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War, art, and sanctions: social network analysis on the NACP's databases of sanctioned Russian individuals and art collectors

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Abstract
Until March 2024, Ukraine's National Agency on Corruption Prevention (NACP) was tasked with maintaining databases of individuals sanctioned for their support of Russian military action in Ukraine and monitoring works of art owned by these individuals to prevent their being sold in violation of sanctions. The present study gathered data from the NACP's War & Sanctions and War & Art databases through a combination of web scraping and API requests. These data were then examined using measures of network analysis (including degree centrality, eigenvector centrality, and clustering coefficient), which allowed the visualisation and statistical analysis of the network of Russian elite. This research is the first that has conducted scientific analysis on these datasets. Investigation determined that the social network of individuals in the upper strata of Russian society is vast and moderately centralised, with over a dozen clusters around influential Russian oligarchs, politicians, and celebrities. It also determined that art collectors have a more central role in this network than non-collectors of art. The network exhibits a clear presence of hubs and nodes with high degree centrality and a high degree-betweenness centrality correlation, indicating that information can flow quickly and efficiently. However, the network's dependence on a few key individuals could constitute a vulnerability, with the extraction or isolation of these figures potentially disrupting the network's function and coordination. This research also identified inconsistencies in the imposition of sanctions, creating grey areas that could allow the continued trade of cultural goods, potentially bypassing international restrictions.

Keywords Social network analysis · Ukraine · Russia · Cultural heritage · Art collectors · Data analysis

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1 Introduction

The Russian "special military operation" in Ukraine began on 24 February 2022 and has led to extensive casualties of lives, infrastructure, and cultural heritage (AJLabs, 2023; Faulconbridge, 2023; Novikov, 2023; World Bank, 2023). Donations to support the humanitarian response in Ukraine, reconstruction, and evacuation from the country are in the billions of dollars as the international community works to minimise long-term losses. In response to misappropriation of funds in the Ukrainian government, the National Agency on Corruption Prevention (NACP, also NAZK) has been mandated to oversee the distribution of the donations.

The NACP was also tasked with establishing two extensive databases of information on individuals and organisations facing international sanctions for their direct or indirect support of detrimental military policy during the conflict.[1]The first, "War & Sanctions," identified individuals related to the war including members of the Russian government, celebrities who have endorsed the operation, business owners, oligarchs, and members of the military. The database included data on individuals against whom sanctions had been imposed by at least one of the following: Ukraine, the European Union (EU), Switzerland, United Kingdom (UK), United States of America (USA), Poland, Canada, Japan, Australia, or New Zealand, or for whom the NACP is recommending sanctions. For the purposes of the present study, an individual sanctioned by at least one of the State or regional actors named above is referred to as 'sanctioned'; otherwise, they are classified as 'unsanctioned.' As of the most recent data collection, 10,691 sanctioned individuals were identified, with an additional 23,682 recommended for sanctions. Each record includes as much of the following information as possible, in English, Ukrainian, and Russian: name of the individual, their credentials (e.g., Member of the political party "United Russia," Member of Russia's Armed Forces General Staff, Deputy of the "so-called State Council of the Republic of Crimea," etc.), date and place of birth, reason for imposing sanctions, a list of their assets (including artworks and cultural objects), and a list of their connections, including colleagues and business partners, family members, allies, friends, and subordinates. The present study focuses on the latter two pieces of information: their assets and their connections.

Artworks and cultural objects owned by sanctioned individuals were registered in the second database administered by the NACP: the "War & Art" portal (Dafoe, 2023). The portal was developed in cooperation with cultural institutions and experts in Ukraine and abroad, including the Art Sanct Task Force (an initiative of the NACP) and the Stanford-based Yermak-McFaul Expert Group on Russian Sanctions.[2]The database aimed to aid in the imposition of sanctions by curbing the trade of sanctioned material and, through its registry of objects looted from Ukrainian cultural

[1] Since March 2024, the databases under study have been removed from the NACP's server and are in the process of being transferred to the management of Ukraine's Main Directorate of Intelligence. The databases can still be accessed using the internet archive Wayback Machine.

[2] The Expert Group has developed an "Individual Sanctions Roadmap" to which the NACP adheres in developing its sanctions recommendations.

institutions, to tackle the trafficking of stolen art and antiquities. The database stored information on three categories of items:

- Art and antiquities that formerly belonged to now-sanctioned individuals,
- Art and antiquities currently owned by a sanctioned individual, and.
- Art and antiquities illicitly removed from occupied territories.

By using this portal for due diligence, art market participants (including museums and auction houses as well as individual dealers and collectors) could determine whether an item is legally available for purchase and, if not, report the object and seller to the NACP where the piece may be subject to seizure and forfeiture (Tarsis, 2023). Considering War & Art was only launched in August 2023 and both databases have since been taken down (pending their transfer to the server of Ukraine's Main Directorate of Intelligence), the present study offers the first social network analysis (SNA) of the data presented therein, investigating the place of art collectors among the Russian elite and analysing the opportunities for illicit trade within the system.

2 Research aim

While some scholarship has briefly mentioned the War & Sanctions database (Kravchuk & Ivashchuk, 2022; Tarsis, 2023; Zvonar & Holovko, 2023), these have been in passing and have not engaged with the data nor offered any analysis. Conversely, the only publications on the War & Art database have been news reporting, which have focused on the role the database could play in preventing the sale of artworks in violation of sanctions (Boffey, 2023; Dafoe, 2023; Nowakowski, 2023). In view of the extensive network data presented by War & Sanctions and the thousands of records on cultural goods provided by War & Art, the present study leverages SNA to determine the structure of the network of sanctioned individuals and offer insights on the role of art and antiquities collectors within it.

This research sought to answer the following questions:

- What are the structural characteristics (including size, shape, and the presence of cliques and bridges) of the social network?
- How central are art collectors in the network, and how does their centrality compare to non-collectors?
- Do any conditions exist in the network that could enable the illicit trade of cultural goods?

To answer these questions, this paper first presents the methodology employed for data collection and analysis, then reviews the analytical approach of SNA, particularly as it applies to cultural goods trafficking networks. Next, the Results section focuses first on the structural characteristics of the network and the most central nodes, and then indicates the role of art collectors within the network. This continues in the Discussion section, which also highlights implications for the tackling of illicit trade. This research complements the efforts of the United Nations (UN) and NACP

in preventing illicit trade in violation of sanctions, highlighting the prevalence of the art and antiquities trade among members of the Russian elite, and demonstrating the richness and benefit of the NACP databases as datasets for additional future analysis.

3 Methodology for data gathering and preparation

Data collection for this research was conducted under the auspices of RITHMS (Research, Intelligence and Technology for Heritage and Market Security), a Horizon Europe-funded project to develop a platform to aid European law enforcement agencies in tackling the illicit trade in art and antiquities.[3]The initial operative phase of the project involved the gathering of data from existing repositories of stolen or missing art and antiquities to construct a network-focused model of the trade in cultural goods centring around actors and social relations. While the War & Art portal maintained by the NACP consisted largely of legally acquired objects, the dataset draws attention to works which are in danger of being smuggled or sold in violation of imposed sanctions. Further, the War & Sanctions database shed light on the social networks that exist within the upper strata of Russian society which may be complicit in the trade of other, less provenanced pieces. The richness and novelty of these data, combined with the current state of heritage protection in Ukraine and Russia, led us to draft and publish this research in advance of its formal integration with the RITHMS project.

Data collected for the present study were gathered through a combination of scraping programs and use of the War & Sanctions API, formerly available for public use on the War & Sanctions website. It should be noted that the data for the present study were gathered on 12 February 2024. Two different scraping programs were written using the Python programming language to collect data for analysis. The first gathered data from the War & Art portal on each of the 1,948 objects registered in the database. Full records include an image of the artwork or cultural object, its title (and original title, if it was previously known by another name), artist, year of creation, dimensions, materials, object type, and status, as well as information about its acquisition: date of purchase, purchase price, seller (e.g., Sotheby's auction house), and owner. However, many of the entries do not have all this information, with some only offering a blurry photo of an unidentified artwork or cultural object taken from surveillance footage or social media. The first scraping program collected as much information as was available for each item.

