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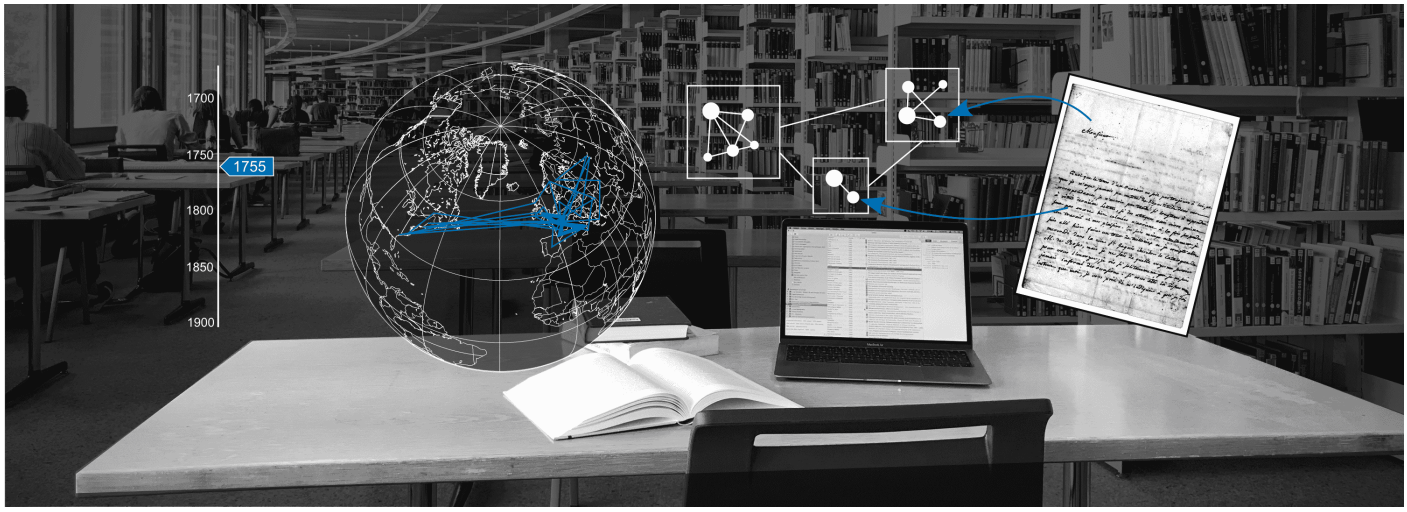

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Unnamed Actors and Groups in Select Papyri from the Zenon Archive (3rd cent. BCE): Implications for Historical Network Approaches

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Keywords Early Ptolemaic Egypt, Greek, Papyri, Data Collection, Social Network Analysis, Gephi

Abstract In terms of writing on the socio-economic histories of early Ptolemaic Egypt, the papyrus archive of Zenon (263–229 BCE) – the largest to have survived from Ancient Egypt – is an exceptionally rich source of information. The Zenon papyri offer valuable insights into the running of the Ptolemaic empire, but also what it was like to live and work under Ptolemaios II and Ptolemaios III. By using network science, the relational and attribute data retrieved from the ancient texts can be modeled and analyzed in the form of networks.

As network researchers, we intuitively know that how we conceptualize and build the datasets used for formal network analysis affects the models and analysis that follow. Still, we rarely have time to carefully check how, and to what extent the decisions made as we design our networks and collect our data impact the models and affect the measures applied. This article presents a test case exploring the implications of choosing to either include or exclude unnamed persons and collective actors when retrieving network data from selected Zenon papyri.

After introducing the archive, samples and networks under study, the author measured and compared bipartite (co-attestation) and monopartite (interpersonal) networks with and without nodes representing unnamed persons and groups. The results of this study reveal that the nodes added have only a minor impact on the network structure, suggesting that the general traits of the sample (and by extension the archive as a whole) are captured regardless of their

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presence or absence. However, it also demonstrates how – especially for the interpersonal network approach – choosing to integrate impersonal and collective actors and their relationships adds to the model's value as qualitative network research. The findings provide useful insights that can help us to better predict the relevance of tediously recording such actors and their relations when asking relational questions of historical networks.

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Introducing the Topic

The network perspective[1] made its way into modern consciousness around the turn of the millennium, and as part of this 'relational' or 'network turn' came a blossoming of network theories and methods – including in the Humanities.[2] At the time of writing, aspects of network science have gained momentum in a number of archaeological and historical disciplines, with scholars demonstrating how digital tools and network theoretical frameworks can also aid us in better understanding relational phenomena and complex systems of the past.[3]

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Data Accessibility Statement Supporting information, high-resolution images and graph files are shared via Zenodo: https://doi.org/10.5281/zenodo.14190908. For questions or comments, please contact the author.

1 This article presents an early test case conducted in the framework of my larger Zenon project "Interpersonal Relationships in Early Ptolemaic Egypt: A Network Analytical Study of the Zenon Archive (263–229 BCE)". This project is introduced in Tambs, 'Social and Economic Life'; Tambs, 'People and Things'; and will be synthesized in Tambs, *Linked People and Places*.

2 Ahnert et al., *Network Turn,* 3.

3 For publications discussing the relevance of network approaches in archaeology and history, see e.g. Collar et al., 'Networks in Archaeology'; Lemercier, 'Formal Network Methods in History'. For overviews of network analytical studies in history and archaeology, e.g. Bixler, 'Wurzeln der Historischen Netzwerkforschung'; Brughmans, 'Connecting Dots', 278–284; Brughmans, 'Thinking Through Networks'; Brughmans, 'Roots and Shoots of Archaeological Network Analysis'; Brughmans and Peeples, 'Trends in Archaeological Network Research'; Brughmans and Peeples, 'Spatial Networks', 275–277; Chollier, 'SNA in Egyptology'; Crabtree and Borck, 'Social Networks for Archaeological Research', esp. 5–12; Düring and Eumann, 'Historische Netzwerkforschung', esp. 372–377; Holland-Lulewicz and Roberts Thompson, 'Incomplete Histories and Hidden Lives', esp. 1029–1031; Martinet, 'Pratique de SNA En Égyptologie', 4–6; Mills, 'SNA in Archaeology'; Östborn and Gerding, 'Network Analysis of Archaeological Data', esp. 77–79; Peeples, 'Finding Place for Networks in Archaeology'; Ruffini, *Social Networks in Byzan-*

Part of the multidisciplinary appeal of network science is that the same mathematical models and tools can be used to study seemingly different systems.[4] Surveying the published historical and archaeological network research thus reveals that formal network analysis has been used to explore a great variety of subject matters and datasets. This reflects the network perspective's wide reach of relevance – including for ancient studies.[5]

When approaching the distant past with network science, the theories and methods of Social Network Analysis (SNA) have proven particularly useful.[6] Such research makes frequent use of network jargon, but given this journal's network analytical focus, no technical glossary is included here. Rather, unfamiliar readers are directed to recently published glossaries.[7]

In adopting and adapting network scientific tools, historians and archaeologists have suggested a number of creative ways to model and analyze the network data extracted from diverse types of historical and archaeological sources. They have also shown how such approaches can be meaningfully used *alongside* other methodologies, such as categorical analysis, close readings of ancient texts, or geographic information systems (GIS). The success of the network approach

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tine Egypt, 14–20; Stefanović, *SNA and Egyptology,* 20–26; Waerzeggers, 'SNA of Cuneiform Archives', esp. 213–216. For a more complete list of archaeological and historical network studies, see the continuously updated bibliography of the Historical Network Research community: https://historicalnetworkresearch.org/bibliography/ (accessed 04.11.25).

4 Ahnert et al., *Network Turn,* 1–4.

5 Tambs et al., 'Bridging Historical, Archaeological and Criminal Network Research'.

6 For handbooks, see e.g. Borgatti, Everett, and Johnson, *Analyzing Social Networks;* Prell, *Social Network Analysis;* Scott, *Social Network Analysis;* Wasserman and Faust, *Social Network Analysis.* It should, however, be stressed that the *need* for SNA tools has also been questioned, e.g. in Sarris, 'Ruffini. Social Networks in Byzantine Egypt'. Also, SNA is a less obvious match for archaeological networks analysis, as it often results in archaeologists combining aspects of SNA with other analytical and modelling approaches (e.g. Tambs et al., 'Bridging Historical, Archaeological and Criminal Network Research'). Actor-Network Theory (ANT) is occasionally also highlighted (e.g. in Stefanović, *SNA and Egyptology*). ANT is, however, rooted in science and technology studies (STS), not network science. Moreover, the English version (actor-network) of the French term (acteur-réseau) is unfortunate and misleading, e.g. Hodder, *Entangled. A New Archaeology,* 174; Hodder, 'The Entanglements of Humans and Things', 23–24; Mol, *The Connected Caribbean,* 258, n. 2; and esp. Mol, 'Actor-Network Theory'. For the principles of ANT, see esp. Latour, *Reassembling the Social;* also e.g. Czarniawska, 'Actor-Network Theory'. For a comparison of ANT and SNA, Vicsek, Király, and Kónya, 'Networks in Social Sciences'; Venturini, Munk, and Jacomy, 'Actor-Network vs Network Analysis vs Digital Networks'.

7 Most of the applied terms are explained in App. A of Tambs, 'People and Things' (published open access). More substantial glossaries include Brughmans and Peeples, *Network Science in Archaeology,* 294–309; Collar et al., 'Networks in Archaeology', 17–25; Tambs, *Socio-Economic Relations,* 2022, 2:1–6.

should not, however, be taken for granted, and demands careful considerations at various stages of the research process.

For every application of formal network analysis, the researcher must consciously design and reflect upon every stage of the workflow, while simultaneously keeping in mind their knowledge about the model, dataset, source material, historical period, etc. Although every historical network model – like every historical study – is unique, there are also common denominators. This article highlights and discusses the role of one such component, namely the human agent(s) involved in the research process.

The Main Objective

Acknowledging that SNA offers useful additions to the ancient scholar's toolbox, but also that network analytical measures are not as 'formal' as they might first appear, I set out to explore how the choices we make are reflected in the networks we study, and how their manifestations impact the network analytical results at various scales. The network data behind the models visualized and discussed in this article was, for example, extracted from ancient written sources through a semi-automated process (outlined below), but the author was actively involved in all stages of the workflow. An example is how *she* defined the network boundaries; another is how *she* selected the software and metrics used to measure the graphs.

So, if we, the researchers, are heavily involved in the reconstruction and representation of the ancient networks we study, how can we be confident that what we do makes sense? Knowing what we know about our sources, datasets, and their biases, how representative and trustworthy can we consider our network models to be? Below, such concerns are addressed through a test case where a humble selection of 36 documents from the earliest phase of the Zenon archive is modeled and analyzed as networks.

The Zenon Papyri

The so-called Zenon Archive constitutes a unique collection of *c.* 1845 papyri covering a brief period of some 35 years (263–229 BCE). It is the largest archive to have survived from ancient Egypt and consists mostly of letters and other types of documentary texts (accounts, contracts, lists, petitions, receipts, etc.) filed by Zenon and others.[8] Within them, we meet royalty and commoners, high officials and peasants, men and women, wealthy and poor people struggling to make ends

8 Vandorpe, 'Zenon Son of Agreophon', 453–55; Pestman, *Guide to the Zenon Archive (P. L. Bat. 21 A),* 183–94.

Fig. 1 Map showing the locations of Kaunos, Alexandria and Philadelphia (Map by author, created in Google Earth [Image Landsat/Copernicus. Data SIO, NOAA, U.S. Navy, NGA, GEBCO. Scale 800 km], with coordinates from Trismegistos Places [TM_Geo_100, TM_Geo_1022 and TM_Geo_1760], 31. 05. 2024).

meet. As an archival group, the Zenon papyri offer unique insights into the social and economic lives of people living and working in early Ptolemaic Egypt and beyond,[9] but studying them collectively poses a number of challenges. Here, a very brief outline of the known career of the principal owner, Zenon, will suffice as an indication of the range of locations, people and subject matters that are covered by the sources.[10]

Zenon, son of Agreophon, was born in Kaunos in Caria (modern-day Türkiye, Fig. 1) around 285 BCE. At least by 261 BCE, Zenon had become a trusted employee of Apollonios, the *dioiketes* (διοικητής) or 'minister of finance' of Ptolemaios II Philadelphos (reg. 285–246 BCE). For most of the period covered by the archive, Zenon served as the private agent (ὁ παρά) of Apollonios, but his job description changed several times: in 260–258 BCE he travelled and conducted business in the Levant; in 258–256 he accompanied the finance minister on inspection tours within Egypt's borders, or resided with Apollonios' household in Alexandria in the Delta; and in 256–229 BCE he lived in Philadelphia in the Fayum (Egypt, Fig. 1). Here, his *main* duty was to manage Apollonios' large gift estate (δωρεά), until he eventually retired to live off the private businesses he had established alongside his many other obligations.

Such brief and linear summaries necessarily simplify the situation to the extreme, but the point here is that Zenon was a man with a very wide range of responsibilities, through which he encountered a large number of people. As a trusted employee of the finance minister, but also through his private business and affairs, he was both directly and indirectly involved in many cases and practices, as well as interacting with various systems and institutions, particularly in Egypt and the Levant. Moreover, the archive shows how individuals and groups of different social standing sought his audience.[11]

Studying the Archive of Zenon with Network Science

The archival context and heterogeneity of the subject matters covered by the sources add to the Zenon papyri's relevance for reconstructing social histories. By preserving glimpses of lived experiences, they shed light on various aspects of life under Ptolemaios II Philadelphos and Ptolemaios III Euergetes (reg. 246–222 BCE). In order to make sense of the wonderful chaos and complexity they

9 On the preservation of papyri and their potential for writing history, see e.g. Bagnall, *Reading Papyri*.

10 For a more thorough outline of Zenon's life and affairs, see e.g. Durand, *Des Grecs en Palestine,* 25–30; Edgar, 'Selected Papyri (Nos. 1–10)', 160–61; Edgar, *Zenon Papyri (Michigan),* 15–50; Tambs, 'Social and Economic Life', 370–72; Vandorpe, 'Zenon Son of Agreophon', 448–53; Vandorpe, 'Life Portraits', 273–75.

