

Game of Networks: Family Ties Within the Swedish Council of the Realm (1523-1680)

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<p>Tiivistelmä – Abstract</p> <p>Pro gradu -työni aiheena on Ruotsin valtaneuvosten väliset sukuverkostot aikavälillä 1523-1680. Työni yhdistää digitaalisia ihmistieteitä ja esimodernin ajan tutkimusta. Työn teoreettinen viitekehys ja menetelmä on tietokoneavusteinen verkostoanalyysi.</p> <p>Työn aineistona on käytetty Marko Hakasen ja Ulla Koskisen kokoamaa <i>Swedish Councils of the Realm, 1523-1680</i> -tietokantaa. Aineistoon tallennetut valtaneuvosten sukulaisuussuhheet erottelaan automaattisesti omaksi tietorakenteekseen toteuttamallani Python-ohjelmalla. Varsinainen verkostoanalyysi, eli verkon visuaalinen esitys ja tunnuslukujen lasku, on tehty Gephi-työkalulla. Tämän lisäksi aineistosta lasketaan analyssia tukevia (tilastollisia) tunnuslukuja R-ohjelointiympäristössä.</p> <p>Kysymyksenasettelu työssäni liittyy sekä aineistoon että menetelmään. Verkostoanalyysi vahvistaa aikaisemman tutkimuksen antamaa kuvaaa siitä, että Ruotsin ylhäisaateli oli varhaismodernilla ajalla verkstoitunutta niin suorien perimyssuheteiden kuin avioliittojenkin kautta. Erityisesti 1600-lukua verkosto on aikaisempaa 1500-luvun verkostoa tiheämpi. Valtaneuvosten verkostoista löytyi kuitenkin myös yksittäisiä henkilöitä, joilla ei ollut takanaan virallista sukuverkstoa. Sosialinen ja kansainvälinen liikkuvuus oli siis mahdollista, vaikkakin harvinaista.</p> <p>Parhaimmillaan tietokoneavusteinen verkostoanalyysi tuottaa ennalta-arvaamatonta tietoa aineiston rakenteesta, ja tiedon käsittelyn automatisointi ohjelmoimalla nopeuttaa tutkimusprosessia ja vähentää ihmisen tekemiä (kirjoitus)virheitä. Aineiston käsittelyn automatisointi vaatii kuitenkin aineiston tuntemusta ja tarkkuutta, eivätkä kaikki verkostoanalyysissä käytetyt tunnusluvut sellaisenaan sovi historiallisen sosiaalisen verkoston analysointiin.</p>	
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1 Introduction

The aim of my master's thesis is to (re)construct and study a network of the family ties inside the Swedish Council of the Realm (*Riksrådet*) from the early 16th century to the late 17th century. The study is conducted by creating data structures and visual representations of graphs depicting the family links. In my thesis *historical network analysis* will be referred to as a computer-aided method. In my work I will be focusing mostly on roughly two main sectors: the first of which is the theory and implementation of the actual network analysis, and the second one is the results from analyzing the given dataset.

In general, the scope of this work is cross disciplinary and explorative. The use of programming and computational network analysis links this work directly to the field of *digital humanities*. However, the time frame of this study (1520-1680) ties this work also to the more traditional field of *early modern history*. My work can also be understood as a *history of nobility*, and it also holds elements of *political history*, due to the themes of authority, and the Council of the Realm as an influential political institution. Methodologically, the study is mostly a macro-level quantitative study.

Studying patterns and events on the macro-level does sometimes lead to fascinating and compelling questions about the details of the subject matter. That was something what happened to me. While constructing the graphs, I ended up wondering the fates and lived lives behind the data points. Why was the year 1601 extremely dire for being a councillor? Why did councillor Hogenskild Nillson Bielke (1538-1605) got executed after serving 36 years in the Council of the Realm, while his contemporary Nils Göransson Gyllenstierna (1526-1601) survived all of the rivalries between Gustav Vasa's sons? What happened to the illegitimate son of Gustav II Adolf? Who were the favorites of the queen Christina? These questions are not my research questions *per se*, but they have shaped the structure of this work, and they will be answered in the latter sections.

Overall, the early modern time period is extremely fascinating. Culturally it is distant from our times, and understanding it requires some imagination and empathizing. How did the individuals build their lives in the world that was torn by religious conflicts, and where hunger, epidemics and child mortality were regular tragedies? As we can still perceive the lingering sense of uncertainty or outright doom from the *baroque* art of the time.

In the contingent world of early modern Sweden community and family networks provided safety. They were an integral part of the life in every estate, from the noblemen on the *Riddarhuset* (palace of knights) to the poorest peasants.¹ In the context of noble houses the family links were valued so high, that arranging festivities and hosting visiting

¹Karonen 2009a, pp. 27-28.

relatives not only costed fortunes but also determined the architecture of their mansions.² Understanding the social networks of the time is a key element in understanding the politics, mentality and culture of the time period.

This work is divided into four sections. An introduction will present the premises of this work, while the method—as a focal point of this work—is discussed separately in the longest section of this thesis. The third section is to lay out the results of the actual network analysis, and the last section collects everything together as a conclusion. The historical background and context of this work are presented both in the section for introduction and method.

1.1 Research Questions

The research questions are:

1. Can historical network analysis reveal new or unseen patterns in the affiliations between Swedish councillors of the Realm?
 - How dense is the network (how linked the Council was in general)?
 - Are there any isolated nodes (councillors who have no relatives in the Council)?
 - Can the graph be visually divided into clear sub graphs (is there a certain groups or 'houses' of related councillors)?
2. What are the potential difficulties and pitfalls in the implementation and interpretation of historical network analysis in this specific dataset, and further in the field of early modern history?
 - To what extent can pre-processing the dataset for the network analysis be automated with a script?

The source material for this study is the *Swedish Councillors of the Realm, 1523-1680* dataset, which also dictates the timespan of this study. The period is relatively long and momentous in Swedish history, including many important events, such as, adoption of hereditary kingship in 1544, the conflicts between the sons of Gustav Vasa from 1560's to early 1600's, the Thirty Years War between 1618 and 1648, and queen Christina abdicating the throne in 1654.³ These events and shifts obviously have had a significant impact on the ensemble and activities of the Swedish council of the realm. Yet, instead of event-history or decisions made by the councillors in response to certain circumstances, the focus of this study is on the macro level, in (re)constructing a visual and computational graph of the family relations between the councillors. As seen in the subsection 3.3

²Hakanen and Koskinen 2020, pp. 185-189.

³Karonen, Hakanen, and Einonen 2017, pp. 8-9.

and Figure 6 a longer timespan is necessary in order to the generations of family links to accumulate enough to make a graph meaningful to study.