The second scraping program collected information from the War & Sanctions portal on the individuals registered therein. Data were collected on all individuals regardless of whether sanctions were currently imposed or whether they were just identified by the NACP for the future imposition of sanctions. The reason for this was to develop as accurate an image of the social network as possible. Works of art and antiquities registered in the War & Art portal belong exclusively to individuals against whom sanctions are already imposed, so the inclusion of unsanctioned individuals in the scraped data does not affect the category of objects included in the project. Further, the preparation of War & Sanctions by the NACP does not appear

[3] For more information about RITHMS project (G.A. 101073932), see https://rithms.eu/.

to have been influenced by art collectors or their collections as the database (War & Sanctions) focuses solely on sanctions-related data published by various open sources; it is important to note this point as it reduces the chance of confirmation bias affecting the results of the network analysis. While it is possible that more connections were reported for art collectors due to additional research conducted by the NACP into these individuals, we argue that the risk of confirmation bias is minimal as most research was ostensibly and explicitly motivated by an interest in applying sanctions rather than tracing trade networks. This is evidenced by the fact that War & Sanctions predated the creation of War & Art by roughly 16 months, meaning the NACP's focus on art collectors came secondary to its focus on sanctions as a coercive measure to halt the ongoing conflict.

The scraping program collected the following information on each individual: their name and database ID, and the names, database IDs, and relationship of their connections. For instance, Abdulkhakim Kutbudinovich Gadzhiev is registered with ID #1 and has just one connection in the database: his business partner Viktor Vasiliyevich Zolotov (ID #833). The database also includes records on legal entities that have been sanctioned or identified for future sanctioning, which at the time of writing numbers 8,108. Of these, only four had reported connections to individuals: the Federal Security Service (FSB), the Central Bank of Russia, the "Kronstadt Naval Cathedral of St. Nicholas" International Charitable Fund, and the Cali Cartel, which were reported as the workplace or employer of several dozen individuals. Therefore, while the dataset analysed consists primarily of individuals (of entity type 'person'), four entities of the type 'legal entity' are also included. In total, 9,764 relationships were identified among 7,023 entities.

Additional information about each individual, such as their job title, birth date and place, reason for imposition of sanctions, and which countries have imposed sanctions, was retrieved through use of the NACP War & Sanctions API version 6 in the third and final phase of data collection. This information was gathered to supplement the data on individuals collected by the scrapers. The reasons for not relying entirely on the API are twofold: first, there is no API for the War & Art portal to collect data on the artworks owned by sanctioned individuals. Further, the API does not provide data on the nature of each relationship, for instance that Zolotov is a *business partner* of Gadzhiev rather than simply a connection. The API, however, provides a huge amount of additional contextual information about each individual in a matter of seconds, so its value to the data collection cannot be overstated.

The data collected by the scrapers and API were cleaned to remove superfluous characters or tags, and then saved in JSON format to maximise efficiency of data transfer and processing. The data on the connections of sanctioned individuals were also saved in GEXF format to facilitate analysis and visualisation using Gephi software.

The network data were analysed using the Networkx library in Python to assess degree centrality, eigenvector centrality, betweenness centrality, closeness centrality, and average clustering coefficient. In SNA, *degree* is a measure that reflects the number of connections an individual (or node) has. Degree *centrality* describes the number of links for each node, divided by the total number of nodes minus one. Eigenvector centrality takes into consideration the influence of these nodes, assign-

ing higher relative scores to individuals who themselves are linked to other influential nodes. Betweenness assesses the total number of 'shortest paths' between nodes – in other words, how many paths between nodes pass through each individual. Similarly, closeness centrality looks at the sum of the shortest paths from each node to every other node, or how close each individual is to the others in the network. The clustering coefficient reflects how 'cliquish' the network is, or to what degree individuals are linked to each other (or, alternatively, whether individuals are connected primarily to central nodes and have minimal connections with each other). Each of these centralities was assessed using probability values, standard scores, and Pearson's correlation coefficients. A probability value, or p-value, indicates the likelihood of a given measure or event; for the present study, a p-value less than 0.0001 reflects extremely high statistical significance. A standard score, or z-score, reflects the deviation of a measure above or below the mean – for the present study, this represents the degree to which the network of Russian elite deviates from the structure of randomly generated networks. Lastly, Pearson's correlation coefficient indicates, from −1 to 1, the degree of correlation between two centrality measures. Overall, these analyses enabled assessment of the nature of the network's communication and breadth and highlighted individuals and clusters that play a particularly important role in the social structure (Hagberg et al., 2008; Freeman et al., 1991).

4 Social network modelling and the illicit trade

While the art market in Russia has been substantially affected by the onset of the current military operation and imposition of sanctions, it was formerly one of the largest in Europe. Russian art collectors in the 2000s, bankrolled by the privatisation of formerly Soviet-nationalised industries and surging oil revenues, "set records for everything from Fabergé to Freud," participated in high-profile art fairs, joined the boards of museums across Europe, and opened dozens of galleries in Moscow and Saint Petersburg (Kazakina, 2022). Although this upward trend dipped following the 2008 financial crisis, and again after the first round of international sanctions imposed following the annexation of Crimea in 2014, the market endured. As of 2019, Moscow boasted the most billionaires in Europe (though this status has since been usurped by London) and a lucrative art market, driven primarily by oligarchs and ultra-wealthy businessmen (Kazakina, 2022; Tognini, 2020; Varoli, 2006, 2019).

Participants in the market include artists, collectors, philanthropists, professional intermediaries (dealers, commercial galleries, and auction houses), critics, and legislative institutions (the Ministry of Culture and other organisations which regulate the sale and purchase of objects). Didenko and Tatischeva (2019) have conducted a study on participants in the Russian art market and the ways in which their interactions enable the circulation of cultural goods, focusing on the category of 'professional intermediary' and concluding with a recommendation for greater state regulation of the market to foster its stability.

The present study focuses on the category of collectors, whose demand motivates the movement of cultural goods within the network. The War & Art database provides initial data on art collectors in Russia, the extent of their collections, and when they

were formed. These data were correlated with network data from War & Sanctions, which was prepared by NACP analysts based on nearly 250 OSINT sources, including news, independent journalism, and sanctions reports of the EU and UN Member States.[4]To our knowledge, no social network analyses have been conducted on the network data in the NACP databases, owing mainly to the fact that the sources were published so recently. SNA, however, allows the visualisation of the social structure of the Russian elite – tens of thousands of individuals whose economic, political, and sociocultural activities have directly or indirectly endorsed the conflict in Ukraine.

This research operates under the assumption that the data extracted from War & Sanctions accurately reflect the real-world network they purport to represent. In all social network analyses, it should be recognised that limitations exist as to the ability of data to accurately reflect connections within the network, their existence and strength over time, and the system's boundaries. Due to the NACP's methodology of data collection from 248 open sources and comprehensive triangulation of material from multiple disciplines, varying perspectives, and dozens of publishers, it was determined that these data are reasonably reliable. Data appear to have been collected on sanctioned individuals first, followed by their connections. Manual validation was unable to identify a single oligarch or known member of the Russian upper class omitted from the database. Of course, the database cannot claim to be perfectly complete or exhaustive (and in fact, manual research located three documented connections among individuals that were not reported in the database, as outlined further in the Discussion section), but its merits according to principles of data integrity, including attributability, rigour, and consistency, indicate that this source reflects the real-world network to a relatively high degree.