11 In a forthcoming chapter, we explore how Zenon's multiple identities are manifested in the archive, Tambs and Lindén, 'Co-Attestations'.

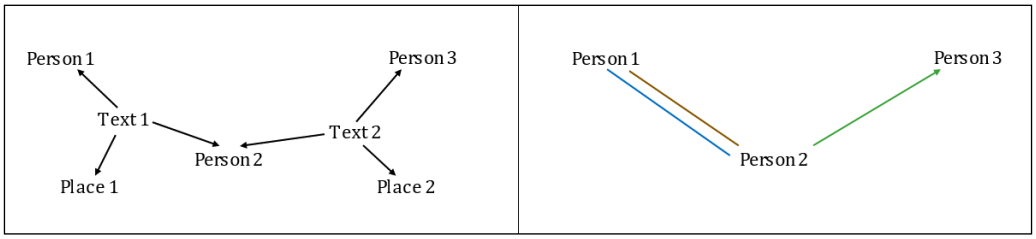

Fig. 2 Schematic illustration of the directed monoplex co-attestation (left) and mixed multiplex interpersonal (right) networks studied in the larger Zenon project that this test case relates to. In this article, only person and text nodes are modelled in bipartite and monopartite networks.

portray, systematic and computational methods are, however, instrumental. In this respect, the network scientific approach is fitting as it comes with conceptual and methodological tools that enable us to simultaneously model and study the scarce pieces of empirical evidence in larger contexts, as well as zoom in on specific parts of these larger network models to answer specific questions. Such a multi-scale analysis allows us to study larger formal and informal systems, but also to account for variability, for example reflecting the different personal ties and positions of influence held by the people that ran this empire.[12] For our purpose, SNA offers suitable tools for abstracting and modeling such complexities.

Below, we shall model two types of networks from the ancient sources: (1) co-attestation, and (2) interpersonal networks. The former takes the shape of directed bipartite networks in which people are linked to the ancient texts they are attested in, whereas the latter are 'true' social networks in which people are linked to others by edges representing the social and economic ties they shared in antiquity (Fig. 2).

The Test Case

In the past, I have often restricted my data collection to only recording the attribute and relational data concerning individuals who are explicitly mentioned and named.[13] However, to study the Zenon archive from a network perspective, it was deemed relevant to consider whether it was more fruitful to also incorporate unnamed individuals and groups in my networks. The focus of this article is an early test case designed to identify and assess changes occurring in the dataset if we opt to also represent unnamed individuals – i.e. people referred to by a relationship

12 The significance of the personalities and personal influence of officeholders, including our *dioiketes,* is outlined in Bagnall, *Administration of Ptolemaic Possessions,* 226–27.

13 For my process, see esp. Tambs, *Socio-Economic Relations,* 2022, 1:94–122.

or function ('the young assistant', 'wife of X', 'the cook', etc.) rather than their personal name[14] – and collective actors (such as the 'employees of x') as nodes in the two types of networks (Fig. 2). By treating unnamed persons and groups as separate categories while the network data is recorded, they can be easily identified in the software. This ensures that they can be studied collectively and alongside named individuals, but also easily highlighted or hidden.

Before analyzing a larger network – for example one representing the archive at large – it is recommended to test the methodology on a smaller and more comprehensible sample. Through such exploration, the researcher can gain valuable insights into the sources, network data and models that will help them refine the methods before tackling a much larger dataset.[15] For the tests presented here, we will use a sample of 36 papyri selected from the much larger Zenon archive.

The networks analyzed below represent data retrieved from 36 documents, written either before or while Zenon was travelling as Apollonios' delegate in the Levant. In selecting the sample, I identified texts with known dates from the earliest phase of the archive (i.e. written 263–258 BCE). This period was favored for the following reasons: a) it constitutes the earliest documents (and thus serves as a good introduction to the archive); b) fewer texts are preserved from this early period (so I could include a relatively large part of the available sources with the limited time at my disposal); and c) because this is the period of greatest interest to the center under which the research was conducted (since many of these texts concern Zenon's activities in the Levant).

Although the small sample size prevents us from drawing firm conclusions about the archive as a whole, it was deemed sufficiently large for the task at hand: the resulting networks are considered large enough to suggest general trends and potential methodological issues, yet small enough for the researcher to retain an overview of the network data and texts being studied that are necessary to critically assess the results and read the findings in context. Moreover, the results are case specific yet expected to have greater methodological and historical ramifications: publishing such explorations help network-oriented historians to better predict how networks with similar characteristics might respond to similar manipulations and, for writing social histories, such tests provide valuable insights that can help us realize the potential and limits of our networks. Such lessons

14 By this definition, even 'the king' would be conceived of as an unnamed individual, when the expression refers to the person but designates him by the function of king while omitting his name(s).

15 In my case: the Trismegistos lists of attested persons retrieved from 1845 Zenon papyri amount to 11237 attestations of 3992 persons across 1612 (87.4%) texts mentioning at least one person. Since the TM lists do not include impersonal and collective actors, this is counting named individuals only and using the TM data *as is.* Although not big data *per se,* this dataset is already exceptionally large by Egyptological standards.

help us refine our strategies for modeling and analyzing past relations and establish mixed-method approaches that combine SNA with other methods in fruitful ways.

The Network Models Discussed in this Article

Using the 36 texts that make up the sample, we will model and compare bipartite and monopartite networks with and without unnamed and collective human actors. For this purpose, I collected data for modelling two versions of two distinct types of networks (amounting to four models, as summarized in Fig. 3): bipartite (or 2-mode) networks of 'people' linked to ancient 'texts' (2a–b), and monopartite (or 1-mode) networks in which every node represents 'people' who are directly connected to people they had social and/or economic relations with (1a–b). The bipartite networks (with people and text nodes) are directed and monoplex, with every edge pointing from a text to a person node, thus signaling that the latter is mentioned in the former. In contrast, the monopartite models (with only people) are mixed and multiplex, since pairs of human actors can be connected by various kinds of relationships, which may or may not have an inherent direction. It should be clarified that the human nodes of the networks discussed in this article strive to represent individuals (as opposed to, for example, occupational groups, functions or homonyms).

For each network type, I first followed a strict data collection policy in which only information on individuals who are explicitly mentioned by name were included in the node and edge lists (Networks 1a and 2a).[16] At this stage, I already

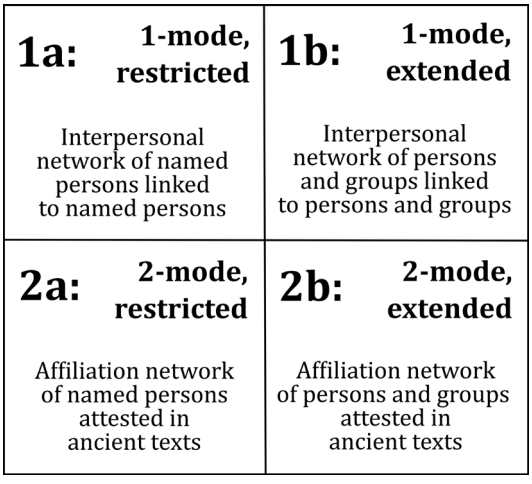

Fig. 3 Schematic model of the four networks.

16 This aligns with the data collection method I developed for studying ancient archives from the bilingual community of Pathyris (Gebelein) in Upper Egypt, described in Tambs, *Socio-Economic Relations,* 2022, 1:esp. 95–96, 119–120.

found myself ignoring many actors and relationships that seem relevant to understanding the social and economic dynamics at play and that the ancient documents *do* reflect. Considering the potential of the material for writing social histories, I deemed it worthwhile to check what sort of changes I would see in the datasets if I were to loosen this network boundary. In essence: how would unnamed persons and collective actors affect the network models? To explore this question, I returned to the ancient sources and created an extended version of each network type, namely one that includes unnamed and collective actors in addition to named individuals (Networks 1b and 2b).

As a concrete example of what the four models represent, I cite a Greek letter written on 4 April 258 BCE (TM_678/P.Cair.Zen. I 59018)[17] in translation (by J. S. Kloppenborg).[18] On the verso is written '*To Oryas*'.

> Alexander to Oryas, greetings. I have received your letter, to which you subjoined for me the letter that Zenon had written to Yeddous, saying that unless he gave the money to Straton, Zenon's agent, we were to hand over his pledge to him (Straton).
>
> Now I happened to be unwell as a result of taking some medicine, so I sent a young assistant with Straton, and I wrote a letter to Yeddous. When they returned they told me that he had taken no account of my letter, but had laid hands on them and thrown them out of the village. So I am writing to you (for your information).
>
> Goodbye. (Year) 27, Peritios intercalary day 20.

In order to model networks based on such sources, my semi-automated data collection process starts with the prosopographical baseline and lists of attested people offered by the online Trismegistos (TM) databases.[19] The list from this specific letter, for example, includes nine attestations of people (Fig. 4). These Trismegistos lists form the backbone of my datasets and are of crucial importance to the project. While one should always use existing datasets with care, checking the lists of randomly selected Zenon papyri against relevant publications, including text editions, this does suggest that the lists offered for Zenon papyri are relatively trustworthy.[20] Still, my approach requires me to manually check and add

17 For a list of the studied texts, with sigla, see Appendix A. In this article, ancient texts are primarily referred to by their TM text id. At first mention, these contain a hyperlink to the relevant TM Text record, as well as the text's sigla, standardized according to the Checklist of Editions of Greek, Latin Demotic and Coptic Papyri, Ostraca, and Tablets, available at https://papyri.info/docs/checklist (accessed 04.11.25).

18 Kloppenborg, *Tenants in the Vineyard,* 364–65.

19 Depauw and Gheldof, 'Trismegistos'; Broux and Depauw, 'Developing Onomastic Gazetteers'. The lists were scraped using F. Alvares Freire's 'attestation per document' tool.

20 Sometimes a place name is, for example, wrongly included in the list of attested persons and, although Trismegistos often links to the online *Berichtigungsliste* (BL), the revisions

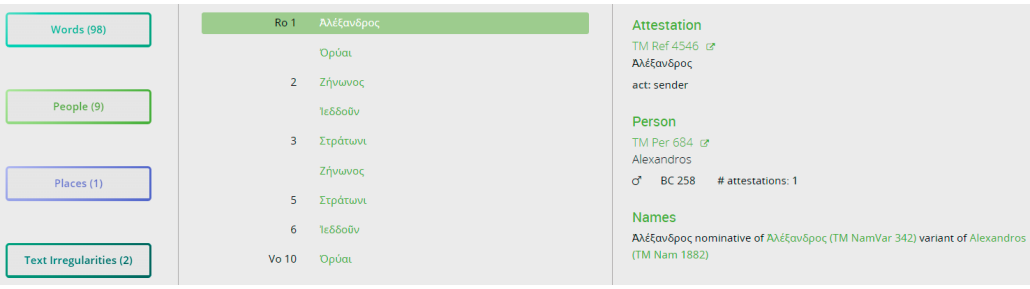

Fig. 4 Trismegistos People list of individuals attested in TM_678 (https://www.trismegistos.org/text/678, accessed 19.10.23).

various relational and attribute data revealed by the sources.[21] In this next stage, I clean and restructure, but also manually edit and add additional information to the project database. This part of the data collection process is very time-consuming, as it involves a literature review and a close reading of the ancient texts. Much time also goes into deciding whether to model two namesakes as a single node, or rather as two separate nodes.[22]

Compared to the information Trismegistos offers, the node and edge lists used for this test case also contain additional information recorded as node and edge attributes.[23] Nonetheless, by adhering to the stricter data collection method (Networks 1a and 2a), my node lists (mostly) contain records of the same individuals. For example, to model the highlighted letter as a bipartite affiliation network in Gephi,[24] the restricted edge list connects the nodes representing named individ-

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it presents are seldom reflected in the TM lists of attested persons. As a case in point, reviewing BL entries for TM_2174 (used as an example below) suggest readings that might affect how we understand and model the relational ties of Melas (see also n. 22). Such resources should ideally be consulted as we work through the material on a text-by-text basis, but given the large size of the Zenon archive (see n. 15), such instances will have little statistical impact on a network that depicts the archive as a whole. For the 36 texts included in this study, all TM lists were checked.

21 For the text in question, I consulted Edgar, *Zenon Papyri (Nos 59001–59139),* 1:38; White, *Light from Ancient Letters,* 6–7; Durand, *Des Grecs en Palestine,* 157–58; Kloppenborg, *Tenants in the Vineyard,* 364–65. In the case of TM_678 (above), the name of the sender, Alexander, is largely restored. The challenges this causes for identifying potential cross-identifications of this individual across texts is already reflected in the relevant TM list of attested persons, as he is recorded via a person ID that is only used for this one attestation.

22 To ensure transparency, I record these and other choices made in the data collection process in a textual commentary, to be published in Tambs, *Linked People and Places.*

23 The graph files preserving the sets of node and edge lists studied in this test case are shared via Zenodo: https://doi.org/10.5281/zenodo.14190908.