The time period from 1523 to 1680 was remarkable for the religious, social and political changes. It has been retroactively divided in different epochs due the political and religious changes. According to Jan Melin and his colleagues year 1523 was the end of the (late) medieval times (*medeltiden*) and beginning of the modern time (*nya tiden*) in the kingdom of Sweden. On the religious sphere the 1523-1680 timespan was divided to the time of (the Lutheran) reformation (*reformationtiden*, 1527-1600) and the time of orthodoxy (*ortodoxins tid*, 1600-1700). The time of orthodoxy meaning a puritan reading of the Lutheran faith. Politically the time was divided to time of reformations (*Reformationsperioden* 1521-1611) and the Swedish age of greatness (*Stormaktstiden*, 1611-1718). According to the ruling royal houses the time was divided into time of Vasa dynasty (*Vasaätten*, 1521/1523-1654) and the time of the house of Palatinate-Zweibrücken (*Pfalziska ätten*, 1654-1720). The change happened when queen Christina abdicated the throne.⁴

These divisions into different epochs are not fixed. For example in his classic monograph *Pohjoinen Suurvalta* Petri Karonen divides the political epochs into the Vasa period (1521-1611) and the Swedish age of greatness (1620-1720).⁵ Using these divisions we must remember that they were not created or emphasized by the contemporaries. However they are a helpful tool in categorizing and understanding the characteristics of the time periods.

This study is conducted with a quantitative dataset instead of more traditional way of qualitative text analysis. Therefore, the source criticism is done for the dataset as a whole. For example, by assessing the sources of the dataset, looking for possible human errors in the data and considering the original purpose and use of the dataset. The source criticism is discussed further in the subsection 1.4.

The basis and context of this thesis will lay on the pre-existing literature concerning the Swedish Council of the Realm and the Swedish kingdom in the early modern period. Previous historical research and prior knowledge on the early modern social realm will form the base for the parameters of the graphs, and direct the choices for the data processing. These decisions include, for instance, the choice between directed or undirected graph, or whether or not to draw the link between brothers if they are already connected to same father present in the graph. These decisions are explicated in the subsection 2.1.

According to historians Miia Kuha and Petri Karonen, majority of historiography concerning Nordic countries in the early modern period is written in the national languages, in this case, Swedish or Finnish.⁶ To make the subject, dataset and method more approachable for international—or at least Nordic—scientific community, I decided to write

⁴Melin, Johansson, and Hedenborg 2006, pp. 458-459.

⁵Karonen 2014, pp. 7-9.

⁶Kuha and Karonen 2024, p. 6.

this work in English. This is a natural option also because English is a language widely used in the field of programming and statistics.

1.2 Previous Research

Historical network analysis can be understood as, to a certain degree established, but developing method. According to Finnish political historians Kimmo Elo and Olli Kleemola, the roots of historical network analysis are as far as in the late 19th century, yet, the modern appliance of the method is due the invention of computers, increase in the computing capacity and availability of user friendly network analysis software. They estimate that historical network analysis has gained its popularity from somewhere in the late 2000's.⁷

It appears that Elo and Kleemola approach historical network analysis as a predominantly digital or computational research method.⁸ However, the definition is not that straightforward. Social network analysis, which is the basis for historical network analysis, involves theorising, model building and empirical research focusing on the patterns formed inside the networks.⁹ (Social) network analysis has been employed in the field of history before the turn of the millenia, previous to the era of intuitive software.¹⁰ So, the field of historical network analysis can be roughly divided in two approaches: one with more descriptive or theorising stance and the another that treats network analysis as a quantitative computer-aided method. In the context of this work, (historical) network analysis will be treated primarily as a computer-aided method, similarly to the article of Elo and Kleemola, therefore focusing mainly on the previous research with computational approach. The further theory and practice will be covered in the section 2.

The international *Historical Network Research Community* (HNR) was found in 2009. The community has grown over time, and nowadays HNR runs workshops, conferences, lectures and a Slack (chat) group, and publishes an open access journal, a newsletter and a research bibliography.¹¹ On the word of Kimmo Elo, historical network analysis has been the most popular computational method amongst historians.¹²

Scanning the HNR research bibliography, it appears that historical network analysis has been applied by researchers and research teams from around the globe in variety of research topics. The topics vary from the social networks of Chinese gods to the technical implementation of historical network analysis, and to the historical study of reconnaissance during the Cold War.¹³ More relevant for this study, network analysis has

⁷Elo and Kleemola 2015, pp. 415-417.

⁸Elo and Kleemola 2015, pp. 415-417.

⁹Keats-Rohan 2007, pp. 22-24.

¹⁰Aronsson, Fagerlund, and Samuelson 1999, TODO check!

¹¹"About HNR" 2021.

¹²Elo 2016, p. 22.

¹³Elo 2016, p. 22. "HNR Bibliography" 2024.

been utilized in the study of ruling elite and power in the pre-modern period.¹⁴

In Finland, Kimmo Elo is one of the researchers highly profiled on the use of the historical network analysis. Among other things, he has co-authored two articles addressing the method in more explorative manner. The first article is "*Verkostoanalyysi historiallisten aineistojen eksploratiivisena analyysimenetelmänä : esimerkkinä sotavalokuvat*" written by Elo and Olli Kleemola. In the article they focus mainly on the applicability of historical network analysis. As their data, they use German war propaganda pictures taken from Finland during the second world war.¹⁵

The another article is "*Networks of Revolutionary Workers: Socialist Red Women in Finland in 1918*" written by Elo and political historian Tiina Lintunen. In this article the method of historical network analysis is applied on the connections between the women who participated to the Finnish civil war in 1918 on the side of the socialists also known as "reds".¹⁶ Both of these articles share the exploratory perspective with this study, and therefore, offer a point of reference.

When it comes to the literature discussing early modern Sweden, historian Petteri Impola has made a quantitative analysis on the social groups studied by Swedish and Finnish historians. Generally the early modern royals and nobility was the the focal point within the Swedish scholars till the 1950's, whereas their Finnish colleagues have been more focused on the peasants and other lower-ranking groups. Overall, in the latter half of 20th century more attention was paid towards lower social groups. Yet, a resurgence of interest in the nobility has occurred in the beginning of the 21st century. This new research examining nobility has been focusing on women, family connections and further social networks.¹⁷ My work seems to be similar with the modern study of the nobility.

As a significant administration the members and activities of the Swedish Council of the Realm have been to some extent covered by previous research. For instance, the development and affairs of the council as an institution are addressed in the works of historians such as Petri Karonen, Pentti Renvall and Kurt Ågren.¹⁸ Additionally, short biographies of some members of the council can be found easily in the *Biografiskt lexikon för Finland* (Biographical Dictionary of Finland).¹⁹ Those biographies include an assortment of notables found in the councillors dataset, such as, Herman (Claesson) Fleming,

¹⁴Sigurðsson and Småberg 2013, See e. g. Ruth Ahnert's and Sebastian E. Ahnert's book *Tudor Networks of Power* (2023) or Paul D Mclean's article *Widening Access While Tightening Control: Office-Holding, Marriages, and Elite Consolidation in Early Modern Poland* (2004).