Correlating the data from the War & Art database with that from War & Sanctions can help determine the place of art collectors in the network. This can flag well-connected, influential, and high-profile individuals within the Russian elite (which, as outlined above, has enabled a lucrative art market) who could leverage these connections to sustain the circulation of cultural goods in violation of international sanctions. Identifying these individuals and their networks can therefore thwart the illicit trade of cultural objects and limit incomes that may be repurposed to bolster a sanctioned administration.

The primary advantage of SNA is that a large amount of textual, qualitative data is converted to nodes and edges, allowing it to be analysed statistically and visualised graphically to derive conclusions on the structure of the network. SNA has already been conducted on some aspects of the antiquities trade, including auctions and black-market trafficking, as well as organised crime in general (Bright et al., 2012; D'Ippolito, 2014; Fabiani & Marrone, 2021; Reid et al., 2007; Sciandra, 2019). Fabiani and Marrone (2021) have analysed the relations between auction houses and art dealers to determine that these art market participants often contribute to the legitimisation of unprovenanced goods. Sciandra (2019) looks more broadly at the shape

[4]A full list of the open sources from which the NACP based their research can be found on the War & Sanctions' website's 'OSINT Tracker', available here: https://sanctions.nazk.gov.ua/en/osint/index/. Due to the databases having been removed from the NACP server, this page can now only be accessed using an internet archive such as the Wayback Machine.

of trafficking networks, recognising that it "is not a monolithic crime" but instead "shows various dimensions of social organisation" involving both fixed and fluid roles. D'Ippolito (2014), similarly, recognises that various measures of centrality influence the flow of goods and information within a network and reflect the influence of key individuals in the system.

The present study builds on the existing literature to produce the first SNA conducted on the specific context of art collectors within the network of Russian elite.

The data collected from the NACP databases were modelled in Gephi to illustrate the vast social network of this group (see Fig. 1). Each node represents an individual who has either been sanctioned by one of the state or regional actors mentioned above[5]or has been identified by the NACP for the future imposition of sanctions. The edges, or links, between nodes represent a connection between two individu-

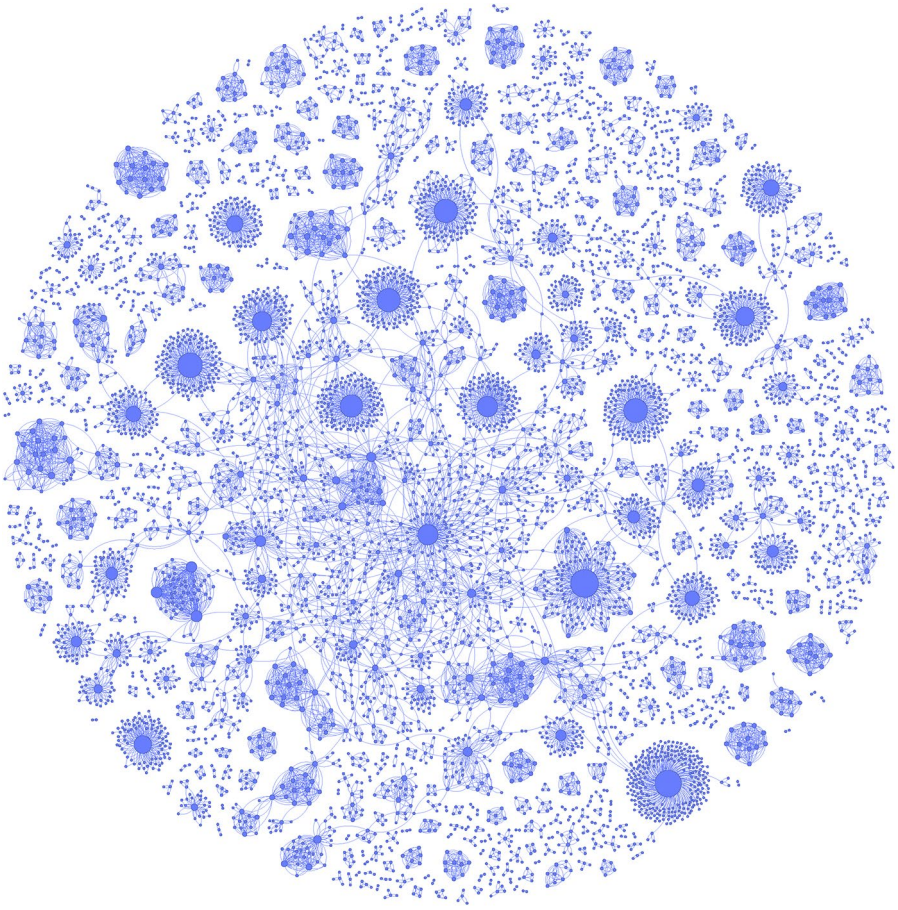

Fig. 1 Social network of individuals in the Russian elite

[5] Ukraine, the EU, Switzerland, United Kingdom, USA, Poland, Canada, Japan, Australia, or New Zealand.

als, the nature of which could either be professional (business partner, subordinate, colleague, etc.), personal (friend, acquaintance, confidant, etc.), or familial (spouse, brother, sister-in-law, stepfather, goddaughter, etc.). In general, the data indicate that the more connections an individual has, the more likely they are to have registered connections of all three types (professional, personal, and familial).

Of the 27,788 individuals identified in the data collection phase, only 7,021 have reported connections. These connections are mixed, representing both *undirected* relationships (for instance, where two individuals are colleagues; in other words, Person A is a colleague of Person B and vice versa) or *directed* relationships (where, for example, Person A is the daughter of Person B, but Person B is not the daughter of Person A). There is an opportunity for future research on currently unregistered connections, some of which are identified and examined in the Discussion. As is clear from Fig. 1, there are several large clusters centred around key officials of the Russian bureaucracy, oligarchs, and owners of large businesses. There are also many isolated couplets, which tend to represent familial relationships, e.g., father-son or spouses, or pairs of business partners. Overall, it is evident that there is a moderate to low degree of cliquishness in the network, with individuals tending to be linked to a well-connected oligarch or political figure and unconnected to the other individuals in that person's network. To a certain extent, this may have resulted from the availability of data available to the NACP, whose research focused primarily on sanctioned individuals; in other words, connections with a sanctioned individual are likely better evidenced than connections among unsanctioned individuals.

5 Results

Centrality analyses have been conducted on the largest connected component, which comprises roughly 50% of the network: 3,470 nodes (of a total 7,023) and 4,745 edges (of a total 19,116). Table 1 lists the top twenty most central individuals according to degree (number of connections) and degree centrality (as a normalised score from 0 to 1). The most central node according to these measures is the Federal Security Service (FSB), a legal entity which is expanded on in the Discussion section. The most central *individuals* are Daniil Vyacheslavovich Egorov (Member of the Coordination Council under the Government of the Russian Federation to Meet the Needs of the Armed Forces), Maxim Alekseevich Shaskolsky (Head of the Federal Antimonopoly Service), and Roman Evgenievich Artyukhin (Head of the Federal Treasury). Interestingly, of the twenty highest degree nodes, only nine are currently sanctioned and are indicated in the table by asterisks next to their names. From the perspective of SNA, highly central but unsanctioned individuals represent possible entry and exit points through which cultural goods could be traded legally, because they are well-connected to potential buyers in the network and their economic activities are not limited by sanctions. This constitutes a grey area for tackling the illicit trade of cultural goods where the legality of an object changes depending on its current owner; an object could not be sold legally by the sanctioned President, but it could, for instance, be sold by one of his well-connected but unsanctioned colleagues. The fact that there is no mechanism that could prevent this represents a limitation of legal

Table 1 Most central individuals in the network, according to degree and degree centrality, with sanctioned individuals indicated with an asterisk (*)