24 Bastian, Heymann, and Jacomy, 'Gephi'.

uals – amounting to five men – to the node representing the text.[25] Whereas the prosopographical baseline offered by Trismegistos is also very helpful for building the monopartite interpersonal networks, these models are mostly recorded manually and are therefore far more time-consuming to make. In the monopartite networks, pairs of individuals are linked when an ancient text explicitly reveals them to have shared a social or economic relationship of interest.[26] The node-link diagrams representing the restricted data sets extracted from TM_678 thus show a monopartite network consisting of five nodes (representing named individuals, Fig. 5b) and a bipartite network with six nodes (including the text node, Fig. 5a) respectively.

Although such models will never mirror reality, my aim is to build models that reflect real-world relationships, networks and events. With this in mind, it is admittedly problematic that with the stricter data-collection criteria, I deliberately ignore a number of persons and relationships that the documentation *does* refer to – just not by name. For example, the 'young assistant' (νεανίσκον), who clearly took an active role in the affairs reported in TM_678, is not represented in these visualizations (or the Trismegistos list of people mentioned in this text).[27] So, what happens if we loosen the data collection policy and write him into the story?

To check how and to what degree the presence of unnamed persons, but also groups and people whose identity have been lost in lacunas, change the picture, I created extended versions of the datasets, in which such actors are also incorporated into the node and edge lists (Fig. 6). While adding a 'young assistant' node barely makes a difference to the bipartite network (cf. Fig. 6a and 5a), we can observe that he has a greater impact on the monopartite network (cf. Fig. 6b and 5b). In addition to the models with the 'young assistant' being slightly larger, the presence of this one unnamed actor already changes the frequency of recorded edge types and impacts the relative importance of other nodes. For example, when measuring and comparing the nodes' degree centrality scores across the re-

25 In the network data, personal IDs ensure that nodes reflect (named or unnamed) individuals or groups, but each attestation is recorded as a separate edge. This method was preferred since it allows for parallel edges, as well as for contextual and qualitative information to be recorded as edge attributes. When relevant, the parallel edges can be converted to edge weights, for example during the Gephi import. See also n. 35.

26 Although far more time-consuming, this meticulous method was preferred over projecting the bipartite graph onto a monopartite network, since it allows interpersonal relations to be encoded and studied as multiplex networks. In contrast, projecting the bipartite dataset would result in a single-layered co-attestation network. For the difference between compressed and interpersonal monopartite networks, cf. Tambs, 'People and Things', figs 2c and 2d. The categories of recorded relationships, like those listed in figure captions, are defined by the author.

27 He is indirectly recorded in the node and edge attributes of the restricted networks, but they do not do him justice.

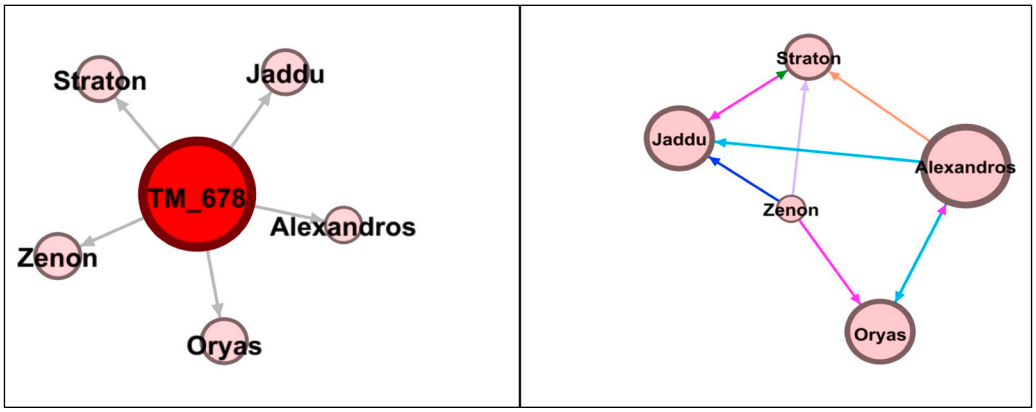

Fig. 5 The 2-mode (a) and 1-mode (b) network visualizations of TM_678, including explicitly mentioned persons only. Node color: red = text; pink = person. Node size: (a) out-degree/(b) degree centrality. Edge color: (a) grey = attestation/(b) light blue = communication; pink = request; light purple = hierarchical; blue = loan; orange = collaboration; green = mistreat; red-brown = refusal (Graphs by author, created in Gephi).

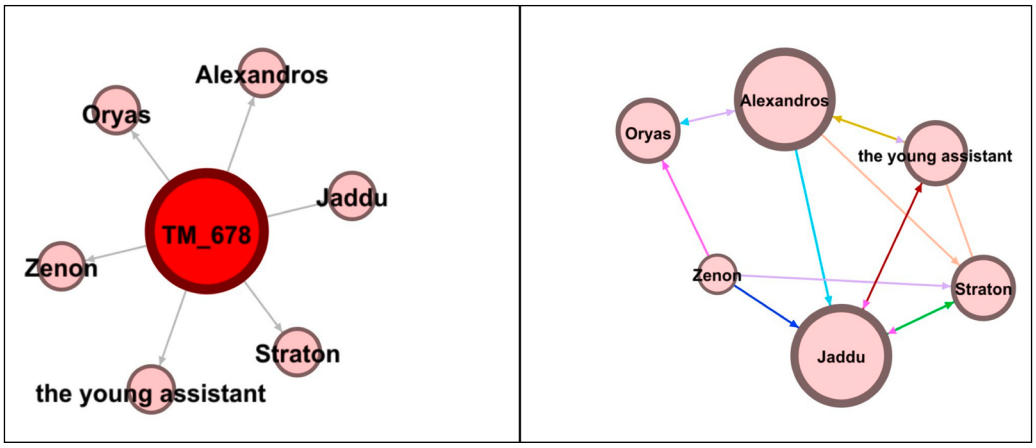

Fig. 6 The 2-mode (a) and 1-mode (b) network visualizations of TM_678, also representing unnamed persons and groups (here: the 'young assistant'). Node color: red = text; pink = person. Node size: (a) out-degree/(b) degree centrality. Edge color: (a) grey = attestation/(b) pink = request; light blue = communication; light purple = hierarchical; orange = collaboration; green = mistreat; red-brown = refusal; yellow = service; blue = loan; (Graphs by author, created in Gephi).

stricted and extended interpersonal networks, we see an increase in Straton and Jaddu's degree centrality (from five to six and six to nine, respectively).

So far, we have zoomed in on a single document. This was useful for explaining the method, but the recorded datasets are, of course, far too small to provide any trustworthy indications of the positions and functions of unnamed persons and groups in the corpus. As we have seen, the presence or absence of a single person can cause noticeable changes to a network this small, but the influence of this young assistant will decrease as the dataset grows.

Although 36 is still a small number of ancient sources, more interesting and less easily predictable results are encountered once we move beyond the limits of this text and start exploring networks informed by the sample. App. A lists the texts that inform the models below, with sigla. All are preserved on Greek papyri and are considered to have been written in the earliest phase of the archive,[28] i.e. before or while Zenon served as the *dioiketes'* private agent in the Levant. It is therefore not surprising that the vast majority of these texts are accounts and letters (Fig. 7).

As in the case of the letter presented above (TM_678), data for both restricted and extended models were collected, and subsequently the sets of monopartite and bipartite networks were analyzed and compared.

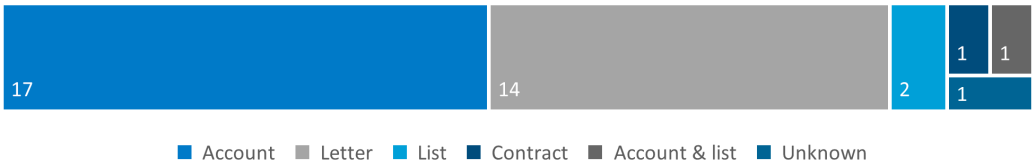

Fig. 7 Threemap of the document types of the sample that make up the case study (Chart by author).

28 For my system of using three chronological classification systems (precise dates, phases, and predefined time-slots), see Tambs, 'People and Things', 10.

The Impact of Unnamed Individuals and Groups on the Bipartite Network

The bipartite network data consists of pairs of human actors and written sources, which are linked by a directed edge if the target person (or group) is attested in the ancient source. For the sample analyzed, the tables below summarize the characteristics of the restricted (Tab. 1) and extended (Tab. 2) networks.

As expected, the size of the network increases as we loosen the criteria for inclusion. More precisely, by welcoming unnamed and collective actors, the model grows with 34 nodes and 99 edges.[29] Although a lower percentage of the nodes in the extended model represent named individuals, the ratio of such actors in the core components – i.e. the largest connected component identified in a network – compared to the whole networks remain similar: in each instance, we observe an increase of roughly 2% in the core. Whereas unnamed persons are also

	Nodes	Edges	Connected components	Average degree	Density
Whole network	231*	396	9	1.714	0.007
Core component	204**	371	1	1.819	0.009

* 36 (15.58%) texts; 195 (84.42%) named persons.
** 28 (13.73%) texts; 176 (86.27%) named persons.

Tab. 1 Network characteristics of the restricted 2-mode network (Network 2a).

	Nodes	Edges	Connected components	Average degree	Density
Whole network	265*	495	9	1.868	0.007
Core component	230**	462	1	2.009	0.009

* 36 (13.58%) texts; 198 (74.72%) named persons; 21 (7.92%) groups; 8 (3.02%) unnamed persons; 2 (0.75%) unknown.
** 28 (12.17%) texts; 177 (76.96%) named persons; 18 (7.83%) groups; 7 (3.04%) unnamed persons.

Tab. 2 Network characteristics of the extended 2-mode network (Network 2b).

29 The fact that the number of persons named increases from 195 to 198 across the whole networks (and 176 to 177 in the core) is explained by the extended model also including three persons whose identity was lost in lacunae (one of which is positioned in the core component).

marginally better represented in the core component of the extended network, the percentage of groups drops slightly. A marginally smaller percentage of the edges in the extended model are also situated in its core.[30] To get a better impression of the new elements' distributional patterns, it is useful to visualize the networks as node-link diagrams, with the layout set by the ForceAtlas2 algorithm in Gephi (cf. Fig. 8 and Fig. 9).[31]

That the new nodes and edges are relatively evenly distributed in Fig. 9 is confirmed by a visual examination of the network models. When comparing the color-coded models, we observe that some smaller components have grown, but also that the new additions (i.e. the blue, purple, and grey nodes, as well as their edges) do not noticeably change the network structure. The number of connected components is stable (9) and in both cases, one component is vastly larger than the rest. The relative size of this core component drops marginally,[32] but comparing global metrics like average degree and density across the two models confirms that unnamed persons and groups have only a small impact on the network structure of the bipartite data, even if the texts positioned in the core and whole network mention slightly more people on average in the extended version (cf. Tab. 1 and Tab. 2).[33]

These findings are perhaps unsurprising, given how unnamed and collective actors are less likely to be securely identified across multiple ancient texts, but the formal network approach enables us to verify and quantify this suspicion. To begin exploring how the unnamed persons' (purple) and groups' (blue) nodes impact their local neighborhoods, we can for example effortlessly shift perspective and measure the nodes' in-degree centrality. Doing so reveals that in the extended network, two unnamed persons and four groups have in-degree centrality scores above '1'.[34] When interpreting these outputs, we must remember

30 The core components make up some 94% of the edges of the restricted and 93% of the extended network.

31 Jacomy et al., 'ForceAtlas2'; Bastian, Heymann, and Jacomy, 'Gephi'.

32 The core components make up 88.31% of the nodes and 93.69% of the edges of the restricted network, and 86.79% of the nodes and 93.33% of the edges of the extended whole network.

33 Although graph density is a problematic cohesion measure to run on bipartite networks (Borgatti, '2-Mode Concepts in SNA'), it is used here (without normalization) as a simple means to compare models of the same type and a similar size. However, it should be stressed that the results are only relevant as a comparative measure within this study.

34 They are 'the cook' (Unn_Per_2), 'slaves' (G_5), 'the cook' (Unn_Per_4), 'grooms' (G_7), 'bakers' (G_9), and 'the employees of Rabbelos' (G_18), with in-degree scores of 50, 9, 6, 2, 2, and 2 respectively.

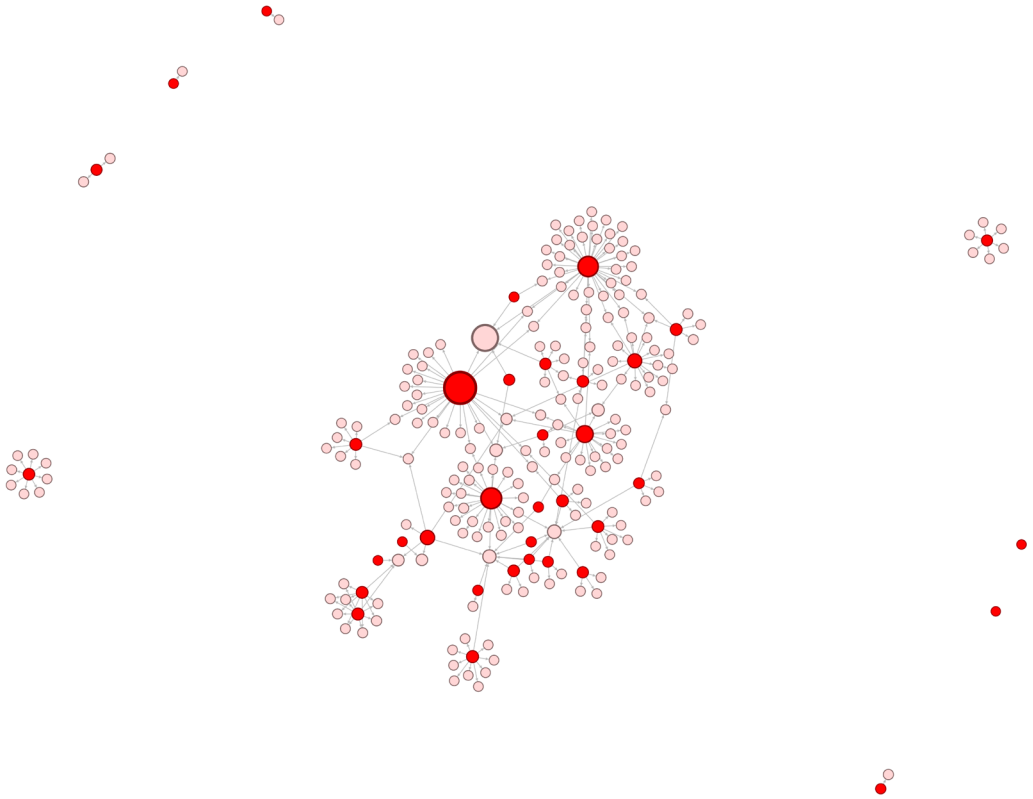

Fig. 8 Restricted 2-mode network, excluding unnamed persons and groups. Node color: red = text; pink = person (if B/W print: dark = text; light = person). Node size: degree centrality. Edge color: grey = attestation (Graph by author, created in Gephi).