¹⁵Elo and Kleemola 2015.

¹⁶Lintunen and Elo 2019, Almost the same article is found in Finnish in the *Historiallinen Aikakauskirja* 116 (2/2018).

¹⁷Impola 2024.

¹⁸Karonen 2014; 2009b, See e. g. Pentti Renvall "*Keskityn hallintolaitoksen kehitys*" in *Suomen kulttuurihistoria. II* (1934) or Kurt Ågren "*Rise and decline of an aristocracy: The Swedish social and political elite in the 17th century*" in the *Scandinavian journal of history* (1976).

¹⁹"BLF – Biografiskt lexikon för Finland" 2014.

Gabriel Bengtsson Oxenstierna (af Korsholm och Wasa) or Lorentz (Ernstsson) Creutz d.ä.²⁰ Even so, the Council of the Realm has not been examined thoroughly down to the last man. And based on historians Marko Hakanen and Ulla Koskinen, the council as a focal point, does still hold some uncovered parts.²¹

Authors of the councillors dataset, Hakanen and Koskinen, have explained the dataset's background in their article *The Gentle Art of Counseling Monarchs (1560-1655)*. In their study the council is approached through the concept of personal agency.²² In the article, Hakanen and Koskinen also mention some prior collection and utilisation of datasets on the study of said councillors and their networks. Namely, Jan Samuleson has listed councillors and their affiliations from years 1523 – 1611, Kurt Ågren has collected councillors and their families from years 1602 – 1647, and Björn Asker made a similar collection from years 1640 – 1680. Unfortunately, some of the datasets remain unpublished.²³

All in all, computer-aided historical network analysis is somewhat rare compared to the traditional methods of historiography. Nevertheless, it also seems that the pre-modern elite is collectively understood as a network amongst historians, and the ties between the members of nobility have been in the scope of interest for some time now. Which makes applying the computer-aided network analysis relevant. The aim of this work is to join the rather uncommon method of historical network analysis with the classic research topic, and to further explore and develop the method in the context of historical research.

1.3 the Council of the Realm

The position of the councillors of the realm was well recognized by the whole society. They were an elite group which enjoyed formal position in the power structure. Their job was to help the monarch reach decisions.

(Karonen and Hakanen 2017, p. 26.)

In the early modern Sweden the Council of the Realm (Privy Council, swe. Riksrådet, fi. valtaneuvosto) was to give council to the Royal Majesty (monarch, king or queen) on decision making. The Council consisted of noblemen loyal to the monarch. The councillors held a significant power and authority on the realm, yet, the Council did not have the ability to make decisions bypassing or opposing the monarch. Ideally decisions would be made in concensus with the king or queen and the Council.²⁴

The position of the Council as an institution was established in the early Middle Ages. With the elective kingship in the medieval period, the elections of Swedish kings were made with the consent of the Council. The authority and power possessed by the Council

²⁰“Artiklar A-Ö” 2014.

²¹Hakanen and Koskinen 2017b, pp. 47-48.

²²Hakanen and Koskinen 2017b.

²³Hakanen and Koskinen 2017b, p. 48, 67 (cite 4).

²⁴Karonen 2009a, pp. 13-14, Hakanen and Koskinen 2017b, pp. 47-50.

fluctuated from time to time, but it is said to have been on in its peak during the 15th century. However, in the early decades of the 16th century, the Council took part in the plot against the personal union of Sweden and Denmark *Kalmar Union* (1397-1523) and the Danish king. Consequently, ten councillors lost their lives in the dramatic events of *Stockholm Bloodpath* or "the coronation of King Christian II of Denmark" in November 1520. These occurrences soon lead to the splitting of the Kalmar Union and Gustavus Vasa's (1495/1496-1560) rise to power.²⁵

Following Gustavus Vasa's and his descendants ascension of the throne, the authority and power of the Council and upper aristocracy weakened. The Council was only called on by the king, further, the king was the one who chose the members of the Council, hence being able to favour the ones conforming him.²⁶ Gustavus Vasa and his sons perceived the upper aristocrats as rivals, therefore relying on the unofficial help and support of their ignoble²⁷ secretaries.²⁸

Overall, the timeperiod between 1560 and 1611 was politically turbulent and unpredictable in the Swedish realm. The passing of Gustavus Vasa in 1560 lead to the bitter rivalry and struggle over the inheritance of the throne between his three sons. Each of his sons ruled Sweden for relatively short period of time, and the unforeseen changes of monarchs meant that the Council and nobility had to adapt and swear allegiance to the right sovereign at the right time. Loyalty to the wrong party lead to fall from favour at best or execution at worst. It can be considered essentially dangerous to be in a position of power during that timeperiod.²⁹

The Council faced the most severe crisis during the 1590's civil war. The warfare over Swedish throne was fought between Gustavus Vasa's youngest son Duke Charles (future king Charles IX 1550-1611) and Gustavus Vasa's grandson the king of Poland Sigismund. The war lead to the Duke Charles' rise to power, and the demise of the noblemen and councillors who had opposed him.³⁰ In fact, the Council was practically decimated in 1601, nonetheless, the kingdom needed the help of a legitimate Council in order to take care of the administrative and diplomatic tasks. In 1602 Duke Charles appointed 15 new councillors.³¹

After the death of Charles IX in 1611, Charles' oldest son Gustavus Adolphus (Gustav II Adolf 1594-1632) became the king. At that time, the kingdom was at war with Denmark. To appease the nobility and settle the political situation within Sweden, Gustavus Adolphus gave a charter of guarantees, which, for example assured all of the high

²⁵Hakanen and Koskinen 2017b, pp. 49-50, Karonen, Hakanen, and Einonen 2017, pp. 8-9.

²⁶Karonen 2014, p. 58.

²⁷Nonaristocratic, common.

²⁸Hakanen and Koskinen 2017b, p. 53.

²⁹Karonen 2014, pp. 96-121, Hakanen and Koskinen 2017b, pp. 51-52.

³⁰Hakanen and Koskinen 2017b, pp. 57-60, Karonen 2014, pp. 96-121.

³¹Hakanen and Koskinen 2017b, pp. 57-59.