Node	Degree	Degree centrality	Type
Federal Security Service (FSB)*	257	0.0741	Legal Entity
Daniil Vyacheslavovich Egorov*	135	0.0389	Person
Maxim Alekseevich Shaskolsky	118	0.0340	Person
Roman Evgenievich Artyukhin	114	0.0329	Person
Arkady Alexandrovich Gostev*	112	0.0323	Person
Dmitry Vasilievich Aristov	111	0.0320	Person
Oleg Aleksandrovich Skufinsky	106	0.0306	Person
Vladimir Vladimirovich Putin*	97	0.0280	Person
Vladimir Mikhailovich Gundyaev*	91	0.0262	Person
Mikhail Yurievich Ivankov	87	0.0251	Person
Petr Valerievich Ivanov	69	0.0199	Person
Vadim Vladimirovich Yakovenko	65	0.0187	Person
Alexandr Vyacheslavovich Trembitsky*	56	0.0162	Person
Ramzan Akhmatovich Kadyrov*	52	0.0150	Person
Maxim Gennadyevich Reshetnikov*	52	0.0150	Person
Andrei Nikolaevich Artizov	50	0.0144	Person
Viktor Fedorovich Basargin	47	0.0136	Person
Sergey Kuzhugetovich Shoigu*	44	0.0127	Person
Sergey Alekseevich Dankvert	44	0.0127	Person
Dmitry Anatolyevich Medvedev	38	0.0110	Person

implements for protecting cultural goods during times of war where economic sanctions are one of the strongest tools available for bringing about an end of the conflict.

Table 2 Indicates the most influential nodes according to eigenvector centrality analysis. In keeping with the conventions of presentation of the other centrality measures, the table also lists the top 20 nodes. However, it should be noted that from the eighth node (Igor Nikolaevich Bolvachev) to the 258th, the eigenvector centrality score is the same, at 0.0440; the order of these nodes in the table simply reflects the IDs assigned to them in War & sanctions, in ascending order. Notably, President Vladimir Putin is not among the 258 most influential individuals, suggesting that a degree of isolation exists among oligarchs and influential politicians, businesspeople, etc., who operate mainly within their own spheres of influence. Rather, the most influential individuals are Aleksandr Vasilievich Bortnikov (Chairman of the Federal Security Service (FSB) and permanent member of Russia's Security Council), Dmitry Valerievich Ivanov (Head of the FSB Department for the Chelyabinsk Region), Sergei Borisovich Korolev (First Deputy Director of the FSB), and Victor Evdokimovich Gavrilov (Head of the Economic Security Service of the FSB). It is important to note that these individuals are all highly placed in the Federal Security Service, which is expanded on below. However, while the top five most influential nodes have been sanctioned, 85.4% of the next 253 have not. This creates another grey area for the movement of cultural goods which, due to the centrality of these individuals, could circulate somewhat freely throughout the network's central cluster without violating international sanctions

Table 2 Most central individuals in the network, according to eigenvector centrality, with sanctioned individuals indicated with an asterisk (*)

Node	Eigenvector	Type
Federal Security Service (FSB)*	0.7066	Legal Entity
Aleksandr Vasilievich Bortnikov*	0.0544	Person
Dmitry Valerievich Ivanov*	0.0480	Person
Victor Evdokimovich Gavrilov*	0.0474	Person
Sergei Borisovich Korolev/Korolyov*	0.0474	Person
Alexander Anatolievich Kuvshinov	0.0444	Person
Andrey Yurievich Pototsky	0.0444	Person
Dmitry Vyacheslavovich Polyakov	0.0440	Person
Alexey Ivanocih Pochechuev*	0.0440	Person
Alexander Petrovich Veselev	0.0440	Person
Leonid Yurievich Vakalov	0.0440	Person
Vadim Viktorovich Shmelev	0.0440	Person
Sergey Alexandrovich Sundukov	0.0440	Person
Maxim Alexandrovich Mishustin	0.0440	Person
Dmitry Valerievich Presnyakov	0.0440	Person
Eduard Erikovich Ledyaev	0.0440	Person
Dmitry Nikolaevich Dryahlitsyn	0.0440	Person
Alexandr Igorevich Gerasimov	0.0440	Person
Gennady Borisovich Anatsky	0.0440	Person
Igor Anatolievich Sidorov	0.0440	Person

The top twenty most influential individuals according to betweenness centrality are listed in Table 3. These individuals, identified as the best connectors in the network, include Vladimir Vladimirovich Putin (President of Russia), Mikhail Vladimirovich Mishustin (Prime Minister of the Russian Government), Daniil Vyacheslavovich Egorov (introduced above), and Konstantin Anatolyevich Chuychenko (Minister of Justice). These individuals are all key components of the Russian government and bureaucracy. Perhaps due to their visibility, a significantly higher percentage (85%) of the best connecting nodes are currently under sanctions.

The final network analysis conducted was that of closeness centrality. Vladimir Putin was found to be the most central according to this attribute, followed by Alexander Vladimirovich Gutsan (Plenipotentiary Representative of the President in the Northwestern Federal District), Victoria Valerievna Abramchenko (Deputy Prime Ministry), and Tatyana Alekseevna Golikoya (Deputy Prime Minister for Social Policy, Labour, Health Care, and Pension Provision). Table 4 illustrates that the individuals who scored in the top twenty in this analysis are similarly sanctioned as those highlighted by the betweenness centrality analysis (85%), suggesting they are similarly high-profile and have either played a significant role in sanctionable activities or were implicated in illicit activities since Russia's formal incorporation of Crimea in 2014 (at which point the first round of international sanctions were imposed).

Table 3 Most central individuals in the network, according to betweenness centrality, with sanctioned individuals indicated with an asterisk (*)

Node	Betweenness	Type
Vladimir Vladimirovich Putin*	0.6787	Person
Mikhail Vladimirovich Mishustin*	0.2248	Person
Daniil Vyacheslavovich Egorov*	0.1809	Person
Konstantin Anatolyevich Chuychenko*	0.1776	Person
Dmitry Anatolyevich Medvedev*	0.1753	Person
Alexander Vladimirovich Gutsan*	0.1666	Person
Federal Security Service (FSB)	0.1428	Legal Entity
Aleksandr Vasilievich Bortnikov*	0.1426	Person
Alexey Borisovich Miller/Millier*	0.1423	Person
Arkady Alexandrovich Gostev*	0.1359	Person
Vitaly Gennadyevich Savelyev*	0.1340	Person
Sergei Semyonovich Sobyanin*	0.1195	Person
Anton Germanovich Siluanov+	0.1171	Person
Maxim Alekseevich Shaskolsky	0.1051	Person
Marat Shakirzyanovich Khusnullin*	0.0973	Person
Sergey Viktorovich Chemezov*	0.0957	Person
Airat Radinovich Shafigullin	0.0882	Person
Vladimir Alexandrovich Kolokoltsev*	0.0761	Person
Anatoly Anatolyevich Seryshev*	0.0663	Person
Dmitry Vasilievich Aristov	0.0662	Person

The average degree centrality in the network is low, with a value of 0.0008. This suggests that, on average, nodes have relatively few connections, indicating a sparse network with limited interactions. However, comparing the degree of the large connected component with randomly generated $G_{n,p}$ graphs (Batagelj & Brandes, 2005), the z-score of 48.65, with a p-value lower than 0.0001, indicates a significant difference, where there are more connections on average than would be expected in a typical network. The social network under scrutiny exhibits a degree centrality pattern that significantly deviates from randomly generated graphs, suggesting that the structure could be influenced by explicit organisational policies, social hierarchies, or targeted collaborations.

The average betweenness centrality is also low, with a value of 0.0020 and a maximum of 0.6787, indicating that there is a low number of nodes playing critical bridging roles in the network. This is reflected in the high z-score of 5.3449 and a p-value of 9.045×10^{-8}, which points to a significant difference from random networks. This highlights the presence of specific nodes that act as important connectors, which is also meaningful with regards to common art market dynamics, where a few individuals are responsible for linking multiple clusters with diverse roles (e.g., looters, restorers, dealers, collectors, and experts) (Balcells, 2023; Fabiani & Marrone, 2021; Rufián & Sabrine, 2021).