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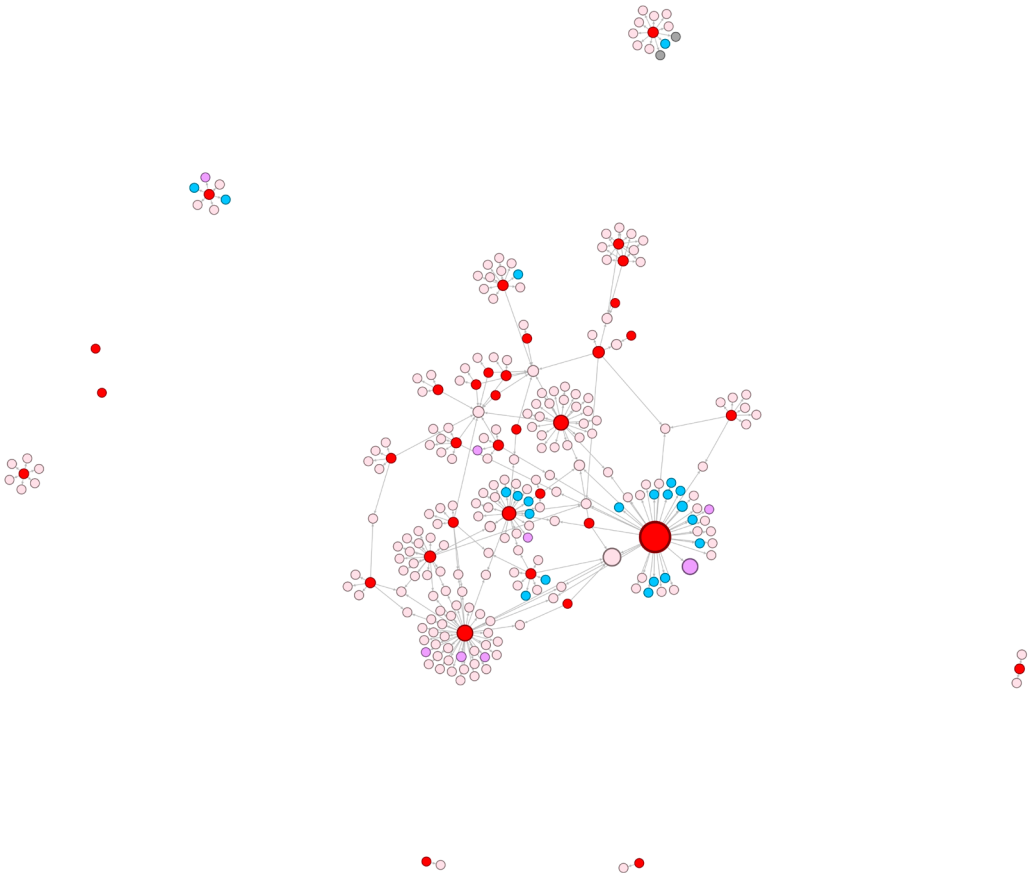

Fig. 9 Extended 2-mode network, including unnamed persons and groups. Node color: red = text; pink = person; blue = group; purple = unnamed person; grey = unknown (if B/W print: dark = text; medium dark = added actors; light = actors also in Fig. 8). Node size: degree centrality. Edge color: grey = attestation (Graph by author, created in Gephi).

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that the networks discussed contain parallel edges,[35] so the significance of the in-degree scores should be read in the context of the network structure. Identifying the network position of the new nodes, we note that several texts mention unnamed persons and/or groups, but also that such nodes are only attested in a single document. In other words, the relatively high in-degree score of certain unnamed persons and groups in this dataset reflects the fact that they are mentioned multiple times in a single document, rather than reappearing across multiple ancient texts (see also Tab. 8 below).

From this rather simple network analysis, we can conclude that the unnamed persons and groups attested in the 36 papyri that make up the sample do not cause major changes to the bipartite network. These are, however, co-attestation networks far removed from the complexity of real-world relations. The question remains as to whether a more interesting picture would emerge if, rather than linking them to the documents, we connected human actors directly to each other. What sort of changes would we observe in such interpersonal networks, where the papyri themselves step into the background?

The Impact of Unnamed Individuals and Groups on the Monopartite Network

In the mixed monopartite network data, the pairs of nodes representing ancient people are linked by edges representing the social and economic ties they shared in antiquity – as far as these are reflected in the texts studied. For this sample, the tables below summarize the size and characteristics of the restricted (Tab. 3) and extended (Tab. 4) networks.

When we loosen the criteria for inclusion, the size of the interpersonal network grows with 29 nodes and 28 edges.[36] It is worth noting here that more texts are (indirectly) represented in the extended model: interpersonal relations linking pairs of named individuals are revealed by 21 of the 36 papyri, whereas this

35 For my network research, parallel edges are often allowed since they offer a means to record contextual information provided by the ancient text as edge attributes. This information is stored in the project database, but I have found that also incorporating such details into the network models makes a powerful and interactive research tool that can be used and explored as part of the network analysis. The consequences of opting to 'sum' (i.e. translate parallel edges into edge weights) or 'don't merge' (keep) parallel edges as different types of network data are imported into Gephi is explored in Tambs, 'People and Things', 14 (for *k*-partite affiliation networks); Tambs and Lindén, 'Co-Attestations', App. B (for monopartite networks of people mentioned together in ancient texts).

36 The observed increase of named individuals, from 80 to 92 across the whole network (and 57 to 58 in the core) is explained by conventions of data collection regarding persons whose identity is lost (as above), but also that more named persons are modelled when they can be paired with unnamed and collective actors.

	Nodes	Edges	Connected components	Average degree	Density
Whole network	80*	150	12	3.750	0.047
Core component	57**	136	1	4.772	0.084

* 80 (100%) named persons.
** 57 (100%) named persons.

Tab. 3 Network characteristics of the restricted 1-mode network (Network 1a).

	Nodes	Edges	Connected components	Average degree	Density
Whole network	109*	178	22	3.266	0.030
Core component	61**	146	1	4.787	0.079

* 92 (84.40%) named persons; 11 (10.09%) groups; 4 (3.67%) unnamed persons; 2 (1.83%) unknown.
** 58 (95.08%) named persons; 2 (3.28%) groups; 1 (1.64%) unnamed person.

Tab. 4 Network characteristics of the extended 1-mode network (Network 1b).

number rises to 25 when the recorded social and economic relationships can involve unnamed persons or groups.

Moreover, a greater difference in the relative representation of node types is detected in the monopartite compared to the bipartite data (cf. Tab. 3 and Tab. 4 with Tab. 1 and Tab. 2). For the bipartite networks, we observed how the ratio of node types in the cores vs the whole networks remained similar. In comparison, we find that unnamed and collective actors are more poorly represented in the core component of the extended monopartite network. Here, unnamed persons make up nearly 4% of the whole network and less than 2% of the core, while the presence of groups drops from c. 10% in the whole network to c. 3% in the core. A greater difference in how many of the edges are positioned in the core,[37] combined with a more or less stable average degree measured inside them, further signals that most new edges connect pairs of nodes that are *not* tied to the extended network's core component.

By visualizing the monopartite networks as node-link diagrams following the same principles as above (Fig. 10 and Fig. 11), we get visual confirmation that most of the nodes positioned in the core component represent named individuals

37 The core components make up some 91% of the edges of the restricted and 82% of the extended network.

(Fig. 11).[38] Since they were already included in the restricted model, we might suspect that the new actors also have only a minor structural impact on the monopartite network. To check the validity of this notion, we will also measure and explore these graphs in a little more detail.

A similar structure is detected across the restricted and extended models, in that both whole networks are characterized by one component being much larger than the rest. By formally measuring the graphs, we learn that the extended version contains ten additional connected components, and that the core components make up 71.25% of the nodes and 90.67% of the edges of the restricted, but only 55.96% of the nodes and 82.02% of the edges of the extended monopartite network.

We already know that most new nodes are excluded from the core, but these visualizations further aid us in seeing how poorly connected most unnamed persons and groups are: most form otherwise unconnected dyads with a single named individual. This means that more named persons are also modelled when unnamed and collective actors are treated as nodes, but these are also structurally insignificant within the network at hand.

It should nonetheless be remembered that we are currently looking at a very small sample of a much larger archive. As more Zenon papyri are incorporated into this model, we can expect that many such dyads will become tied to nodes positioned in the core component. At present, 32 persons with unique Trismegistos People identifiers are included in the extended whole network, but excluded from its core.[39] A glance at the project's bipartite data, representing 1845 documents – as collected from the Trismegistos databases[40] – indicates that (at least) twelve of these are attested in further Zenon papyri. A particularly promising case is Helenos,[41] attested in nine documents. As information learned from these and other texts are added, such actors – and the nodes directly or indirectly linked to them – may eventually be incorporated into the core. Once they are, their network positions, but also their known connections to unnamed persons and groups, will become more interesting to analyze.

38 In addition to the two groups and one unnamed person, one weakly connected NN (NoName) person (whose identity is lost) is tied to members of the core component of the extended model.

39 https://www.trismegistos.org/ref/ (accessed 20. 06. 24). Broux and Depauw, 'Developing Onomastic Gazetteers'.

40 https://www.trismegistos.org/ (accessed 20. 06. 2024). Depauw and Gheldof, 'Trismegistos'. For the retrieved dataset visualized as a node-link diagram, see Tambs, 'People and Things', fig. 1.

41 TM_Per_1600.

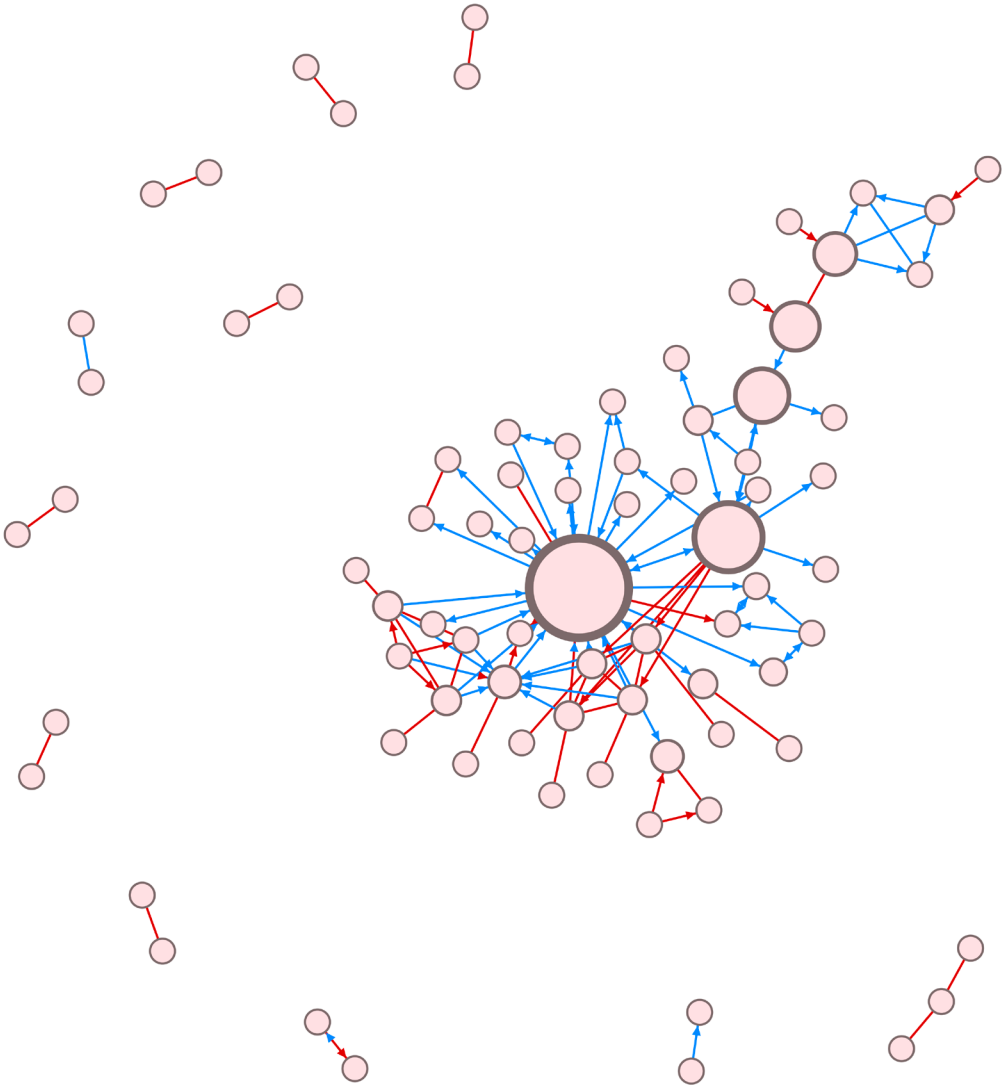

Fig. 10 Restricted 1-mode network, excluding unnamed persons and groups. Node color: pink = person (if B/W print: light = person). Node size: betweenness centrality. Edge color: red = social tie; blue = economic tie (Graph by author, created in Gephi).