Table 1: Summary statistics on the number of councillors between 1520-1680.(Data by Hakanen and Koskinen 2017a, statistics by author)

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1.00	19.00	23.00	24.29	27.00	48.00

posts in civil administration to the nobility by privileges.³² The authority and position of the aristocracy and the Council incremented significantly in the early 17th century. Due that, the Council was able to set the Regency (swe. Förmynadarregering, fi. holhoojahallitus) after the king's sudden death in 1632. Additionally, the Council started to gather recurringly in Stocholm. The 1634 Instrument of Government (swe. regeringsform, fi. valtioniuto) further warranted the position of the nobility and the Council.³³

The position of the nobility and the Council started to decline drastically after the Charles XI's (1655-1697) succession of the throne in 1672. In the Diet of 1680 the monarch practically retracted the status of the Council. In 1681 the Council of the Realm was renamed the *Royal Council* (swe. Kungligt råd, fi. kuninkaallinen neuvos). Concurrently, the Great Reduction was being implemented, meaning that the fiefs³⁴ were reclaimed to the state. The reign of Charles XI is retroactively called the Age of Absolutims in Sweden.³⁵ Finally, in the 18th century the role of the Council steadily declined further, and it was disestablished during the reign of Gustavus III (1772-1792).³⁶

The 1442 Law of Realm ordered the Council to be consisted of 12 noble men and varying number of bishops and other clerics.³⁷ As the religious reformation was implemented during the reign of Gustavus Vasa, the bishops and church men lost their position in the Council. Thereafter, the Council consisted primarily of noble men during the 1523-1680 time period.³⁸

According to the *Swedish councillors of the Realm, 1523-1680*-dataset, between 1520 and 1680 the number of active councillors per year changed between 1 in 1601 to 48 in 1654, the mean being 24.29 and median 23. Most of the time the number was between 19 and 27 (Table 1).³⁹ The fluctuation of the councillors count is visible in the Figure 1.

Generally, it seems that the broader position of the Council and the enclosing aristocracy is proportional to the amount of the councillors. However, such an abstract and broad concept as 'position' should be understood as a *latent variable*. Latent variable

³²Karonen 2014, pp. 121-123, Karonen, Hakanen, and Einonen 2017, pp. 8-9.

³³Karonen 2014, pp. 195-197, Karonen and Hakanen 2017, pp. 16-17, Karonen, Hakanen, and Einonen 2017, pp. 8-9.

³⁴Lands given to the aristocracy.

³⁵Karonen 2014, pp. 289-295, Karonen, Hakanen, and Einonen 2017, pp. 8-9.

³⁶Karonen 2009a, p. 14.

³⁷Hakanen and Koskinen 2017b, p. 49.

³⁸Karonen 2014, pp. 72-75, Karonen and Hakanen 2017, p. 15.

³⁹Median is the middle observation on the data, it usually represents the middle point of the distribution.Box et al. 2005, p. 26, Moore, McCabe, and Craig 2017, pp. 30-31. 1/2 (50%) of the observations lay between the 1st and 3rd quartile.Moore, McCabe, and Craig 2017, pp. 32-33.

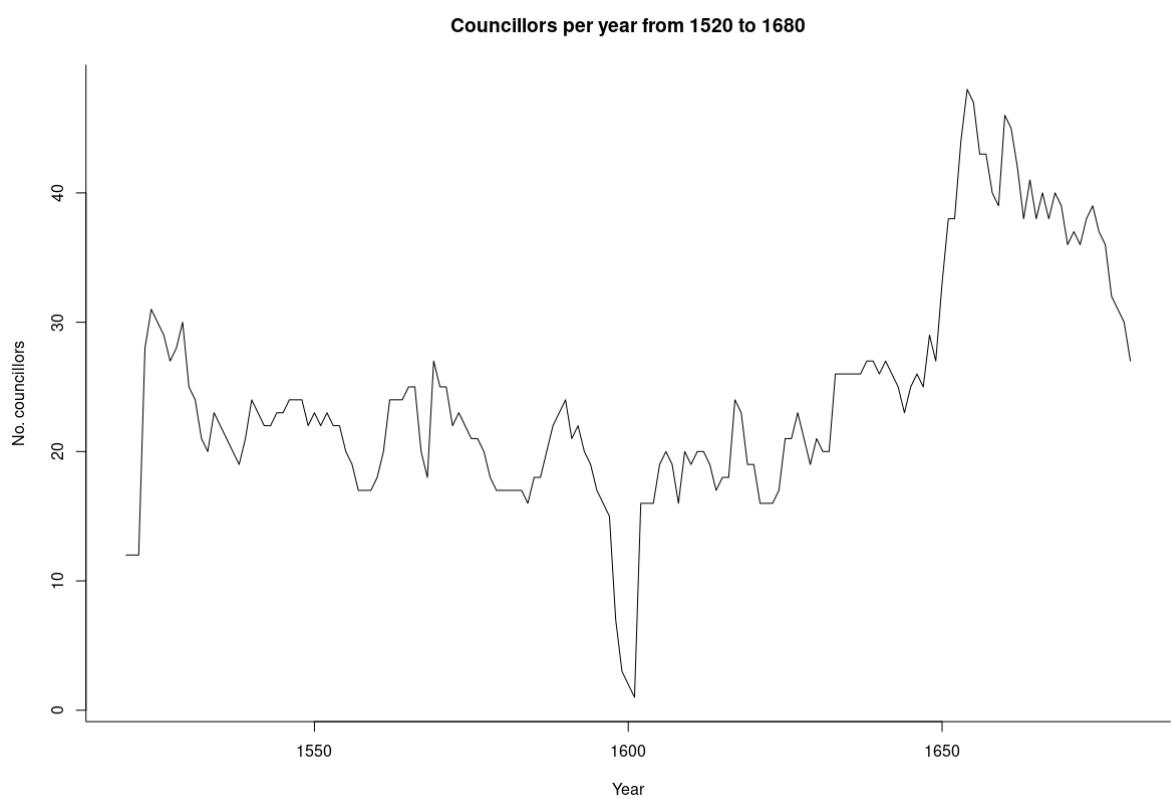


Figure 1: The changes of the number of councillors per each year. (Data by Hakanen and Koskinen 2017a, figure by author)

meaning a factor that is measurable and observable only indirectly through modeling and calculating other variables.⁴⁰. As well as the definition of 'position' as a concept not being that simple and straight forward. It cannot be indubitably quantified in one diagram.

In Figure 1, the amount of councillors declined during the religious reformation in the first half of the 16th century. Then the political instability is seen in the downward spikes after year 1560, most dramatic of those being in the turn of the 16th and 17th century. The amount started a rapid incline somewhere mid 17th century and hit its peak in 1654. It being the year queen Christina (1626-1689) relinquished the throne to her cousin Charles X Gustav (1622-1660).⁴¹ According to Hakanen and Koskinen queen Christina could also have deliberately raised the number of councillors in order to dilute their power.⁴² Yet, closing the year 1680 the number starts to drop exceedingly.

In early modern Sweden the monarch was the highest authority. Practically the deeds of the royal family members were on the second place, and the power of the Council came after these two. Beneath these was the Diet of Sweden (swe. Riksdag, fi. valtiopäivät): the representatives of the four estates—the Nobles, the Clergy, the Burghers and the Peasants—that was to negotiate and legitimate the rules and laws given by the monarch.⁴³ All in all, the place in the Council of the Realm was highly sought after, and compared to the surrounding society or even encompassing nobility, the members enjoyed a significant valuation, authority and most of the time prosperity and wealth.