Table 4 Most central individuals in the network, according to closeness centrality, with sanctioned individuals indicated with an asterisk (*)

Node	Closeness	Type
Vladimir Vladimirovich Putin*	0.2301	Person
Alexander Vladimirovich Gutsan*	0.2054	Person
Victoria Valerievna Abramchenko*	0.2033	Person
Tatyana Alekseevna Golikova*	0.2010	Person
Alexander Valentinovich Novak*	0.2010	Person
Yury Ivanovich Borisov*	0.2009	Person
Alexey Logvinovich Overchuk*	0.2009	Person
Natalia Vladimirovna Poryvai	0.2006	Person
Yury Petrovich Trutnev*	0.1982	Person
Andrey Removich Belousov*	0.1979	Person
Sergei Semyonovich Sobyanin*	0.1973	Person
Diana Gudaevna Gurtskaia	0.1968	Person
Dmitry Anatolyevich Medvedev*	0.1955	Person
Airat Radinovich Shafigullin	0.1948	Person
Sergey Viktorovich Chemezov*	0.1939	Person
Aleksandr Vasilievich Bortnikov*	0.1933	Person
Alexey Borisovich Miller/Millier*	0.1930	Person
Andrei Vladimirovich Yatskyn*	0.1927	Person
Marat Shakirzyanovich Khusnullin*	0.1924	Person
Margarita Simonovna Simonyan*	0.1922	Person

The average closeness centrality is relatively high, with a value of 0.1307 and a maximum of 0.2301. This suggests that nodes in the largest connected component have a good level of cohesion, with shorter average distances between them. The z-score for average closeness is 57.3005, with p-value lower than 0.0001, confirming a significant difference from random networks and implying nodes are closer to each other than would be expected by chance. This fact, paired with a positive global clustering coefficient (0.4821), also points to the existence of different, well-connected clusters.

The average eigenvector centrality is 0.0035, with a maximum of 0.7066, suggesting that most nodes have low network influence. The z-score is 2.3028, with a p-value of 0.0213, denoting a significant difference from random networks. This reveals that the influence of nodes, based on their connections to other influential nodes, is not random but instead highlights the presence of key influential nodes within the network. This significant difference underscores the hierarchical structure and presence of influential hubs in the network, which are characteristic features of non-random, structured networks such as those observed in social and organisational contexts (Ying & Wu, 2009).

Correlations among the centrality measures can offer valuable insights into the network's shape, structure, and underlying social concepts (Fig. 2). This analysis enables key observations based on Pearson's correlation coefficient (Pearson, 1895):

- **Degree Centrality vs. Betweenness (Pearson's r =0.55, p<0.0001)**: the positive correlation indicates that nodes with higher degrees are more likely to lie on the shortest paths between other nodes. In other words, well-connected individuals tend to play critical roles in connecting different parts of the network, potentially acting as bridges for information or influence.
- **Degree Centrality vs. Closeness (Pearson's r =0.12, p <0.0001)**: despite a weak correlation, which indicates that more connections do not necessarily mean a node will be closer to other nodes in terms of the shortest path distance, the significant p-value suggests that the fact that nodes slightly closer to other nodes is not due to random chance. Nevertheless, popularity does not automatically translate into faster access or closer relationships.
- **Degree Centrality vs. Eigenvector (Pearson's r =0.35, p <0.0001)**: the weak to moderate correlation and significant p-value imply that nodes with more connections are likely to have a higher level of influence, based on their connections to other influential nodes.
- **Betweenness vs. Eigenvector (Pearson's r =0.10, p <0.0001)**: the low but positive correlation and significant p-value suggest that nodes that frequently act as bridges (with high betweenness) are more likely to be closer to other nodes in the network.
- **Degree Centrality vs. Eigenvector (Pearson's r =0.35, p <0.0001)**: the weak to moderate correlation and significant p-value imply that nodes with more connections are likely to have a higher level of influence, based on their connections to other influential nodes.
- **Closeness vs. Eigenvector (Pearson's r =0.13, p <0.0001)**: the weak correlation and significant p-value suggest that while nodes closely connected to others tend to have greater influence, this is not a strong relationship, though it is statistically significant.

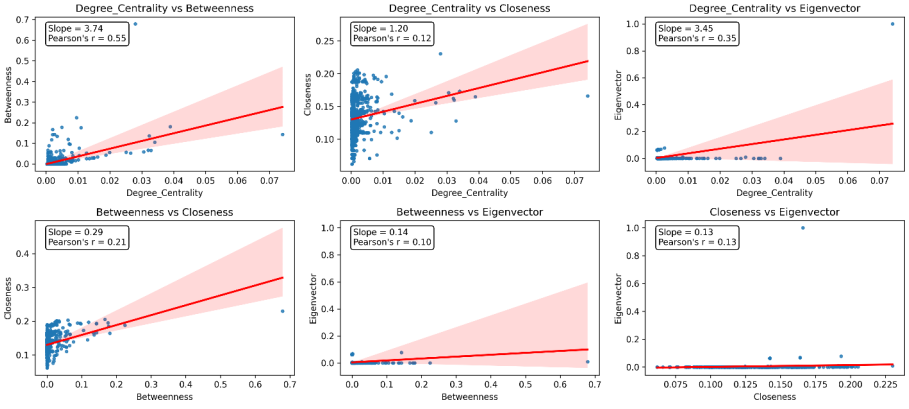

Fig. 2 Linear regression models

The largest connected component appears to have a non-random structure, with significant variation in node centrality measures. The high z-scores for all the centralities indicate that there is a significant difference from a random network (see Fig. 3). This is evidence that the network has a structured hierarchy wherein some nodes hold greater centrality than others. Overall, the results indicate that the network is hierarchical, with Vladimir Putin as the most important node. The network is also well-connected, with the FSB being the node with the most connections to other nodes (see Table 5).

Being that the most informative correlation is between degree and betweenness centralities, it is possible to analyse further these metrics, beginning with the former. Looking at the top fifty nodes with the highest degree centrality, several notable observations emerge:

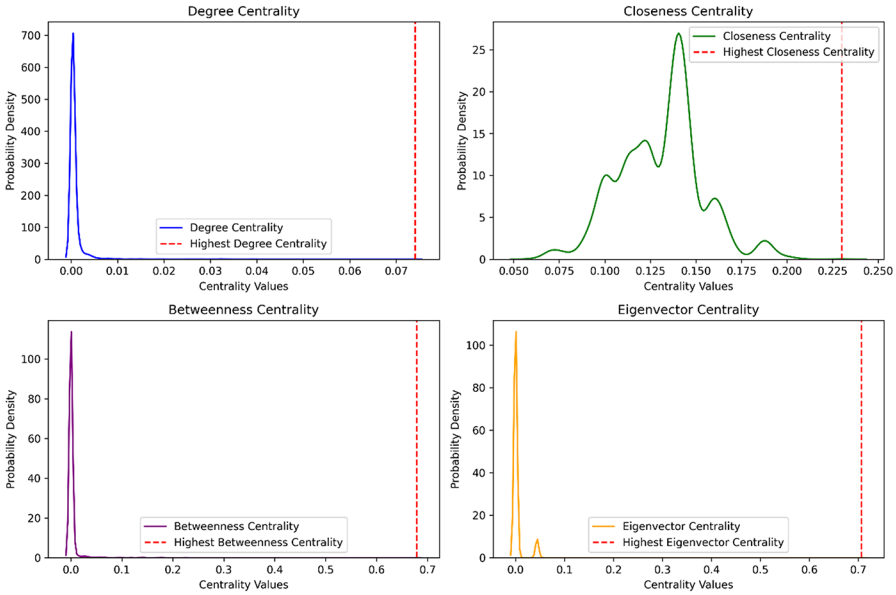

Fig. 3 Centralities distribution

Table 5 Nodes with highest centrality

Centrality measure	Node with highest centrality	Average centrality	Standard deviation	z-score	significance
Degree centrality	Federal Security Service (FSB)	0.0008	0.0024	48.65	True
Closeness centrality	Vladimir Vladimirovich Putin	0. 1307	0.0228	57.30	True
Betweenness centrality	Vladimir Vladimirovich Putin	0.0020	0.0162	5.34	True
Eigenvector centrality	Federal Security Service (FSB)	0.0035	0.0166	2.30	True

