisted of two main components. First, the frequency of ceramic in a given year was plotted. The data were then subsetted to graph the

[80] Forin 2017: 132-70.

[81] Brusić 1999; Duch 2017: 195-97; Egri 2007; Makjanić 1995; Mercando 1972; Mertens 1972; Schindler Kaudelka 1980; Schindler and Zabehlicky Scheffenegger 1977; Tassaux 2004.

[82] This is a question that concerns fineware ceramics more broadly. Although shipwreck evidence confirms that finewares (both terra sigillata and ARS) piggybacked on the maritime trade of other goods, the mechanics of how it travelled inland are more difficult to track (Dannell and Mees 2013: 175-76; Lewit 2015: 115-18).

[83] Brughmans 2022; Knappett 2013.

[84] Despite their usefulness, the application of network and statistical modelling as tools of analysis has not been without critics. Some have questioned whether modern analytical techniques can be used to rigorously test primitive aspects of the economy without an inbuilt bias against them (See van Oyen's 2017 response to Brughmans and Poblome 2016b, alongside Brughmans and Poblome's 2017 reply).

[85] The code and data used in the analysis can be found at Github Repository: Adriatic-to-the-Alps, viewed 12 September 2024, https://github.com/jamespage15/Adriatic-to-the-Alps.

[86] Crema 2012; Johnson 2004; Orton, Morris, and Pipe 2017: 3-5; Steimann and Weissova 2021: 290.

[87] Steimann and Weissova 2021: 289-290.

[88] Franconi *et al.* 2023 provides a template for the analysis undertaken in this study. For other examples of studies that have used aoristic analysis, see: Carrignon, Brughmans, and Romanowska 2020; Fentress *et al.* 2004; Romanowska, Bobou, and Raja 2021; Steimann and Weissova 2021.

frequency of ceramic from each zone of production circulating in a given year. For the amphora data, the frequency of containers carrying wine, oil, or fish products in a given year was also graphed. Second, the number of ceramic vessel types in circulation in a given year was plotted. The data were then subsetted to graph the number of ceramic vessel types from each zone of production circulating in a given year. Each analysis was carried out using both the production dates and deposition dates of each sherd.[89] Sherds without a deposition date or with deposition dates spanning more than 200 years were excluded from the deposition analysis. Due to the lack of chronological data for many fragments in the DESTINI dataset, the stone and marble contained within it were not examined using Aoristic analysis.

Hierarchical Clustering

For both the ceramic and stone assemblages, geographic changes in consumption across the datasets were plotted using hierarchical clustering, using the R packages \dplyr and \reshape2. Hierarchical clustering forms a way of grouping data based on the pairwise distance between assemblages.[90] Pairwise distance measures the separation between values of a dataset (in this case the percentage component of each zone of production). The closer the distance between assemblages, the more likely they are to join a cluster, meaning sites with similar characteristics will group together, mapping zones of consumption.[91] In comparison to other forms of cluster analysis, such as k-means, the number of groups that form are not pre-determined in hierarchical clustering, allowing for more nuanced patterns to emerge.[92]

The clustering analysis was carried out by first sub-setting the material into their broad chronological periods. For each period, the percentage component of each zone of consumption within a site's assemblage was calculated. Sherds or fragments without a known zone of production or date were excluded from the analysis. The percentage totals for each site were then placed in a table, which was then analysed using the UPGMA algorithm (Unweighted Pair Group Method with Arithmetic mean). The analysis created a distance table, recording the pairwise distance between each site assemblage based on the provenance of the vessels or lithotypes within it. This was then used to hierarchically cluster the assemblages based on the similarity of their provenance, which was then plotted as a dendrogram. To ensure a rigorous level of analysis, only assemblages that contained more than thirty sherds or fragments were included.

[89] Franconi *et al.* 2023: 9-10, demonstrate the importance of comparing both production and deposition chronologies for ceramic vessels, the distribution of which can vary greatly.

[90] Hodson 1970; Mommsen, Kreuser, and Weber 1988; Shennan 1997: 239–40.

[91] Brughmans 2010: 289-91; Drennan 2010: 79-96.

[92] Baxter 2015: 148; Ducke 2015; Maddison and Schmidt 2020.