1.4 Sources

Since this work is conducted with pre-collected dataset, this work can be vaguely categorized as secondary analysis. Secondary analysis meaning re-analyzing the data with new research questions or approaches, while primary analysis involves the collection of the data. Secondary analysis can also be discerned from meta analysis, which means comparing multiple previous studies (usually with quantitative methods) to create a synthesis on a certain question.⁴⁴

On the contrary in their articles Kimmo Elo and Olli Kleemola or Kimmo Elo and Tiina Lintunen apply a network analysis on their own primary datasets.⁴⁵ However, in the case of this work the benefit of doing secondary analysis is that the focus can be on the implementation and assessment of the method. Furthermore, the existing dataset will be automatically and manually re-examined for possible errors in the process, as will be discussed soon.

As mentioned earlier, this work is based on the *Swedish councillors of the Realm*,

⁴⁰"APA Dictionary of Psychology" 2018.

⁴¹Karonen, Hakanen, and Einonen 2017, pp. 8-9.

⁴²Hakanen and Koskinen 2017b, pp. 63-64.

⁴³Karonen 2014, pp. 57-61.

⁴⁴Card and Little 2012, pp. 4-5.

⁴⁵Elo and Kleemola 2015; Lintunen and Elo 2019.

1523-1680 -dataset authored by Marko Hakanen and Ulla Koskinen. The dataset was published in 2017 and can be found in Digital repository of University of Jyväskylä under the license CC BY 4.0. The dataset was collected as a part of the research conducted for the anthology *Personal Agency at the Swedish Age of Greatness 1560–1720*.

To be precise, discussing the data I deliberately use the term *dataset*, whereas the original authors call it *database*. The difference between dataset and database is not clear-cut, but for example the U.S. Geological Survey (USGS) compactly defines dataset as a structured collection of data and database as a collection of multiple datasets. USGS also mentions that the data in databases can (typically) be updated and manipulated easily in real time.⁴⁶ Hence, databases are generally more complicated interfaces for data management, and for this purpose the term dataset is more suitable.

The dataset consists of information from 257 Swedish councillors of the realm. Each councillor has the following feature attributes: date of birth, year of death, year, date and age of appointment, noble rank, spouse(s) along with father's spouse and the individual's family links between other councillors. The councillors are identified with their full name and id number.⁴⁷

Hakanen and Koskinen have compiled the data from secondary sources such as biographical registers and databases, biography collections, lineage databases and research literature. The dataset's sources are listed in the dataset and in the article written by Hakanen and Koskinen, those include for instance Nordic Family Book (Nordisk familjebok), National Biography of Finland (Finland's nationalbiografi, Kansallisbiografia), genealogies of old Swedish aristocratic families (Äldre svenska frälsesläkter) and further refereed literature.⁴⁸ As reported by Hakanen and Koskinen the dataset is collected using methodologies of collective biography, new prosopography and source criticism.⁴⁹

Even though the dataset can be assessed as reliable and generally accurate, there is the general problem of some missing data. As seen in the example of Table 2, some of the councillors have missing attributes such as date of birth and therefore age of appointment. The missing attributes are most likely due the fact that during the time span of the dataset there was no standard of civil registration.

The order of keeping parish registers (kyrkobok) was given in the Swedish Church Law 1686 (Kyrkio-Lag och Ordning), six years from the endpoint of the dataset. The Church Law made it mandatory for parish vicars to keep certain records and documents concerning the population and economy of the parish. Among other things these parish registers included the records of marriages, births, christens, deaths and funerals. Despite that the Swedish parish registers have been assessed exceptionally comprehensive by historians, there are some considerable deficiencies due to the differing circumstances

⁴⁶“What are the differences between data, a dataset, and a database?” 2022.

⁴⁷Hakanen and Koskinen 2017b, p. 48. 2017a.

⁴⁸Hakanen and Koskinen 2017b, p. 48, 76; 2017a.

⁴⁹Hakanen and Koskinen 2017b, p. 48.

and practices between parishes, furthermore some of the registers have been destroyed or lost. Even though some records do exist from the 16th and 17th centuries, they are notably dispersed.⁵⁰ A case in point: according to the Dictionary of Swedish National Biography (Svenskt biografiskt lexikon) the birth year of king Gustav Vasa (1495 or 1496) is also an estimate.⁵¹

In practice, one of the registers the 1686 Church Law made mandatory to keep, were the books of births and christens (*födde och döpte / födelse- och dopböcker*). At first, it was necessitated to mark the name of the father, child's birthday and the day of the christen with the first name(s) of the newborn to those records. The act of marking the mother's name and age and the godparents was adopted later, during the 18th century. After all, approximately 10 to 20 per cent of children are estimated to be systematically missing from these records prior to the mid-19th century.⁵²

As the parish registers were kept primarily for the needs of local earthly and religious life, the first official census (population tally) was conducted in the kingdom of Sweden in 1749. Yet, the census was based on the same records kept and collected by the parish vicars.⁵³ Therefore, we have generally quite limited knowledge even on the population of early modern Sweden.

For instance, historian Miikka Voutilainen with statisticians Jouni Helske and Harri Höglmander have calculated the approximations of the population of Finland (eastern part of Sweden) between 1647 and 1850 with the parish registers and censuses. Due to the scatteredness and lack of the data they have utilized the *Bayesian statistics* along with computer simulations to calculate the estimated population. According to their model, the population of Finland was slightly less than 500 000 in the latter half of the 17th century, however, as the authors point out, estimating the population in the 17th century is relatively uncertain.⁵⁴ In *Pohjoinen Suurvalta* Petri Karonen refers to scholars who have previously estimated the population of Sweden being ≈ 1.15 million (Finland ≈ 300 000) in 1570, and ≈ 1.5 million (Finland ≈ 330 000) in 1620.⁵⁵

Speaking of the scatteredness of the early modern source material, Bayesian statistics could be an applicable method on the study of the time period. Bayesian statistics is a separate paradigm in the field of statistics. In Bayesian approaches the concept of probability is thought as *inverse* or *subjective* meaning that the observed outcome is subjected to the previously known (*prior*) data. As an illustration, if we notice a street is wet, we most likely suspect a rain cloud or a Street sweeper instead of aliens crying large tears, based on our prior knowledge. Most of the times Bayesian models are based

⁵⁰Viikki 1994, pp. 169-176.

⁵¹Svalenius 1969.

⁵²Eilola 2021a.

⁵³Eilola 2021b.

⁵⁴Voutilainen, Helske, and Höglander 2020.

⁵⁵Karonen 2014, pp. 33-34.

on computer simulations. Yet, instead of fixed values Bayesian models usually produces *posterior distributions* meaning distributions of the most likely outcomes of the model.⁵⁶

Yet, the focus of this work is not on the ages of the councillors, but in their relations to each other. Missing data still directly affects the observation of the family affiliations. The family links in the dataset are the ones that are recorded in the scattered surviving sources. And due the nature of the historical data, it is more likely that something is lost to time, instead of created out of nowhere. It is extremely unlikely that somehow a significant number of false family links has appeared into the source material, and had that happened, we must work what we have.