- **Government Officials and Prominent Figures**: The list includes government officials such as Vladimir Putin, Dmitry Medvedev, and Sergey Shoigu, indicating their widespread connections within the network. This aligns with expectations in a political or organisational context, where influential figures tend to have many connections.
- **Business Leaders**: Prominent business leaders like Arkady Rotenberg and Oleg Deripaska are also present. Their high degree centrality suggests their substantial involvement in various social circles, likely due to their business endeavours and influence. This also highlights the influence of oligarchs in the system, the majority of whom acquired their wealth through the exploitation of newly privatised industries following the dissolution of the Soviet Union.
- **Diversity in Sectors**: In addition to high-profile politicians and business leaders, the list also includes individuals from other sectors, including entertainment and media. This diversity underscores the network's complex nature and the interplay between different domains. This must also be kept in mind when considering the impact on the art market of the different roles played by involved individuals.

Additional insights are available when analysing the top fifty nodes in terms of betweenness centrality:

- **Vladimir Putin's Dominance**: Vladimir Putin emerges as the most significant node with the highest betweenness centrality by a considerable margin; his score of 0.6787 is substantially greater than the second highest score of 0.2248 (Table 3). This reaffirms his pivotal role as a bridge, connecting various parts of the network. He is also linked to multiple large clusters and influential nodes within the largest connected component (see Fig. 4). In a social context, this indicates that he plays a crucial role in information flow and communication.
- **Political Figures**: Many of the top nodes in terms of betweenness centrality nodes are high-ranking political figures like Dmitry Medvedev (Deputy Chairman of the Security Council of Russia), Sergey Shoigu (Secretary of the Security Council), and Minister of Foreign Affairs Sergey Lavrov. This underscores their roles as central figures in facilitating communication within the network.
- **Business and Political Connections**: Notably, ultra-wealthy oligarchs and businessmen like Arkady Rotenberg and Oleg Deripaska also feature among the top nodes in betweenness centrality. This suggests that they not only have extensive connections (as indicated by degree centrality) but also play significant bridging roles, connecting the spheres of business and politics.

The correlation between degree and betweenness centrality in this network highlights the critical role of well-connected individuals such as political leaders and business magnates in bridging different parts of the network. This concept underscores the significance of information flow, influence, and collaboration in a complex social network like the one under analysis. This has important implications for the structure and longevity of such a network. Namely, nodes with high degree centrality not only have extensive social networks but also wield significant influence due to their capacity to connect different groups. Further, individuals with high betweenness central-

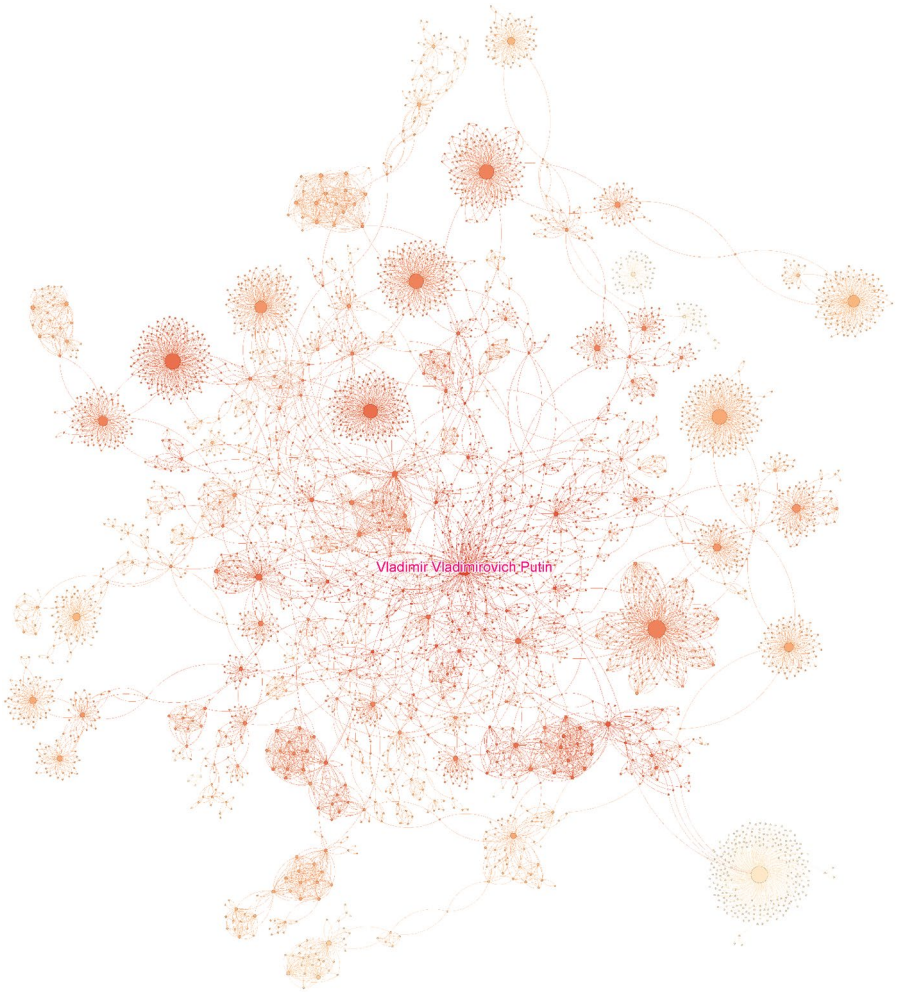

Fig. 4 Vladimir Putin's network, indicating his dominance in the largest connected component

ity, especially Vladimir Putin, act as central hubs for communication. They ensure efficient exchange of information and potentially contribute to consensus-building and decision-making processes. Conversely, these nodes can also play a gatekeeping role, restricting the amount of information (or objects) that flow within a network. Placed on the shortest paths among other nodes– themselves also influential and well-placed– these individuals with high betweenness centrality are well-poised to disrupt the flow of the network at will.

The presence of influential figures from both business and politics suggests a close interplay between these domains, which may involve lobbying, partnerships, or other collaborative efforts. The network's reliance on a few highly central nodes, also referred to in SNA methodology as 'cut points,' could be both a strength and a

vulnerability. While these nodes facilitate efficient communication, their removal or isolation could greatly disrupt the network.

Overall, the strong positive correlation between degree centrality and betweenness centrality reflects that nodes with many direct connections (high degree) are likely to be key intermediaries (high betweenness) in facilitating communication and maintaining the overall structure and function of the network. The network seems to have a moderate level of overall centralisation, characterised by a hierarchy of hubs, efficient communication pathways, and a mix of structural roles. Its resilience is closely tied to the presence and accessibility of these hubs.

6 Discussion

The two sets of data scraped from the NACP databases (War & Art and War & Sanctions) were analysed together to determine which individuals are in possession of artworks and what their centrality is in the social network as a whole (Table 6). Overall, individuals who own artworks are significantly more central (with an average degree of 7.6429) than individuals who do not own cultural objects (average degree 2.8073). This indicates a correlation between cultural capital and social influence in the network. This could mean that the factors that contribute to growth of an art collection (disposable wealth, social connections, and taste) also contribute to the cultivation of a strong and well-connected position in one's social network; while this cannot be proven by the current analyses, previous scholarship has similarly suggested the relevance of art as a means not only to symbolise power but also to expand it or reinforce one's influence within a group (Bourdieu, 1984, 1986; Chan & Goldthorpe, 2007; Lizardo, 2006).