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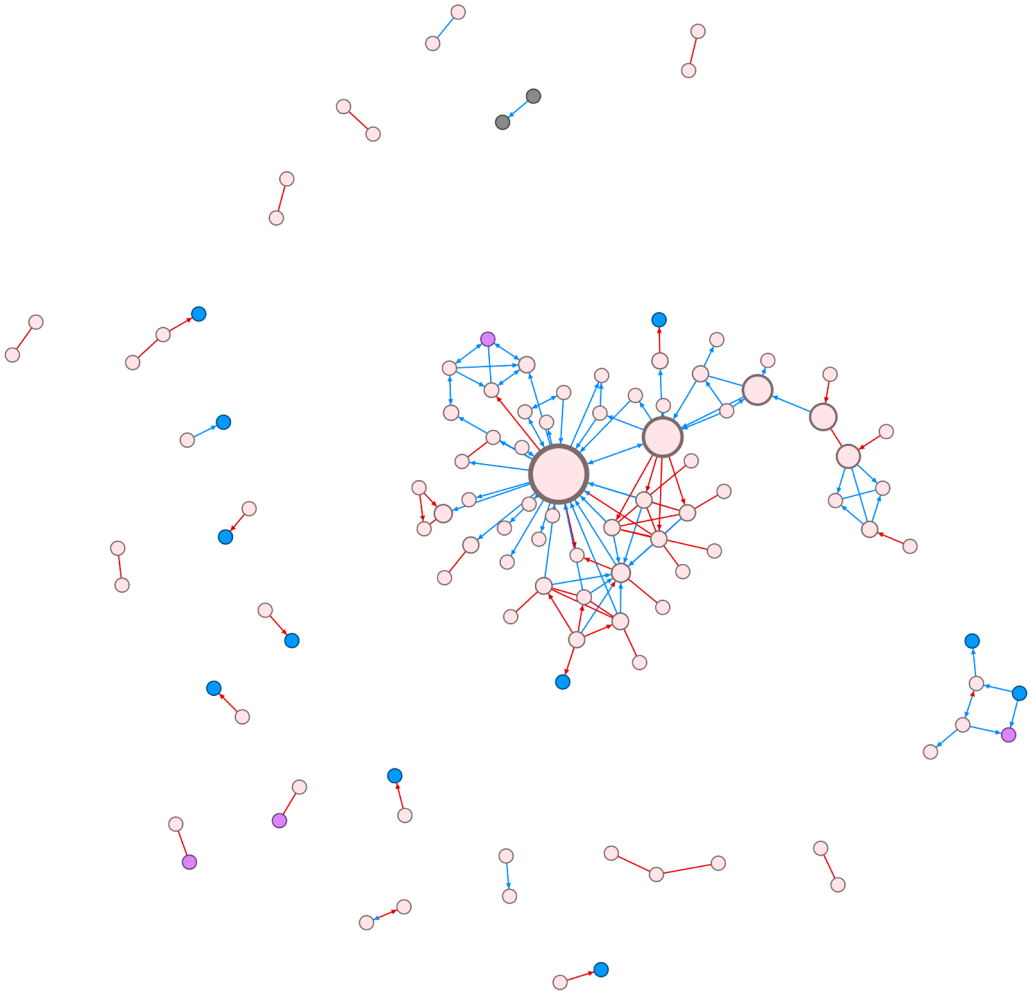

Fig. 11 Extended 1-mode network, including unnamed persons and groups. Node color: pink = person; blue = group; purple = unnamed person; grey = unknown (if B/W print: medium dark = added nodes; light = nodes also in Fig. 10). Node size: betweenness centrality. Edge color: red = social tie; blue = economic tie (Graph by author, created in Gephi).

It is also worth noting that in Fig. 11, all unconnected dyads and small groups apart from the string consisting of two named persons and a group (which reflect information learned from two papyri) originate from a single document. In comparison, the core component already contains edge mapping information learned from 17 ancient texts. It is in such cases, when cross-identifications from numerous ancient texts allows us to map complex webs of past relationships, that historical network analysis truly becomes interesting. That several of the sources studied are already interlinked by the social and economic activities of the people they mention is therefore promising, especially seeing how the test case is based on a small selection of the earliest documents, whereas far more texts are preserved from the later years covered by the archive.[42]

Nonetheless, it must be acknowledged that unnamed persons and groups are unlikely to be identified across multiple texts, which reduces the likelihood of such nodes becoming structurally significant (unless we, for example, opt to merge all 'the cooks' nodes, so as to represent professional groups or roles rather than individuals).[43] It should be clarified that this does not mean these actors were not important people in their time. Many were not identified by name exactly because of their important function in society, close relation to the persons communicating via the given letter, etc. The important point here is that my current methodology does not grant them structurally significant positions in the network graphs. Recognizing their meaning and value to other documented actors therefore requires us to actively look beyond the network models.

At present, only two groups, one unnamed person and one actor whose identity is lost are positioned within the core component. Whereas the unnamed person forms part of a small clique of four nodes, the groups and NN person are each connected to a single node (as discussed below). Consulting the papyrus that informed the edges they activate reveals that all are attested in a single document

42 Pestman, *Guide to the Zenon Archive (P. L. Bat. 21 A),* 171–83.

43 I here refer to the main text(s) preserved on a manuscript, i.e. not counting what Jones calls 'developed messages' (like letters cited within letters, as explained in 'Assyrian Court Scholar', 307) separately. Moreover, in striving to represent ancient people (as opposed to, for example, professions) I take a cautious approach in which I create new nodes to distinguish 'the cooks' of one text from 'the cooks' of another, unless a cross-identification is deemed 'certain'. In my networks, some nodes might therefore refer to the same historical person(s). Critical reflections on who are represented in networks modelled from 21 archives from Pathyris – which result from a similar data collection process but excludes unnamed persons and groups – are offered in Tambs, *Socio-Economic Relations,* 2022, 1:481. For a future study, it would be interesting to also compare the present dataset with a version in which all cross-attestations of a professional role (like 'the cooks') are rather represented by a single node. Modelling such appearances as part of wider interpersonal networks might, for example, shed welcome light on poorly understood professional groups, by offering means to explore their functions and roles in society, traveling parties, etc. in context.

included in the sample, but they are nevertheless positioned in the core since they are linked to (at least) one node with further connections. Next, it will be interesting to observe whether the new nodes have a noticeable effect on who are considered the central actors by common centrality measures.

The Stability Level of Selected Centrality Measures

The exploration of the four network models also included simple robustness tests designed to check how sensitive selected network measures are with regards to observed changes in the datasets discussed.[44] For this purpose, I ran several centrality measures and compared the ranked lists of nodes considered central by the given measure across the two versions of each network type. For the bipartite dataset (Networks 2a–2b), I checked the robustness level of the degree, in-degree and out-degree measures, whereas for the monopartite data (Networks 1a–1b), I compared the nodes' degree, eigenvector and betweenness centrality scores.

44 For examples of more complex robustness tests performed on ancient network data, see e.g. Düring, 'How Reliable Are Centrality Measures'; Groenhuijzen and Verhagen, 'Robustness of Local Network Metrics'; Peeples et al., 'SNA in Archaeology', 74–78; De Valeriola, 'Can Historians Trust Centrality?'; Ryan and Ahnert, 'Measure of Archive'; Bennett, Tambs, and Lindén, 'Letters Have Weight' esp. App. D; Mills et al., 'Dynamics of Social Networks'. Best practices for archaeological networks are offered in Brughmans and Peeples, *Network Science in Archaeology,* Ch. 5. For a broader assessment of the empirical performance of ten [corrected from eleven] centrality measures, see Costenbader and Valente, 'Stability of Centrality Measures'; and Costenbader and Valente, 'Corrigendum'. Their article concerns sociometric networks of bounded communities modelled in studies aimed at interviewing all members, but the issues of incomplete data they address are also relevant to historians and archaeologists, who will never arrive at 100% participation. For the 59 networks with at least 50% response rate, they check the measurements' stability level by sampling the original networks at 80%, 70%, 60%, 50%, 40%, 30%, 20%, and 10%. They also consider how the shape of the network affects how centrality measures respond to the reduced sample size, e.g. noting that 'for centralized networks, we expect the centrality measures to be stable across sampling levels', Costenbader and Valente, 'Stability of Centrality Measures', 289. That this is also to be expected of highly centralized historical networks is suggested by a recent study of correspondence from the reign of King Sargon II. Early in the research process, Bennett, Tambs and Lindén extended their source material from 609 to 727 ancient texts. With the addition of 118 letters, the highly centralized network (with the king's node preserved) grew from 547 nodes (representing individuals) and 1,537 edges (co-attestation) to 734 nodes and 2,269 edges. That network analytical results remained similar suggests that for this highly centralized network, the sample of texts incorporated was already sufficiently large to be representative ('Letters Have Weight', 157–58, 188). We must nevertheless remain cautious of the differences between various networks and studies. For example, Costenbader and Valente stress that their 'results are premised on the notion that sampling provides data missing at random' ('Stability of Centrality Measures', 305). However, the factors that explain missing data in historical and archaeological networks are rarely random or easily accounted for. Hence, we should continue to check the centrality metrics' robustness on ancient network data.

Only the highest-ranking nodes identified in each set of networks are listed in Tab. 5 and Tab. 6,[45] but the Excel file with centrality outputs for all nodes is included in the accompanying online repository.[46]

In general, the tests reveal that the measures checked are highly stable with regards to which nodes are considered central across the two versions of each network. As such, they support the notion that – at least in this dataset – added nodes and edges do not hold structurally important positions in the extended graphs (Networks 2b and 1b). Taking a closer look at the data, we do find some unnamed persons and groups amongst the most central nodes in the extended bipartite network (Network 2b, Tab. 5, visualized in Fig. 9). However, consulting the ancient sources reveal that their perceived importance by degree and in-degree centrality is largely explained by the presence of parallel edges.[47] For a future study, it would be interesting to also import (larger) datasets with the merging strategy 'sum' and compare these weighted models (with parallel edges translated into edge weights) with the sort of unweighted networks (with parallel edges retained) presented here.

In the extended monopartite network (Network 1b, Tab. 6, visualized in Fig. 11), the network positions of new nodes are even less prominent: no unnamed persons or groups are found amongst the twenty highest ranking nodes by either degree, eigenvector or betweenness centrality. With the primary and secondary sorting criteria in place,[48] a person whose identity is lost does hold the 17th highest rank for eigenvector centrality, but checking the network data and ancient evidence reveals that he is only active in two directed edges. Both are informed by TM_2378/P.Lond. VII 1932 (a Greek letter to Zenon written 24 April 258 BCE).[49] As the unknown sender of this letter – in which our NN (NoName) person (IL_3) asks Zenon to ensure that he receives financial help – this person is directly linked to the best integrated and most central node (by all applied measures): Zenon. Since the eigenvector measure takes the perceived importance of a node's direct neighbors into account, and two relationships involving IL_3 were recorded (representing the aforementioned communication and request, Tab. 7), this node

45 In compiling the lists of the highest-ranked actors, nodes that are not present in both versions of a network were deliberately ignored. As a secondary sorting criterion, named persons are organized alphabetically by their personal name, whereas texts are sorted by their unique text identification numbers.

46 For the data, see https://doi.org/10.5281/zenodo.14190908.

47 In Network 2b, the 3rd highest ranking node by degree and 2nd highest by in-degree centrality is 'the cook', mentioned fifty times in a single text (TM_2377), and the group with the 8th highest in-degree rank represents the 'slaves', mentioned nine times in the same text. Another 'the cook' node, with the 11th highest in-degree rank, is only tied to TM_668. On parallel edges, see also n. 35 above.

48 See n. 45.

49 Transcribed and translated in Durand, *Des Grecs en Palestine,* 165–66.

Robustness test	Degree	In-degree	Out-degree
Are the ten most central nodes identical?	Yes* (100%)	Yes** (100%)	No*** (80%)

* One of the highest-ranking nodes in Network 2b is an unnamed person ('the cook'). Since he is ignored in the count and the 11th highest-ranking node equals the 10th highest-ranking node of Network 2a, the lists are considered identical. Also, the relative importance of TM_665/P.Cair.Zen. I 59003 and TM_668/P.Cair.Zen. I 59006 changes, with the former ranked higher in Network 2a and the latter in Network 2b.
** Two of the highest-ranking nodes in Network 2b are unnamed persons. Since they are ignored in the count, the 11th highest-ranking node is a group (i.e. also ignored) and the 12th and 13th equal the 9th and 10th highest-ranking nodes of Network 2a, the lists are thus considered identical.
*** Eight texts are identical across the lists. One text included in the list of Network 2b has the same out-degree score as the 9th and 10th highest-ranking texts in Network 2a, but a higher text id. The final text highlighted in Network 2b has the 16th highest rank in Network 2a. The 9th and 10th most central nodes of Network 2a are the 13th and 14th highest ranking in Network 2b.