Generally, it can be assessed that family links found in the dataset and graph represents the *lower limit* of the actual family ties. It means that the councillors were probably a slightly more connected to each other than observed from the graph. Besides the missing data, the reason for this lays in the programming of the model as discussed later in the subsection 2.1. In the future Bayesian methods could be used to further estimate the uncertainty around the family ties left unnoticed from the modern scholars.

Lastly, as the relatively large dataset is compiled by humans, it leaves some room for typos and errors. While producing the first experimental graph of the dataset, some empty data points were found. These "ghosts" were nodes with only an id number, and one or two links to the other councillors. All in all, there were four "ghosts" with the id numbers 147 (linked to 18 and 152), 215 (linked to 217), 249 (linked to 269) and 254 (linked to 94). With the help of Marko Hakanen it was resolved that those "ghost" nodes were data points removed from the dataset as the authors found out they have not been official councillors, however, some references to their id numbers had been left to the dataset by accident. The "ghost" nodes will be automatically excluded from the latter graphs.

While writing the actual analysis for this thesis, I also came across a question, if counting the Scottish baron Robert Douglas (id 58, 1611-1662) as a councillor was in fact accurate. Robert Douglas was born in Standingstone Scotland in 17th of March 1611. He joined the Swedish army with his two brothers in the early 1630's. He was proven to be successful in his military career, and landed notorious positions in the Swedish army and administration. But according to Kugelberg and colleagues he never became a councillor.⁵⁷

D.[Douglas] besatt även stor duglighet på det civila och administrativa området, varför han ofta användes på andra än rent militära poster. Riksråd blev han dock ej, kanske bl. a. emedan han var reformert.

⁵⁶Kruschke 2015, pp. 16-25. For an example of posterior distribution see e. g. Voutilainen, Helske, and Höglmander 2020, Fig. 3.

⁵⁷Kugelberg, Douglas, and Hildebrand 1945.

(Kugelberg, Douglas, and Hildebrand 1945)

[Douglas was competent in working on the civil and administrative tasks, and therefore he held positions outside the military. He never became a councillor, maybe because he was a (religious) Reformist.]

However, according to the Councillors dataset, Douglas was appointed to the Council in 1657.⁵⁸ This may be caused by an error in the process of collecting the dataset, or an error or conflicting information in the source material, maybe even in the writing of Kugelberg and colleagues. Whether or not Robert Douglas was an actual member of the Council, he still held a significant position amongst the Swedish elite as a Scottish baron.

⁵⁸Hakanen and Koskinen 2017a.

Table 2: Example rows of the dataset: Gyllenhorn, Joen Olsson and Natt och Dag, Måns Johansson (Hakkanen and Koskinen 2017a)

Name	No.	D.O.B.	†	Appointed	Date	Age	Noble rank	Family members in the council	Spouse(s) / Father of Spouse / Date of Marriage
Gyllenhorn, Joen Olsson	82	1556		1529	00.6.		Uradel (Ancient Nobility)	Karin Besé/Nils Nilsson Besé/1529	
Natt och Dag, Måns Johansson	142	1498	1555	1529	00.6.	31	Uradel (Ancient Nobility)	Barbro Eriksdotter Erik Turesson Bielke/ probably 27.6.1524	

Table 3: Example of the raw .csv file

1	Name;	Id;	D.O.B.;	died;	Appointed;	Date;	Age;	Noble_rank;	Family;	Spouse(s) / Father of Spouse / Date of Marriage
2	Ingemar Petri;	162;	;	1530;	1495;	;	;	Estate unknown, Bishop;	;	;
3	Tre Rosor, Ture Jönsson;	231;	;	1532;	1497;	;	;	Uradel (Ancient Nobility); Father CR, Father-in-law CR, Sons 228, Son 230, Son (illegitimate) 175;	Anna Johansdotter / Johan Christiernsson Vasa (CR)	

2 Method

(TODO the history of network analysis) My method is computer aided social network analysis. It is one of the most implemented methods in the field of digital humanities. According to

Quite a few textbooks have been written on (social) network analysis.⁵⁹

To give some examples of the more qualitative side of method: the doctoral dissertations of both historian Marko Hakanen and historian Mirkka Lappalainen have been written using the more theoretical and qualitative methods of network analysis. Marko Hakanen studied the network of clients [lower ranking supporters] around the Count Per Brahe in the 17th century Sweden.⁶⁰ Mirkka Lappalainen on the other hand researched the Creuz family in the 17th century Sweden (and Finland).⁶¹

Alongside these dissertations a master's thesis from the University of Jyväskylä Department of History and Ethnology deserves to be mentioned. In his thesis Jesse Kananen studied the correspondence networks of the rector of the Jyväskylä Seminar Karl Gabriel Leinberg. For his analysis Kananen has collected a remarkable sized dataset of 1147 letters from 487 contacts. Kananen also approaches the subject with a more qualitative stance of social network analysis.⁶²

Besides the subject matter, the inherent form of the graph separates our works. The dataset collected by Kananen forms an **egocentric network**, which means a kind of star shaped network with the one node on the center connected to each node on the sides. However, the links between the nodes on the sides are not taken into account (most of the time).⁶³

Despite on the quantitative sphere, the method in my thesis is still fairly simple and completely explainable. As things like machine learning and artificial intelligence (AI) are particularly popular and to a certain degree hyped at the time of writing, it is important to assess and understand the fundamentals and basics of digital and computational methods. Obviously, it is easier to understand simpler models, and therefore ask important questions. Those questions are for instance: What are the premises for this model? What kind of data is suitable for this model? What kind of interpretations can be made from the results? What is the potential problem, how to fix or adjust the model if something goes wrong or unexpectedly? On the following subsection I will go through the basis of the model.

⁵⁹See e. g. Huhtamäki and Parviainen 2013, or Krishna Raj P. M., Ankith Mohan and K. G. Srinivasan *Practical Social Network Analysis with Python* or Xiaoming Fu et al. *Social Network Analysis: Interdisciplinary Approaches and Case Studies*.

⁶⁰Hakanen 2011.

⁶¹Lappalainen 2005.

⁶²Kananen 2018.

⁶³Kananen 2018, pp. 22-23.