Table 6 Art collectors, their reported collections, and their degree

Name	No. of objects	Degree
Petr Olegovich Aven	369	16
Roman Arkadyevich Abramovich	365	13
Viatcheslav Vladimirovich Kantor	302	2
Viktor Feliksovich Vekselberg	272	1
Alisher Burkhanovich Usmanov	106	8
Vagit Yusufovich Alekperov	78	3
Yana Alexandrovna Rudkovskaya	67	3
Timur Ildarovich Yunusov (a.k.a. Timati)	57	1
Dmitry Yevgenyevich Rybolovlev	37	3
Unknown	8	N/A
Darya Alexandrovna Zhukova	4	1
Oleg Vladimirovich Deripaska	2	10
Andrey Igorevich Melnichenko	1	3
Mikhail Maratovich Fridman	1	14
Arkady Romanovich Rotenberg	1	27
Leonid Viktorovich Mikhelson	1	2
Bidzina Grigoryevich Ivanishvili	1	0

The list of art collectors includes thirteen oligarchs and businesspeople, a rapper, a TV host, and a former Prime Minister of Georgia (who, while a surprising presence, has no reported connections to members of the Russian elite). Figure 5 illustrates the location of art collectors in the network, with the large connected component indicated in orange. Overall, the collectors are well connected, with nine in particular located very close to the central cluster of Vladimir Putin (Alisher Usmanov, Darya Zhukova, Arkady Rotenberg, Roman Abramovich, Mikhail Fridman, Petr Aven, Andrey Melnichenko, Oleg Deripaska, and Viktor Vekselberg).

There is some evidence that collectors have continued participating in the market despite sanctions. Oligarch Arkady Rotenberg, for instance, has been sanctioned since the annexation of Crimea in 2014 but periodically continued to buy and sell artworks, as demonstrated by a U.S. Senate report and the International Consortium of Investigative Journalists (ICIJ) Panama Papers investigation. Following the publication of the investigation, however, major auction houses have declared their commitment to verifying buyers' and sellers' identities against sanctions lists and adhering to principles of due diligence (Fitzgibbon & Boland-Rudder, 2020; Shaw, 2022). The ICIJ's Panama Papers investigation has also highlighted the ways in which cultural

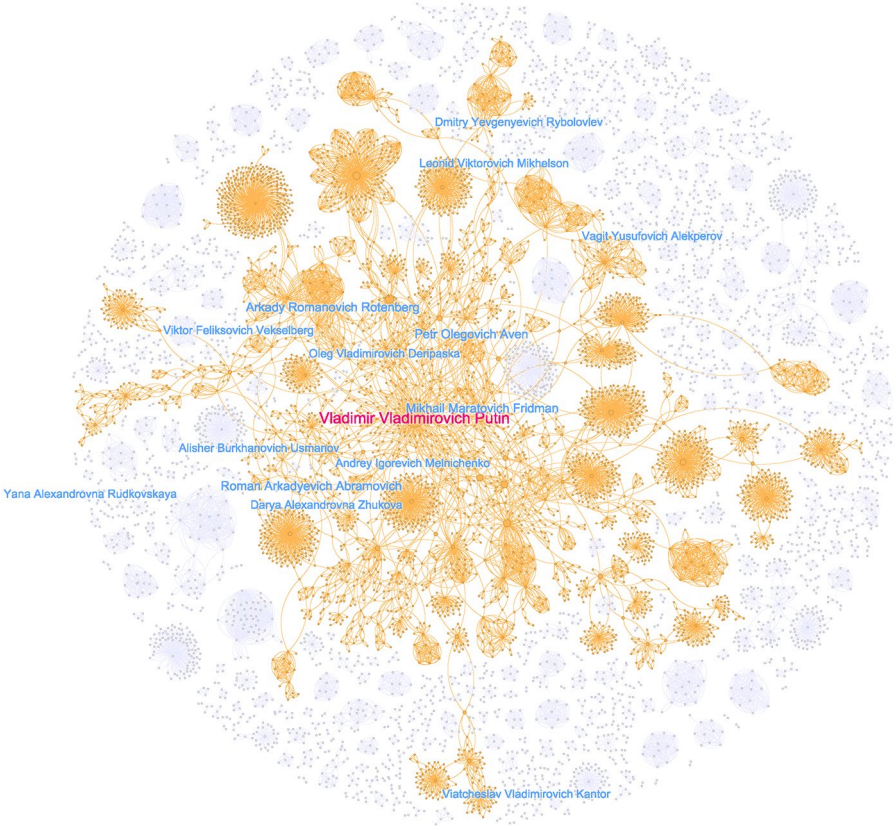

Fig. 5 Art collectors in the social network (names in blue), with the largest connected component indicated in orange

objects have been embroiled in other typologies of criminal activity, including Dmitry Rybolovlev's (ninth in the list of collectors above) use of shell corporations in the British Virgin Islands to evade taxes and conceal assets during his divorce (Davis, 2016). This illustrates how cultural assets are leveraged in the perpetration of white-collar crimes, a frequent practice in markets that rely on a degree of secrecy and opacity; this practice intersects with that of art and antiquities collection, which has itself been condemned as inherently criminogenic (Oosterman et al., 2021).

Many of those who collect art (particularly those with extensive funds) have also invested in the establishment of private art galleries. One such collector-gallerist is the fashion designer Darya Zhukova, who appears eleventh on the list in Table 6. Although only a small percentage of her collection is registered in the NACP database, she is a prolific collector as well as the founder of the Garage Museum of Contemporary Art in Moscow (Kulikova & Malakhov, 2007). She is also the ex-wife of Roman Abramovich, who appears second on the list. Abramovich's collection is one of the largest and most valuable, including Lucian Freud's *Benefits Supervisor Sleeping* (1995) and Francis Bacon's *Triptych* (1976), purchased in the same week in June 2008 for $33.6 million and $86.3 million, respectively (Shaw, 2022). Zhukova's only reported connection in the NACP database is her ex-husband, but she also has unreported professional connections with Oleg Deripaska (twelfth on the list) and his wife Polina, who run Forward Media Group which recruited Zhukova to create the lifestyle and blog-based website Spletnik.ru (Kulikova & Malakhov, 2007). Further, Spletnik.ru was promoted on the business daily website Kommersant, owned by Alisher Usmanov (fifth on the list). Not only do these reflect professional connections that have not yet been updated in the War & Sanctions portal, but they also represent links among major collectors, showing even greater interconnectedness than the modelled social network would suggest.

It is notable that Vladimir Putin does not appear on the list of sanctioned collectors considering he has a significant collection of artworks including, allegedly, pieces by Velazquez, Rubens, da Vinci, Rembrandt, and Michelangelo. A large portion of his collection came from a gift in 2015 by Nina Moleva, who claimed that her late husband's grandfather built the collection throughout the 20th century. After the fall of the Soviet Union, Paris-based auction house Hotel Drouot estimated the collection's value at between $400 million and $2 billion (Neuendorf, 2015). However, the collection's existence and authenticity has never been proven, and the details of other pieces have not been publicised.

It is known, however, to include dozens of works owned by the late musician Mstislav Rostropovich, whose collection was consigned to Sotheby's auction house in 2007. In a rather theatrical move, Alisher Usmanov stopped the auction entirely and made an offer of £25 million for the collected works, which he promptly donated to one of Vladimir Putin's palaces (Shaw, 2022). This information is a valuable first step in delineating the full collections but is notably absent from the NACP database. Despite this gap in the data, however, analysis has still highlighted these two individuals (Vladimir Putin and Alisher Usmanov) as extremely central figures in the network and situated them within the known, demonstrable system of art collectors, indicating SNA as a promising analytical approach for link prediction in art trade networks. In other words, the present analysis flagged Vladimir Putin as a critical

bridge in the network and reinforced his centrality even in the absence of data on his art collection.