Tab. 5 Robustness tests of the 2-mode networks, comparing the highest-ranking nodes of Network 2a (restricted) against those of Network 2b (extended dataset).

Robustness test	Degree	Eigenvector	Betweenness
Are the ten most central nodes identical?	No* (90%)	Yes** (100%)	No*** (90%)

* One person (Jaddu; TM_Per_2070) is only highlighted in Network 1b. He is found in 17th place in Network 1a, but only has a marginally lower degree score (6) than the person in 10th place (7). The only person included in the list of Network 1a has the same degree centrality as the 7th–10th highest ranking nodes in Network 1b, but is listed in 11th place when both sorting criteria are used.
** The same ten persons are highlighted and listed in the exact same order in both networks.
*** Except for the nodes ranked 7th and 8th highest swapping places, the nodes listed 1st to 9th are identical across the two models. The 10th highest ranking nodes in Network 1a is listed in 13th place in Network 1b, whereas the 10th highest ranking node in Network 1b is the 18th highest ranking node in Network 1a.

Tab. 6 Robustness tests of the 1-mode data, comparing the highest-ranking nodes of Network 1a (restricted) against those of Network 1b (extended dataset).

is perceived as slightly more central than the other nodes connected (only) to Zenon. By other measures, IL_3 is, however, poorly connected; since this node is not directly linked to other nodes, it must go through Zenon to reach any other person or group in the core.[50] Consequently, IL_3 for example (like many others) has a betweenness centrality score of 0.0.

Scaling up from the highest-ranking nodes to considering the full list of recorded entities,[51] we find that the measures discussed remain relatively stable on the level of the whole networks. In the bipartite network data, where all dyadic pairs consist of one text and one social (person or group) node, only the centrality scores of the text nodes are affected by the changes. Moreover, the observed variations are small: of the 36 texts, the degree and out-degree centrality scores of 27 remain the same regardless of the data collection strategy, whereas five see an increase of < 5, three see an increase of 5–50, and only one text's centrality score rises by > 50 once the new nodes and edges are added.

All nodes can in principle be linked to any other node in the monopartite network data, so we might expect that the researcher's decision to include or exclude unnamed persons and groups would yield greater deviation in terms of the nodes' centrality scores in this network. Again, comparing the centrality scores assigned to all nodes across the two versions of the dataset does, however, reveal that the centrality metrics used (degree, eigenvector and betweenness) are also relatively stable when looking at the mid- and low-ranked nodes in the interpersonal network. Of the eighty nodes that are modelled in both versions of the network, 73 receive an identical degree centrality score, whereas the remaining seven see only a slight increase (< 5). Fewer nodes have identical eigenvector and betweenness scores. Of the eighty nodes, 28 have an identical eigenvector centrality whereas the score of the remaining 52 vary with < 0.05. Finally, 55 of the eighty nodes have identical betweenness centrality scores, whereas seven see a slight difference (< 5.0), 14 a moderate difference (5.0–50.0), and four experience a noticeable betweenness centrality boost (> 50.0). Among the metrics discussed, betweenness centrality is thus the least robust, also on a global scale.

Since we have already seen how all the measures discussed are relatively stable when only the highest-ranking nodes are considered, it should be clarified that the four nodes whose betweenness centrality rise with > 50.0 include Zenon (the archive owner) and Apollonios (the *dioiketes,* i.e. Zenon's superior) – who are already identified as the first and second most central nodes by betweenness centrality in Network 1a. Reading the observed increase in their betweenness scores in Network 1b within the larger context offered by the network model, the project database, as well as relevant text editions, we find that their betweenness cen-

50 For Zenon's role as a broker or middleman, see Tambs and Lindén, 'Co-Attestations'.
51 See the accompanying Excel file (https://doi.org/10.5281/zenodo.14190908).

trality scores increase further when more (poorly connected) nodes are added to the network. This happens because their already dominant network positions, combined with the peripheral role of many of the other nodes, places them on the shortest path linking even more pairs of nodes in the extended interpersonal network.

In contrast, the betweenness increase of the other two – Toubias and Apollodotos – demonstrates how new nodes and edges can directly affect their local neighborhoods and network positions. Both have betweenness centrality scores of 0.0 in the restricted network (Network 1a) and 59.0 in the extended dataset (Network 1b). Checking the recorded data, we find that the metric recognizes these men as more important in the latter since here each is linked to an otherwise unconnected group node (representing 'grooms of Toubias' and 'employees of Apollodotos' respectively).[52]

Structural Insignificance but Historical Value?

Here we might ask ourselves whether such added information and nuance is in fact useful and worth including. If most unnamed and collective actors are poorly connected, does their presence in the graphs indeed bring us closer to the relational landscape we are trying to capture and model? More specifically, for this case: is it historically meaningful that Toubias and Apollodotos receive higher betweenness scores because we can tie them to these groups? The short answer is yes: in both cases the given group is connected to its superior by a hierarchical edge, signaling the superiority of the latter. The group nodes' presence serves to stress this superiority, as well as the power and responsibilities this entailed. The slightly longer answer is yes and no: the recorded edges serve to represent known historical events and relationships, but the fact that their impact on the model is most noticeable in the case of betweenness centrality may tell us more about the nature and structure of the recorded data than the lived realities of the actors involved. To better understand what is going on here, we shall briefly return to the data 'behind' the extended graph and see what the ancient texts reveal about the relevant relationships.[53]

Like the young assistant – known from the text example above (TM_678) and represented by the purple node positioned in the upper left corner of the core component in Fig. 11 – the groups discussed are connected to the core component but positioned in its periphery. This is because both are exclusively tied to their respective superiors. In Fig. 11, the 'employees of Apollodotos' are represented by the blue node in the upper part of the core component, and the 'grooms of Toubias' by the blue node in the lower part.

52 These are also the only groups found in the model's core component.
53 Highlighted texts are also discussed in Tambs, 'People and Things'.

From TM_666/P.Cair.Zen. I 59004 – an account of flour and places visited during a longer journey – we find the 'employees of Apollodotos' (οἱ παρ' Ἀπολλοδότου) amongst those receiving flour.[54] X. Durand notes that they were probably not permanent members of the travelling group,[55] but the account does not provide further information about them or their superior. That the dyad is tied to the core component of Network 1b is instead thanks to the survival of another early papyrus: a letter concerning grain exports (TM_2021/PSI IV 324) sent from Apollonios the *dioiketes* to Apollodotos, a royal finance officer working outside of Egypt's borders.[56] In this small sample, the nodes representing him and his employees remain weakly connected, but the Trismegistos record of the man referred to by the unique identifier TM_Per_887 suggests that this 'Apollodotos' is attested 15 times across seven papyri within the Zenon archive.[57]

Similarly, we meet the 'grooms of Toubias' (ἱπποκόμοις Τουβίου) in an account of wine distributions from 22 February to 4 May 259 BCE (TM_2377/P.Lond. VII 1930).[58] Aside from documenting that they received one *chous* of wine, this text provides little information about them or their superior. Again, the latter is, however, well known to us: according to the Trismegistos record of the local chieftain Toubias (TM_Per_3794), he is attested 18 times across seven texts.[59] Of these, only one – a contract concerning the sale of a young slave girl (TM_665) – is included in the test case presented here but, as before, all belong to the Zenon archive.

As the model is enlarged with information learned from other Zenon papyri, the network positions of Apollodotos and Toubias are thus likely to become more prominent and representative of their relatively high status and trusted positions. As far as my models strive to represent historical persons (as opposed to functions, for example), it is unlikely that a group comprised of the exact same 'employees of Apollodotos' or 'grooms of Toubias' would be found across multiple

54 Edgar, 'Selected Papyri (Nos. 67–72)', 225–30; Edgar, *Zenon Papyri (Nos 59001–59139),* 1:7–10; Tcherikover and Fuks, *Corpus Papyrorum Judaicarum,* 1:121–22; Durand, *Des Grecs en Palestine,* 55–72.

55 Durand, *Des Grecs en Palestine,* 71.

56 Società italiana, *Papiri Greci e Latini (Ni. 280–445),* 4:64–65; Durand, *Des Grecs en Palestine,* 199; Bagnall and Derow, *Hellenistic Period,* 115.

57 In addition to TM_666 and TM_2021, they are TM_696/P.Cair.Zen. I 59036, TM_697/P.Cair.Zen. I 59037, TM_714/P.Cair.Zen. I 59056 + P.Cair.Zen. III p. 289 (59056), TM_716/P.Cair.Zen. I 59058, and TM_1584/P.Lond. VII 2022. Except for the account (TM_666), all are letters.

58 Skeat, *The Zenon Archive,* 7:4–11; Scholl, *Corpus der ptolemäischen Sklaventexte (Nr. 115–260),* 2:538–553; Durand, *Des Grecs en Palestine,* 73–89.

59 In addition to TM_2377, they are TM_665, TM_667/P.Cair.Zen. I 59005, TM_730/P.Cair.Zen. I 59075, TM_731/P.Cair.Zen. I 59076, TM_1427/P.Cair.Zen. V 59802 and TM_1712/P.Lond. VII 2152. One is a contract (TM_665), two are letters (TM_730, TM_731) and the rest are accounts.

ancient texts. Their network positions are therefore expected to remain insignificant, even if the network data is expanded and the relative importance of their superiors increases. As such, the greatest relevance of incorporating such actors is perhaps their potential to shed light on the nodes they relate to.

Such micro-scale explorations are indicative of the nuances lost in the network approach and help us to assess the model's potential for picking up specific interpersonal interactions, relations and interdependencies that might be important for the interpretative part of the research. Despite being structurally insignificant, I argue that unnamed and collective actors do have qualitative value. They take longer to record, but remind the researcher of the existence of the groups and people they represent. Importantly, the robustness tests performed further suggest that – even in this small sample – their presence does not 'disturb' the commonly applied centrality metrics' ability to identify the most central characters in the dataset.[60]

As a final exercise, we shall scale back up to the whole networks, namely the monopartite and bipartite networks extracted from the sample, in order to explore how unnamed persons and groups add value to such interpersonal and affiliation networks from a more qualitative perspective.

The Qualitative Relevance of Unnamed Actors and Groups in Network 1b

We will first concentrate on the richly attributed monopartite network (Network 1b) and the twenty *new* nodes within it (i.e. the unnamed and collective nodes added because they have at least one relational tie to at least one other node when such actors are also modelled). Of these, eleven nodes represent groups (G), five are people whose identity is lost (IL), and four are unnamed individuals (Unn_Per).

In order to assess and discuss the qualitative potential of adding unnamed and collective nodes when modelling social networks from ancient texts, it is useful to first list the twenty new nodes and their relations. In Tab. 7, the actors added are sorted by their unique IDs (thus grouped by category), whereas the edges are listed alphabetically within the main categories of 'economic' and 'social' ties.[61] Numbers in parentheses reveal how many such edges are recorded,

60 As the dataset grows, their effect in this regard can be expected to decrease further.

61 In addition to recording various types of relationships, I mark recorded edges as either 'social' or 'economic' as a means of filtering these multilayered networks by bundles of relations conceived of as being *more* social or *more* economic in nature. For a list of edge kinds tagged with each category under the author's Pathyris project, see Tambs, *Socio-Economic Relations,* 2022, 2:315, 317–18. This list formed the basis for, but is gradually being revised and extended under, the ongoing Zenon project.

and how many unique nodes they link them to.[62] Tab. 7 thus gives an impression of the relations and types of actors that are attested but ignored in the stricter data collection process.

The table clearly shows how most new nodes (14/20) activate a single edge and that nearly all (18/20) are exclusively recorded in either social *or* economic relationships. The sample data is not large enough to be statistically significant, but it does signal that groups are rarely recorded in more than one edge and that they are most frequently recorded in social relationships. In contrast, persons whose identity is lost (in lacunae, etc.) mostly engage in economic activities. Of the eleven groups, eight are exclusively active in hierarchical relations linking them to their named superior. The last three are 'tenants' quarreling with 'the *komomisthotes*' and Melas (as discussed below), 'workers' of the city receiving wine (mentioned in the same letter, TM_2174/PSI VI 554), and 'slaves (?)' possibly imported to Egypt ('uncertain' edge, informed by TM_672/P.Cair.Zen. I 59011). In contrast, only one of five people whose identity is lost is tied by a hierarchical edge. All (5/5) do, however, engage in activities classified as economic: all activate edges representing acts of communication, and three are also involved in requests or services (acting as a representative, etc.).

For the unnamed persons – of which only four are recorded in interpersonal relations – it is more difficult to spot clear relational patterns. Two are women who, when receiving fish in an account (TM_668), are identified as the unnamed wife of a named husband; the other two are men documented because of their activities. One is 'the young assistant' from the text example above (TM_678), who was sent with Straton on behalf of Alexander, since the latter claimed to be ill. From the rather detailed report of the events, several relations that reflect the collaborative attempt at retrieving the loan, but also the related abuse, were recorded. The other is 'the *komomisthotes*', who the 'tenants' mentioned above complained about.[63] The relevant letter (TM_2174),[64] believed to report matters of Apollonios' estate in Baitanata,[65] will serve as an example of the qualitative relevance of also considering the interrelations and activities of the unnamed and collective actors revealed by such sources.

62 The latter numbers reveal that none of the added actors are engaged in parallel edges. G_1 is involved in two 'quarrel' ties and IL_1 in two 'service' ties, but in both instances these edges link them to two different nodes.

63 For a discussion on the *komomisthotes* and his duties, see Kloppenborg, *Tenants in the Vineyard,* 361 (l.13), 363.

64 Società italiana, *Papiri Greci e Latini (Ni. 551–730),* 6:6–9; Durand, *Des Grecs en Palestine,* 151–56; Kloppenborg, *Tenants in the Vineyard,* 359–64.