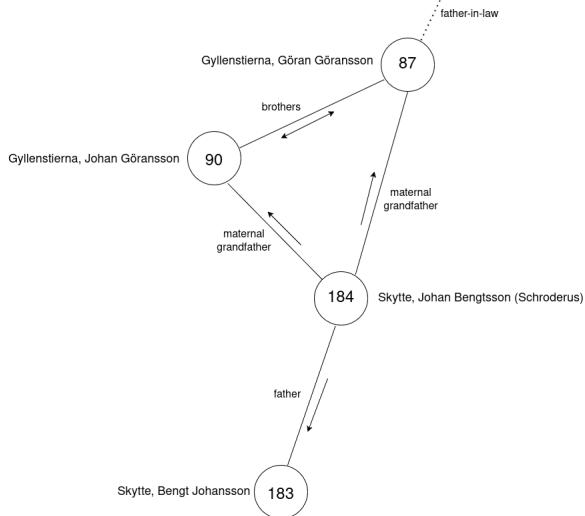


Figure 2: A sample from the graph (Data by Hakanen and Koskinen 2017a graph by author)

2.1 Defining the Network

Network analysis combines mathematics, statistics and social sciences. Primarily it is based on the mathematical graph theory. A graph is a representation of the network. Graph includes **nodes** (also called vertices) and **edges** (also called links and connections).⁶⁴ If an edge exist between nodes, they are called as **neighbors**.⁶⁵

In this context the graph's nodes depict individual councillors with the input of name and id number. Correspondingly the edges represent the kinships between two nodes. For instance, in Figure 2 we can see that Johan Bengtsson (Schroderus) Skytte (id 184) is Bengt Johansson Skytte's (id 183) father, and a maternal grandfather for Johan Göransson Gyllenstierna (id 90) and Göran Göransson Gyllenstierna (id 87). Johan and Göran Göransson are brothers, however, their father is not mentioned in the dataset. Göran Göransson also has further links in the network.

The node depicting Johan Bengtsson (Schroderus) Skytte (id 184) is a neighbor to all of the other nodes. On the contrary the node depicting Bengt Johansson Skytte (id 183) is not neighbor to Johan Göransson Gyllenstierna (id 90) or Göran Göransson Gyllenstierna (id 87). They are linked indirectly, neighbor's neighbors or formally second-order neighbors or distance two neighbors.

A graph can be **directed** or **undirected**. In a directed graph the edges have directions, like in a correspondence network a letter has a sender and a receiver. The directions are marked with an arrow. In undirected graphs the edges are bidirectional [two way], for example a relationship between two brothers can be understood as undirected. Di-

⁶⁴Huhtamäki and Parviainen 2013, p. 247, 248-249. Raj P. M., Mohan, and Srinivasa 2018b, pp. vi-vii.

⁶⁵Raj P. M., Mohan, and Srinivasa 2018b, p. vii.

rected graphs have more features and a more complex structures, for instance, the degrees of inbound and outbound edges can be counted separately.⁶⁶ For simplicity, the graphs presented in this work are undirected.

Calculating different statistics is a crucial part of the network analysis. One of the most important measures is the **node degree**. The node degree simply means the number of edges adjoined to a specific node.⁶⁷ For example, the degree of the node depicting Johan Bengtsson (Schroderus) Skytte (id 184) is three, and the degree of the node depicting Bengt Johansson Skytte (id 183) is one.

The **average degree** is the mean of all the node degrees of the specific graph. It is calculated by adding all the node degrees and dividing the sum with the number of nodes.⁶⁸ In the case of this study, the average degree describes the average number of direct family links councillors had within the Council. The average degree of Figure 2 is $\frac{1+3+2+3}{4} = 2.25$.

The **density** of the network is also based on the node degrees. In a dense network almost every node is connected to each other, but a sparse graph has just a few edges between the nodes. The density is calculated by dividing the number of actual edges with the maximum number of edges. The scale of density is from 0 to 1, 1 implying a **complete graph**. In the complete graph each node is adjoined to each other node.⁶⁹ In practice, density is probably not the most depicting parameter of social networks because it is heavily dependant on the size of the network.

The maximum edges—meaning the amount of all possible edges—increases rapidly with the number of nodes. Formally, the maximum edges follows the *binomial coefficient*. The formula being:⁷⁰

$$\binom{n}{k} = \frac{n!}{k!(n-k)!} = \frac{n(n-1)...(n-k+1)}{k!}$$

In this case $k = 2$, because two nodes share one edge. The variable n is the amount of nodes in the graph. In R environment this can be calculated easily using the function `choose(n,k)`. For example in a graph consisting of 257 nodes (the amount of the councillors in the dataset) the amount of possible edges is 32 896:

$$\binom{257}{2} = \frac{257!}{2!(257-2)!}$$

or `choose(257, 2)` with R.

In practice the rapidly growing amount of possible edges makes it inefficient to compare two graphs of different size. The number of possible edges in a graph with 100 nodes

⁶⁶Raj P. M., Mohan, and Srinivasa 2018a, pp. 1-2.

⁶⁷Raj P. M., Mohan, and Srinivasa 2018a, pp. 2-3.

⁶⁸Raj P. M., Mohan, and Srinivasa 2018a, pp. 3-4.

⁶⁹Raj P. M., Mohan, and Srinivasa 2018a, pp. 5-6.

⁷⁰Laininen 2002, p. 16. Raj P. M., Mohan, and Srinivasa 2018a, pp. 5-6.

is 4 950 and in a graph with 101 nodes it is 5 050 a difference of 100 possible edges. In the context of social networks the difference is significant.

As structures graphs hold a plethora of further possibilities in representing data. For example, attributes like **weight** or **type** could be added to the graph's edges. Weight indicates the strength of the connection, in this case it could mean that a father's tie to son is stronger than the cousins tie with each other. Type indicates the nature of the relationship, such as, brother or son-in-law. The weights and types can be used in categorizing the network or counting statistics. A graph with weighted edges is called **weighted graph**.⁷¹ For simplicity the graphs presented in this work are unweighted and do not hold any attributes on the edges.

2.2 Implementation of the Network Analysis

I use the combination of Python programming language and Gephi software in the data processing and analysis. Python is used for extracting the data from the councillors-dataset and formulating it in the right format: readable for Gephi. Whereas the actual network analysis: visualization and calculating statistics, is performed with Gephi.

Python is a high level⁷² programming language. Python can be used in variety of tasks including data processing, machine learning (AI models) or web development. Python is intended to be of object oriented programming style, however, it is not determined to be used only on that paradigm.⁷³ For instance, my personal programming style is more in the imperative style.

I selected Python due its simple syntax and ease in implementing relatively small tasks in data processing. The language is understandable and widely used amongst scientists, which makes the work replicable. To be precise the scripts are written with Python 3, exact version being Python 3.11.7.

As graphs are structures commonly used in programming, it would have been possible to conduct the actual network analysis using tools provided by Python or R⁷⁴, yet, Gephi software provides a graphical user interface (GUI) and more intuitive tools for the manipulation and visualization of the graph. Furthermore, the Gephi format makes the data and graph accessible also for non programmers.

Gephi is a software for network visualization and analysis. It contains tools for manipulating, filtering, clustering and visualizing the graph. It has built in appliances for fixing

⁷¹Raj P. M., Mohan, and Srinivasa 2018a, pp. 11-12.