The collections of VTB Bank and Alfa Bank are under sanctions as well, but it is similarly unclear how extensive both collections are and where they are held. The chairman of Alfa Bank's board of directors, Petr Aven, does appear in the NACP database as the owner of the most registered artworks. His collection includes works by Marc Chagall, Wassily Kandinsky, and Henry Moore, as well as dozens of unidentified pieces. Sculptures by Moore, as well as Louise Bourgeois and Lynn Chadwick, also populate the garden of his house in Surrey, UK. His plans to open a private museum for his collection in Riga, Latvia, have been put on hold due to the imposition of sanctions (Shaw, 2022). Aven is quite close with Vladimir Putin, described in the War & Sanctions database as a "business partner"; in fact, Aven has been described in EU legal documents as "one of approximately 50 wealthy Russian businessmen who regularly meet with Vladimir Putin in the Kremlin" (Council of the European Union, 2022).

Viktor Vekselberg is another collector whose activities have been curtailed by the imposition of sanctions. A whopping 272 pieces from Vekselberg's collection have been registered in the NACP database, including a painting by Boris Kustodiev titled *Odalisque* purchased for $2.7 million. A major donor to the Tate Modern in London, ties were cut between Vekselberg (along with Aven) and the museum upon the imposition of sanctions by the US and UK (Chow, 2022a). Other sanctioned Russian oligarchs who stepped down from cultural institutions include Vladimir Potanin, formerly on the board of the Guggenheim Museum, and Aven, formerly a trustee of the Royal Academy in London (Kinsella, 2022b). Aven's donation to the Academy in support of the exhibition "Francis Bacon: Man and Beast" was also returned to him upon imposition of sanctions (Chow, 2022b).

Finally, oligarch Oleg Deripaska has been under sanctions since 2018, four years after the Russian incorporation of Crimea, for allegedly laundering money for the Russian government. Deripaska was once Russia's richest person (and the ninth richest person in the world), having made his wealth off the industrialisation of resources, particularly aluminum, which became privatised following the dissolution of the Soviet Union (Forbes, 2023). A new task force established by the US Justice Department in cooperation with the FBI, *KleptoCapture*, conducted a raid in the fall of 2021 in which authorities seized several works of art from Deripaska's residence including a painting by Diego Rivera (Kinsella, 2022a). This information, that Oleg Deripaska used to own a Diego Rivera painting, is included on the NACP database. However, in the absence of a photograph, title, or year for the painting, or price and year of acquisition, the value of this entry is limited.

As introduced above, the War & Sanctions portal also has a database of legal entities that have been sanctioned or identified for future sanctioning, though only four have reported connections. The SNA conducted for this study reinforces the influence of the FSB more so than the others as the former was found to be one of the best-connected nodes in the network and the employer of 257 registered individuals. The FSB is the main intelligence agency of Russia and the successor to the Soviet KGB (Committee for State Security). The agency is responsible for intelligence, surveillance, security, and counter-terrorism activities across the country and abroad,

and the director is personally appointed by and answerable to Vladimir Putin. In the network analysis, the FSB is the most influential node according to degree and eigenvector centralities, and seventh most central according to betweenness centrality. As a result, it represents a major cluster in the social network, but one that is somewhat isolated from the rest of the system. Chairman Bortnikov acts as a bridge, linking the FSB cluster to the larger network of political figures and oligarchs. The central role of the FSB in the social network is unsurprising considering the agency allegedly has representatives (or "curators") in "almost every single large enterprise" across the country (Volchek, 2015). Understandably, however, the precise roles of these "curators" are not made clear in the NACP datasets. In contrast, the Central Bank (the second-best connected legal entity in the dataset) has just 1/10th the reported connections (at 25) and a comparatively low centrality according to all measures. The other two legal entities hold even less influence in the network. Further, unlike the FSB, these other legal entities are not connected to art collectors and so do not feature in the present analysis.

Unlike the studies conducted by D'Ippolito (2014) and Sciandra (2019), the case study of art ownership and social network analysis among the Russian elite does not exhibit a hierarchical pyramidal structure, but a sprawling network with hubs and bridges facilitating communication and acting as intermediaries. This results from the data reflecting a social network with over a dozen influential and well-connected oligarchs across multiple industries rather than a singular leader and pyramidal chain of authority. Further, the place of art collectors in this network does not take into consideration the provenance or chain of ownership of cultural items, but rather dichotomises those who own cultural objects and those who do not. Opportunities for additional research include the comparison of this data with auction house records to augment knowledge of each piece's provenance, purchase date, and price, as well as to connect the network of Russian art collectors to collectors, dealers, and auction houses in Europe and around the world. Further, as the NACP datasets were collected under the auspices of RITHMS project, they will be integrated into the complex digital platform developed by the project to visualise and analyse social networks in the circulation of cultural goods. The combination of multiple datasets from diverse data sources will provide law enforcement agencies with triangulated intelligence to support them in tackling the illicit trade and other typologies of cultural heritage crime.

7 Conclusion

The thousands of individuals registered in the NACP's War & Sanctions portal represent oligarchs, officials of Russian companies and banks, politicians, celebrities and musicians, and others in the upper strata of Russian and international society who have endorsed the so-called "special military operation" in Ukraine. The individuals under sanctions have been identified by the EU and individual UN Member States for their participation in the implementation of policies that reproduce misinformation and suppress Ukrainian sovereignty. The portals developed by the NACP and made available for public use represent a valuable but as-yet underutilised resource for

the protection of cultural objects implicated in the conflict, at risk of being illicitly bought, sold, or traded in violation of sanctions.

This article has modelled the network data presented in the War & Sanctions portal to consider the centrality and influence of key individuals in the Russian elite. While many in the Russian bureaucracy are already under sanctions, there are thousands of central and influential individuals who have not yet been sanctioned by international governments. This functionally creates open channels in the network which can facilitate the legal circulation of cultural goods whose trade would otherwise be considered illicit. The Head of the NACP, Oleksandr Novikov, has enlisted international support to expand the coverage of both portals and improve the entries therein. We similarly encourage researchers and data analysts to make use of this resource, improve its coverage, and expand on our analysis of the available data.

Oleg Deripaska, former owner of the unidentified Diego Rivera painting and formerly the richest person in Russia, has spoken out on the sanctions imposed on the country's elite, suggesting that "Russia could run out of money by next year" (2024) unless foreign investments are significantly increased. Deripaska reported that the Russian government has "already begun to shake us down" in the face of "severe" financial pressure from the international sanctions regime (Neate, 2023). This is evidence that the work of the NACP, government agencies, and heritage experts is having an impact on the current military operation but increases the likelihood that cultural goods may be illicitly traded to raise capital for further sanctionable activities. A concerted international effort involving sanctions, research, and market due diligence has the potential to thwart the trafficking of cultural goods in this context and improve the protection of vulnerable cultural heritage.

Finally, the ongoing analysis of such a peculiar network involving high-ranking and wealthy individuals can help shed light on the dynamics of the high-end art market, often prone to shady and sudden creation of large art collections. Better appreciating this market and its cut points in context can disrupt the chain of illicit trade of cultural goods more efficiently.

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Author contributions Conceptualisation, M.L., R.G., M.D., and A.T.; methodology, R.G., M.D., and A.T.; software and data collection, M.L.; formal analysis, M.L. and R.G.; writing—original draft preparation, M.L. and R.G.; writing—review and editing, M.D. and A.T.; visualisation, R.G.; supervision, M.D. and A.T.; project administration, M.D. and A.T.; funding acquisition, A.T. All authors have read and agreed to the published version of the manuscript.

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Data availability The datasets presented in this article are not readily available because they are part of the ongoing RITHMS project. These data were derived from the following resources which, now offline, can

be accessed indirectly through an internet archive: War & Sanctions https://sanctions.nazk.gov.ua/en/ and War & Art https://sanctions.nazk.gov.ua/en/art/.

Declarations

Competing interests The authors declare no competing interests.

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