65 TM_Geo_391. For the estate, see e.g. Kloppenborg, *Tenants in the Vineyard,* 362–63.

Node id*	Label	Edges	Degree
G_1	tenants	Economic: Quarrel (2, 2) Social: –	2
G_2	workers	Economic: Supply (1, 1) Social: –	1
G_4	slaves (?)	Economic: – Social: Hierarchical (1, 1)	1
G_6	agents (?) of Helenos	Economic: – Social: Hierarchical (1, 1)	1
G_8	grooms of Toubias	Economic: – Social: Hierarchical (1, 1)	1
G_11	scribes of Kidramyas	Economic: – Social: Hierarchical (1, 1)	1
G_16	slaves (?)	Economic: Delivery (1, 1) Social: –	1
G_18	employees of Rabbelos	Economic: – Social: Hierarchical (1, 1)	1
G_19	employees of Apollodotos	Economic: – Social: Hierarchical (1, 1)	1
G_20	employees of Melesippos	Economic: – Social: Hierarchical (1, 1)	1
G_21	employees of Zabinas (?)	Economic: – Social: Hierarchical (1, 1)	1
IL_1	NN	Economic: Communication (1, 1); Request (1, 1); Service (2, 2) Social: Hierarchical (1, 1)	5
IL_2	NN	Economic: Communication (1, 1); Service (1, 1) Social: –	2
IL_3	NN	Economic: Communication (1, 1); Request (1, 1) Social: –	2
IL_4	NN	Economic: Communication (1, 1) Social: –	1
IL_5	NN	Economic: Communication (1, 1) Social: –	1
Unn_Per_1	the *komomisthotes*	Economic: Quarrel (1, 1); Service (1, 1) Social: –	2
Unn_Per_5	the wife of Antiochos	Economic: – Social: Close kin (1, 1)	1
Unn_Per_6	the wife of Philokles	Economic: – Social: Close kin (1, 1)	1
Unn_Per_7	the young assistant	Economic: Collaboration (1, 1); Mistreat (1, 1); Refusal (1, 1); Request (1, 1); Service (1, 1) Social: Hierarchical (1, 1)	6

* Codes are 'G' for group, 'IL' for actors whose identity is lost, and 'Unn_Per' for unnamed persons.

Tab. 7 The nodes added to Network 1b (cf. Network 1a) and their relationships.

The papyrus in question is fragmented, and the names of the sender and recipient are lost.[66] In fact, only the name of one man – Melas, who likely managed Apollonios' foreign estate – is preserved. Consequently, no relational data revealed by this text is recorded in the interpersonal network model that follows the stricter data collection process (Network 1a, Fig. 10). The text does, however, reveal several details about the social dynamics and tensions reported upon. For example, we learn from the section detailing the tenants' complaint about the grape harvest that (as translated by J. S. Kloppenborg):[67]

> Melas acknowledged to have taken them, because the place suffered from a lack of water and they ruined the grape pressing. He needed (wine) for the workers he had in the city and most of (the tenants) owned their own vineyards from which they could get pressings. To those who did not own vineyards he promised that he would provide sufficient (pressing).

Such passages offer lively impressions of the socio-economic relations, choices, and conditions the ancient subjects lived under, but are often left out or glossed over in more quantitatively or structurally focused network approaches. One reason is that formal network analysis necessarily abstracts and simplifies the complexities of life to a point where relational phenomena can be represented and analyzed as dots and lines. Were the aim, for example, to study past networks bound by interpersonal relationships, we might opt to focus on human actors and only record information relating to places (cities, fields, buildings) or things (harvested grapes, water, vineyards) as node and edge *attributes*. We might also consider such details 'beyond the scope of this study'. Another reason is that disambiguating nodes and mapping often complex relational patterns (which are not readily available or easily retrieved through semi-automated methods of data collection) can be an extremely time-consuming processes. There are limits to how much empirical network data one person can retrieve and manually record in a day or even a year, thus depending on the project's resources (the size of the team, the amount of time at their disposal, etc.), it might not be feasible to record detailed, quality data for the full corpus.

In this respect, it is promising that the tests presented indicate that the global characteristics of the networks are already picked up in the stricter network models, which only include named individuals. If the activities involving unnamed persons and groups cannot be recorded for the entire archive or other text group, this suggests that the network researcher can, for example, use such restricted models as 'treasure maps' to help identify subsets of the network or

66 For a discussion of their possible identities, see Durand, *Des Grecs en Palestine,* 153; Kloppenborg, *Tenants in the Vineyard,* 362.

67 Kloppenborg, *Tenants in the Vineyard,* 360.

studied text group, from which more detailed and complex network data can be extracted and analyzed to answer specific questions.

Returning to the test case, a new connected component is manifested in the extended whole network (Network 1b) once we loosen the criteria for inclusion. It is the second largest component, situated to the far right of the node-link diagram shown in Fig. 11. A glance at the text ID edge attribute reveals that this new connected component is solely informed by TM_2174 (used as an example above). If we isolate this subset of the network and color the recorded relations by edge kind, we get a better impression of the range of relational and social dynamics reflected within this one letter (Fig. 12).

One potential benefit of multilayered and richly attributed networks is that they may enable the researcher to consider impersonal (groups of) actors in context. The working hypothesis is that accumulating dyads of interpersonal re-

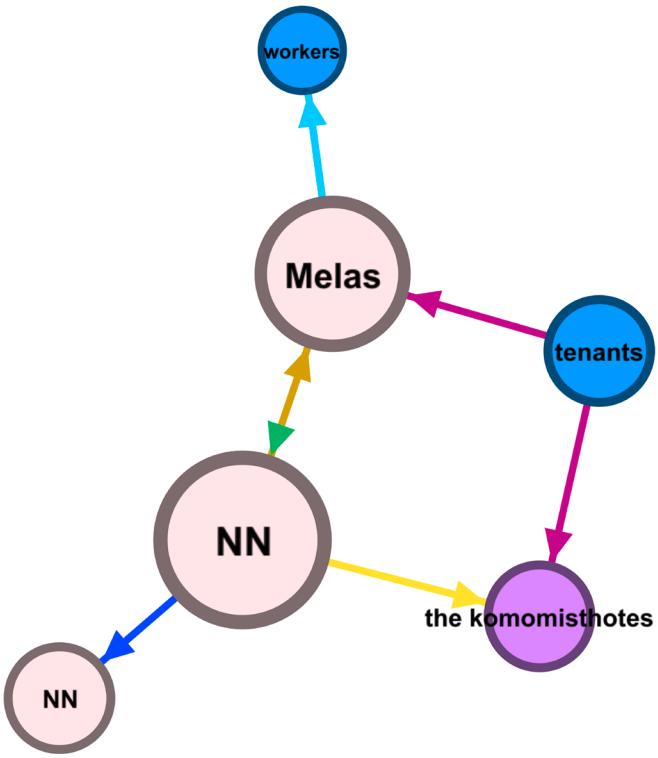

Fig. 12 Extended 1-mode network on TM_2174, including unnamed persons and groups. Node color: pink = person; blue = group; purple = unnamed person (if B/W print: dark = collective and unnamed nodes; light = named or presumably named persons). Node size: degree centrality. Edge color: yellow = service; dark pink = quarrel; light blue = supply; brown = hierarchical; green = request; dark blue = communication (Graph by author, created in Gephi).

lations recorded from a group of texts that share many named individuals will also enable us to view impersonal individuals and collective groups as important pieces of a bigger picture. Here, loosening the data collection criteria led to a number of nodes and edges being added. As the dataset grows beyond this sample, such models can perhaps shed new light on the conditions of workers or tenants, but also how their ties to other people and things affected their lives.

Since no node attested in TM_2174 reappears in the other 35 texts under study, the group remains disconnected from the core component of Network 1b (Fig. 11). However, the person of interest does reappear in other Zenon papyri: according to Trismegistos, this Melas (TM_Per_2418) is attested five times across three texts.[68] The fact that both additional texts mention Apollonios as well as other well-attested persons means that the now isolated component will be integrated into the network's core component as more texts are incorporated into the model.

If, in a much larger network reflecting the Zenon archive, Melas (and through him also the 'workers', 'tenants' and others referred to in TM_2174) can be meaningfully linked to others, the complaints of these workers might for example be compared against the recorded struggles of workers employed at Apollonios' other estates. Apollonios owned several estates, and some of their managers are known to us.[69] On 14 April 257 BCE, for example, Zenon received several letters from the manager of Apollonios' Memphite estate, Nikon, while travelling in Mendes. One, TM_1868/P.Zen.Pestm. 37 concerns payments made to a group of gardeners who threatened to abandon their work.

As isolated cases, it might be difficult to see how problems reported in these texts can increase our understanding of larger historical processes and socio-economic dynamics. That they are recorded does, however, show that they were important to the ancient subjects, who felt that collectively complaining about matters was both necessary and potentially worthwhile. The section cited above concerns specific relationships and events, but also suggests why the reported actions were taken. In justifying why Melas confiscated (all or most of) the harvest, he explains that only those tenants who owned their own vineyard were not pro-

68 In addition to TM_2174, they are TM_1511/P.Lond. VII 1948 and TM_2204/PSI VI 594. All are letters and are part of the Zenon archive. The three letters mentioning this Melas are dated 23 January 258 BCE, 10 May 257 BCE and c. May 257 BCE, respectively. Moreover, all indicate that Melas was in or near Baitanata at the time, Ibid., 361 (l.12).

69 On Apollonios' estates, see e.g. Edgar, *Zenon Papyri (Michigan),* 8 ff, 31 ff. Kloppenborg notes that Melas' duties appear to have extended beyond the estate itself (*Tenants in the Vineyard,* 362). The same is surely true of other known estate managers, including Nikon and Zenon: in the period 256–248/7 BCE, Zenon's main duty was to manage Apollonios' estate in Philadelphia, but the documentation reveals how he was simultaneously involved in a range of other private and official business, as recently summarized in Tambs, 'Social and Economic Life', 371.

vided sufficient pressing. Such statements shed light on the conditions of people identifying with the groups mentioned, but also on the formal and informal systems, Melas' personal traits, the nature of his relationship to his superiors, etc.

Studying such nuances with historical networks should involve analyzing the networks alongside other approaches, such as close readings and literature reviews. Even though the networks we model cannot hold or display all relevant and available information, network science can help us move beyond small numbers of texts towards big(ger) data studies. If we have large text corpora with solid prosopographical baselines at our disposal, and we can get *more* empirical data into our models by also modelling the relationships involving unnamed individuals and groups; the relevance of adding such actors might be significant to the point where the potential gain outweighs the costs. Whether it does, however, will always depend on the case at hand.

The Qualitative Relevance of Unnamed Actors and Groups in Network 2b

Finally, we will briefly return to the extended bipartite network data (Network 2b). The lists offered by Trismegistos occasionally include NN persons (whose name is lost in lacunae, for example), but they generally do not list unnamed persons or groups. Adding such actors to the bipartite dataset is quicker, since less research is required to tag and link them to the given text than to evaluate how they can be meaningfully linked to other human actors (as in Network 1b). Still, opting to include them necessarily prolongs the data collection and preparation processes.[70] So, do they also have qualitative potential for these types of networks?

As before, it will be useful to list the *new* nodes, i.e. those modelled in Network 2b but missing from Network 2a. A total of 34 new nodes appear, of which 21 represent groups (G), five are people whose identity is lost (IL), and eight are unnamed individuals (Unn_Per). In Tab. 8, the actors added are again grouped by category.

Listing the new actors in this way serves to highlight two things. The first is that some added nodes have a relatively high degree centrality score, but no unnamed person or group is linked to more than one text in this dataset. Given the large number of Zenon papyri and the limited period they cover, it is likely that some impersonal and collective nodes will represent the same actor(s). Even if

70 For the bipartite networks, this is especially true for questions where the TM data is otherwise deemed sufficiently reflective of the scholarship, since adding them would require manual entry for each included text that would otherwise have been superfluous. A study for which TM attestation data is used *as is* will be published in Tambs and Lindén, 'Co-Attestations'.

Node id*	Label	Degree	# of texts
G_1	tenants	1	1
G_2	workers	1	1
G_3	slaves	1	1
G_4	slaves (?)	1	1
G_5	slaves	9	1
G_6	agents (?) of Helenos	1	1
G_7	grooms	2	1
G_8	grooms of Toubias	1	1
G_9	bakers	2	1
G_10	secretaries	1	1
G_11	scribes of Kidramyas	1	1
G_12	scribes	1	1
G_13	muleteers	1	1
G_14	carters	1	1
G_15	cooks	1	1
G_16	slaves (?)	1	1
G_17	quarrymen	1	1
G_18	employees of Rabbelos	2	1
G_19	employees of Apollodotos	1	1
G_20	employees of Melesippos	1	1
G_21	employees of Zabinas (?)	1	1
IL_1	NN	1	1
IL_2	NN	1	1
IL_3	NN	1	1
IL_4	NN	1	1
IL_5	NN	1	1
Unn_Per_1	the *komomisthotes*	1	1
Unn_Per_2	the cook	50	1
Unn_Per_3	the baker	1	1
Unn_Per_4	the cook	6	1
Unn_Per_5	the wife of Antiochos	1	1
Unn_Per_6	the wife of Philokles	1	1
Unn_Per_7	the young assistant	1	1
Unn_Per_8	the baker	1	1

* Codes are 'G' for group, 'IL' for actors whose identity is lost, and 'Unn_Per' for unnamed persons.

Tab. 8 The nodes added to Network 2b (cf. Network 2a).

every effort were made to also identify such actors across texts, it is, however, unlikely that instances of secure cross-identifications would amount to impersonal or collective nodes that are engaged to a degree that they become structurally significant in these models. Still, the networks might themselves prove useful to subsequently identify nodes that are likely to represent the same persons or groups (as proposed below).

The other observation concerns the types of actors listed. Some are not named because they are identified through another person (wife of x, employees of x) while others are identified through the title or role they fill in the travelling group, event, region, etc. These include individuals (the cook, the baker, the young assistant, the *komomisthotes*) but also groups of people (workers, slaves, secretaries, scribes [of x], quarrymen, grooms, cooks, bakers, carters). Some of the added nodes represent actors that do not often have a voice in ancient texts or studies thereof; others are not specified exactly because they are functionally important or well known in context. In either case, acknowledging their presence in accounts kept by travelling groups can, for example, be relevant for studying the composition of such mobile networks and the practicalities of their trips.[71]

Concluding Remarks and Reflections

This article presents a methodological test case. The main question posed is: how do the unnamed persons and groups mentioned in a small sample of 36 Zenon papyri affect my network models? To explore their impact and potential value, I modelled bipartite networks linking human actors to the texts in which they are mentioned, as well as monopartite networks connecting pairs of human actors that the texts studied reveal shared social or economic relationships (Fig. 3). In each case, I modelled two versions of the network data: one with and one without the nodes representing unnamed persons and groups (Figs. 8–11).

Analyses and comparisons of the two versions of the bipartite (Networks 2a and 2b) and monopartite models (Networks 1a and 1b) showed that the added nodes do not significantly change the characteristics of the whole networks. In the more inclusive interpersonal network (Network 1b), very few new nodes are incorporated into the model's core component (Fig. 11). In the affiliation network (Network 2b), more unnamed and collective actors are represented, and several of these are part of the core component (Fig. 9). Still, adhering to the project's data collection conventions, they remain peripheral and poorly connected.

Similarly, the observed stability level of the centrality measures tested suggests that the presence or absence of unnamed persons and groups has only a

71 As a case in point, the discussed account of flour drawn up during the longer trip (TM_666) includes several employees (of x) but also 'the baker'.

minor effect on commonly applied measures of centrality. The greatest deviations are seen in the bipartite network data, where the presence of parallel edges complicates our interpretation of the results.

It should be stressed that the sample size of the current test case is too small to arrive at statistically significant results. As M. Peeples and colleagues have pointed out,[72] "there are few 'rules' in terms of what measures are appropriate or how much missing data is allowable to accurately characterize a given network." Still, studies using sampling techniques to check the robustness of centrality measures have identified certain overarching patterns, one of which is how reducing the sample size tends to result in increased variability.

In this respect, it is interesting to note that C. W. Jones' recent explorations of the impact that unnamed, unknown and collective actors have on larger Neo-Assyrian correspondence networks led to similar results.[73] Like Jones, I prefer to mitigate the risk of creating unrealistically active nodes by representing actors not known to be identical as separate nodes (as opposed to, for example, using a single node ID for all 'unknown' persons or all 'the cooks').[74] For a future study, it would also be interesting to try merging all representations of 'the cook' across the texts studied into a single node. Such interactive and dynamic network explorations, grounded in empirical data, may help shed light on various professional groups.

This article analyses a small dataset, but argues that through systematically recording unnamed and collective actors from a much larger group of related texts (with an archival or some other type of connection) we can use network approaches to study the conditions and functions of often poorly understood groups, titles, etc. An added value of network analysis is the possibility of doing so on a very large scale – including thousands of texts in a single model. Another is its ability to illuminate the patterns present in the data but difficult to discern without computational aid.

For example, the network perspective might prove useful as a means to suggest tentative identifications of unnamed persons and groups – similar to how Y. Broux showed that an onomastic network approach can be used to determine

72 Peeples et al., 'SNA in Archaeology', 75.

73 In his Neo-Assyrian networks, Jones found unnamed actors ('brother of x', 'envoys from x', etc.) to be pendant nodes that, with the exception of betweenness centrality, did not affect the network analytical results much (personal communication). After testing different approaches to modelling or excluding persons with no (preserved) name, Jones favored the method of grouping unknown senders/recipients into different nodes, depending on who they correspond with, as explained in 'Assyrian Court Scholar', 308–10.

74 See n. 43. For an example of a large dataset with nodes representing homonyms as well as individuals, e.g. Pagé-Perron, 'Network Analysis for Reproducible Research'.

the linguistic value of names whose meaning is unclear.[75] If unnamed or collective nodes identified by title, function, profession, a relationship, etc. repeatedly appear in the same structural position as (an)other node(s) with similar qualities in the network, it may be worth returning to the relevant texts with more traditional methods for checking whether these nodes are likely to represent the same actor(s), serve the same function in society, etc. Even when efforts are not made to identify impersonal and collective nodes across texts as data is collected, the resulting models may later be used in such attempts. Community detection tools might, for example, aid in such quests, but such explorations are beyond the scope of this article.

With this study, I hope to have illustrated the potential of modelling social networks from ancient texts, while also warning that incorporating unnamed persons and groups in the manner proposed here takes time. If the test cases indicate that they provide little nuance to the formal network analysis and do not have the power to change the big picture, then the gain of adding them will often not outweigh the cost from a quantitative perspective. Still, looking more closely at select parts of the networks and data 'behind' the graphics does show how incorporating such actors into the network data increases the models' qualitative value.

Whether the gains are likely to outweigh the costs must be evaluated anew for every application of network scientific methods. Ideally, relevant tests should thus be carried out in the early stages of the network research, but in practice, this is not always feasible. Although these results are case specific, it is therefore hoped that the more general findings can help others make informed decisions as they design their historical networks, but also that the article will inspire others to conduct and publish similar tests.

In sum, the explorations presented here suggest that the more exclusive approach (only modelling named individuals), which is often significantly quicker to implement, is already sufficiently good at catching both the structural characteristics of the mono- and bipartite networks, and at identifying and detecting the relative importance of the main players (by the aforementioned centrality measures) to be meaningfully employed in historical network research. However, they also suggest that a more inclusive approach (also modelling unnamed persons, groups, and their relations) will often be the most productive for more qualitative network research and questions.

It should be stressed that even for my extended networks, the conventions for inclusion are rather strict. Only actors and relationships that are explicitly mentioned in the document are still recorded and represented in the node-link

75 Broux, 'Graeco-Egyptian Naming Practices', 719.

diagrams visualized in Figs. 6, 9, 11 and 12. While the more inclusive models (Networks 1b and 2b) do come *closer* to reflecting real-world networks, they would admittedly be more detailed if we were willing to loosen the requirements for inclusion even further. For example, also recording the implied close kin relations, reconstructed based on the genealogical data that *is* explicitly stated, would result in richer network data.[76] Such attempts do, however, come at a significant cost – particularly with regards to data validity and trustworthiness. For a future study, it would nevertheless be interesting to also test how such implied actors and relationships would affect the structural characteristics of my networks.

Since the sender of a letter is, for example, likely to consider the recipients' level of prior knowledge, things that would be obvious to the intended audience are often left out. But such issues are not restricted to letters; an account of goods (TM_674/P.Cair.Zen. I 59013) imported into Egypt in 259 BCE, for example, suggests that the *dioiketes,* Apollonios, had previously supplied the relevant travelling party with equipment that was now being returned by the ship's captain.[77] As always, the question of where to draw the lines of the network boundaries lies with the researcher; when designing the network characteristics, one must thus carefully consider the case study and questions to be asked of the model, and be explicit about the choices made.

Finally, the tests performed suggest that the lessons learned from including unnamed and collective actors will become more valuable when more texts are incorporated into the networks – if not because they are themselves well-connected, then because their neighbors might be. In particular, the study suggests that allowing unnamed persons and groups to be recorded as actors will increase the models' 'treasure map' potential. They do not hold the power to dramatically change the big picture (the whole network), but by including them and studying the resulting network alongside relevant databases, text editions, etc., the models can be more fruitfully explored and used to study the distant past. This enables us to capture slightly more of the complexity of life and, in doing so, can shed welcome light, including on poorly understood segments of society. The extended networks thus take longer to model, but also hold greater potential for guiding us towards interesting questions or cases that are worthy of closer inspection or further study.

76 For an example of added interpreted edges, see Chollier, 'Court Society to Power Networks', 138–40, fig. 2.

77 Durand, *Des Grecs en Palestine,* 124.

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Appendix A: List of texts included in the case study

The table below lists the 36 early documents that make up the sample of the case study, with hyperlinks guiding the reader to the relevant Trismegistos record. Sigla refer to papyrological editions and collections, abbreviated as in the standard Checklist of Editions of Greek, Latin Demotic and Coptic Papyri, Ostraca, and Tablets.

Text ID	Sigla	Doc. type	Date	Collection(s)*
TM_665	P.Cair.Zen. I 59003	Contract	26 Apr–24 May 259 BCE	TM_Coll_73
TM_666	P.Cair.Zen. I 59004	Account	259 BCE (?)	TM_Coll_73
TM_667	P.Cair.Zen. I 59005	Account	259 BCE (?)	TM_Coll_73
TM_668	P.Cair.Zen. I 59006	Account	259 BCE (?)	TM_Coll_73
TM_669	P.Cair.Zen. I 59008	Account	c. 259 BCE	TM_Coll_73
TM_670	P.Cair.Zen. I 59009 + PSI VI 628 + P.Cair.Zen. IV p. 285 (59009)	Account	c. 259 BCE	TM_Coll_73 + TM_Coll_128
TM_672	P.Cair.Zen. I 59011	Letter	c. 259 BCE	TM_Coll_73
TM_673	P.Cair.Zen. I 59012	Account	25 May–22 Jun 259 BCE	TM_Coll_73 + TM_Coll_128
TM_674	P.Cair.Zen. I 59013	Account	259 BCE	TM_Coll_73
TM_675	SB XXVI 16505	Account	259 BCE	TM_Coll_73 + TM_Coll_128
TM_676	P.Cair.Zen. I 59015 Ro + P.Cair.Zen. III p. 289 (59015)	Account	27 Oct 259 BCE–26 Oct 258 BCE	TM_Coll_73 + TM_Coll_245
TM_677	P.Cair.Zen. I 59016	Letter	30 Dec 259 BCE	TM_Coll_73
TM_678	P.Cair.Zen. I 59018	Letter	04 Apr 258 BCE	TM_Coll_73
TM_1172	P.Cair.Zen. IV 59536	List	Summer, 261 BCE	TM_Coll_73
TM_1299	P.Cair.Zen. IV 59671	Account	10 Apr–9 May 263 BCE	TM_Coll_73
TM_1301	P.Cair.Zen. IV 59673	Account	260–258 BCE	TM_Coll_73
TM_1325	P.Cair.Zen. IV 59698	Account	260–258 BCE	TM_Coll_73
TM_1426	P.Cair.Zen. V 59801	Letter	Oct–Nov 261 BCE (?)	TM_Coll_73

Text ID	Sigla	Doc. type	Date	Collection(s)*
TM_1427	P.Cair.Zen. V 59802	Account	259 BCE (?)	TM_Coll_73
TM_1701	P.Lond. VII 2141	Account	Mar–Apr 258 BCE	TM_Coll_73 + TM_Coll_192
TM_1708	P.Lond. VII 2148	Account	258–260 BCE (?)	TM_Coll_192
TM_1863	P.Zen.Pestm. 32	Letter	09 Feb 258 BCE (sent) + 05 Mar 258 BCE (received)	TM_Coll_73 + TM_Coll_192 + TM_Coll_245
TM_1890	P.Iand.Zen. 51 + P.Iand. Zen. 52	Account & list	before 25 May–22 Jun 259 BCE (?)	TM_Coll_140
TM_1906	P.Zen.Pestm. 76 a	Letter	27 Jan 258 BCE	TM_Coll_73
TM_1910	P.Mich. Zen. 4	Account	258–260 BCE (?)	TM_Coll_12
TM_2019	PSI IV 322	Letter	260–258 BCE	TM_Coll_128
TM_2021	PSI IV 324	Letter	29 May 261 BCE (?)/16 Jun 260 BCE (?)	TM_Coll_128
TM_2022	PSI IV 325	Letter	29 May 261 BCE (?)/30 May 261 BCE (?)/16 Jun 260 BCE (?)	TM_Coll_128
TM_2173	PSI VI 553	List	29 Sep 260 BCE	TM_Coll_128
TM_2174	PSI VI 554	Letter	23 Jan 258 BCE	TM_Coll_128
TM_2237	PSI VI 631	Letter	after 30 Apr 260 BCE	TM_Coll_128
TM_2293	P.Cair.Zen. I 59002	Letter	23 Nov 260 BCE	TM_Coll_73
TM_2372	P.Zen.Pestm. 76 b	Letter	27 Jan 258 BCE	TM_Coll_245
TM_2377	P.Lond. VII 1930	Account	22 Feb–04 May 259 BCE	TM_Coll_73 + TM_Coll_192
TM_2378	P.Lond. VII 1932	Letter	24 Apr 258 BCE	TM_Coll_192
TM_2436	PSI VII 863 h	Unknown	27 Oct 260 BCE–26 Oct 259 BCE	TM_Coll_128

* Collection codes are TM collection ids: TM_Coll_12 = Ann Arbor. Michigan University Library; TM_Coll_73 = Cairo. Egyptian Museum; TM_Coll_128 = Florence. Biblioteca Medicea Laurenziana; TM_Coll_140 = Giessen. Universitätsbibliothek; TM_Coll_192 = London. British Library; TM_Coll_245 = New York. Columbia University.