⁷²Meaning code intended to be read and understood by humans if compared for example with binary code written only with 0s and 1s.

⁷³Mastrodomenico 2022, p. 1.

⁷⁴See e. g. Raj P.M., Krishna, Ankith Mohan and K.G Srinivasa *Practical Social Network Analysis with Python* or Dehmer, Matthias; Shi, Frank Emmert-Streib and Yongtang Shi *Computational Network Analysis with R*.

errors in data and calculating necessary statistics.⁷⁵ Gephi reads data from text format (comma separated values .csv) or Microsoft Excel tables (XLSX), and Gephi projects are saved as .gephi files. The processed graphs and data can be exported as images or tables.

Nonetheless, Gephi does have some weaknesses. It is not always the most intuitive to use, and especially the visual configurations of the graph causes some issues. I have encountered difficulties with the node labels (the councilor's name next to the node). Sometimes the problems lies in the Gephi settings, but if the whole software crashes when trying to make the node labels visible, the problem lies deep within the software itself. It is most likely caused because Gephi tries to connect to a non-existent graphic card. The problem must be solved while starting the program.⁷⁶

Lastly, I use R programming language and environment for calculations and statistical analysis. R is a language and platform particularly designed for statistical analysis. It contains tools and ready-made functions for efficiently calculating and plotting statistical data.⁷⁷ The language is widely used amongst scientists.

All of these tools are open source and free to download. In the name of replicability and transparency, all scripts written for this work available on my GitHub page.⁷⁸

Following and modifying the steps of network analysis given by Huhtamäki and Parviainen, I listed the following six basic steps in network analysis.⁷⁹ The basic steps are :

1. Choosing the subject and data
2. Pre processing the data for the network analysis
3. Constructing the graph and finding possible issues and errors
4. Counting the statistics
5. Deciding the layout (algorithm)
6. Doing the interpretations

In practice the analysis is not that straightforward, sometimes the steps 2 and 3 must be repeated and re-repeated. Yet, on some circumstances the graph is not visualized or the statistics are not deemed important. These steps will be discussed in practice below.

2.2.1 Test Run

To draft the structure of the graph and understand the nuances of the given data, a test run was carried out. The test run was done with a simple Python script, and no attention

⁷⁵"About Gephi".

⁷⁶For Linux environments opening Gephi from command line with command "LIBGL_ALWAYS_SOFTWARE=1 ./gephi" can sometimes help.

⁷⁷R 2020.

⁷⁸<https://github.com/Heidi-Suurkaulio/mastersthesis>

⁷⁹Huhtamäki and Parviainen 2013, p. 258.

was paid to the temporal aspects of the network or the potential directions within the graph. The script and Gephi project used, and the visualization of the graph of the test run is available in GitHub in the TestRun folder⁸⁰

The data processing was started by manually cleaning the data in LibreOffice Calc (equivalent to Microsoft Excel). The columns and rows containing information of the source material of the dataset and councillor's years active were removed. That made the structure of the data coherent and easier to manipulate with the Python script. The manually cleaned data is exported as .csv (comma separated values) file. The .csv file's header (the first line of the file) should be modified so that the column name "No." is changed to "Id" and "Family members in the council of the realm" is changed to "Family", the first one can cause an error if referenced in the Python code, the latter is inconveniently long.

The script itself reads the data from the .csv file. The connections between the councillors are separated from the "Family" column, based on the knowledge that each connection is marked with the id number of another councillor. The connections are then formatted and printed to .csv file. The connections .csv file containing values for "Source" id of the source concillor, "Target" id of target councillor, "Type" standard "Undirected", "Id" id number for the connection, "Weight" standard 1.0. Another .csv file is formatted and printed with the information of councillors' names and id numbers.

Table 4: Example of the connections .csv file

1	Source,	Target,	Type,	Id,	Weight
2	231,	228,	Undirected,	0,	1.0
3	231,	230,	Undirected,	1,	1.0

Table 5: Example of the councillors .csv file

1	Id;	Label
2	162;	Ingemar Petri
3	231;	Tre Rosor, Ture Jönsson

These .csv files are readable for Gephi. The outcome was an undirected graph of the councillors' affiliation network that had accumulated during the 160 years. The graph consisted of 261 nodes (257 real + 4 "ghosts") and 372 edges (including self loops and "ghost" nodes). The test run revealed three problems within the graph: the emergence of the empty "ghost" nodes, **parallel edges** and thirdly **self loops**.

The "ghost" nodes were excess nodes with no name and only an id number and one or two connections in the graph. They were due to the references to the data points removed from the original dataset, and therefore can be ignored. The ghosts are discussed further

⁸⁰<https://github.com/Heidi-Suurkaulio/masterthesis/tree/main/TestRun>

in the subsection 1.4. However, the more essential problem were parallel edges and self loops.

If multiple edges share the same source and destination nodes, they are called parallel edges.⁸¹ These occur because one relationship, such as father and son, is sometimes marked parallel in the dataset. For example, in the case of Göran Göransson Gyllenstierna (id 87) the relatives are "Maternal Grandfather 184, Brother 90, Father-in-law 3, ...", and the same relationship is found in his grandfather's Johan Bengtsson (Schroderus) Skytte's (id 184) links: "Son 183, Grandson through daughter 87". Yet, the connection to Göran Göransson's brother Johan Göransson Gyllenstierna (id 90) is not marked in the grandfathers links. This means that the node of Göran Göransson Gyllenstierna (id 87) has one excess link compared to his brother's node. The case is visualized in the Figure 2.

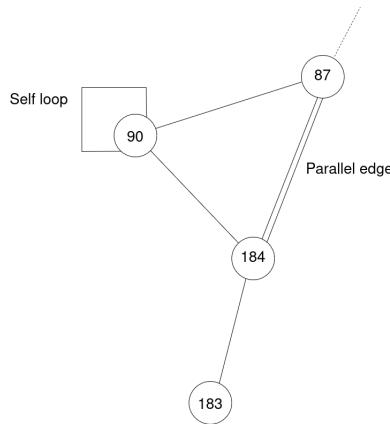


Figure 3: Visualization of the parallel edge and self loop

These duplicate edges would cause bias to the calculation of the node degrees and any statistics based on them. A node degree is a sum of all the edges connected to one node, and if the relationships are inconsistently marked with one or two edges, the factually similar nodes would get different degrees. These inconsistent node degrees would accumulate when counting the average degrees and so forth. The problem of parallel edges is widely recognized in the field of network analysis, and therefore Gephi does have some built-in features for handling it.

While importing data to Gephi (on Import Spreadsheet) the strategy for merging the parallel edges can be chosen. One option is, for example, placing the sum or average of the parallel edges in the edge's degree, yet using only one connection to represent the edge in the graph. In this context a more simple solution was chosen, with the option "First" Gephi will use only the first connection between two nodes ignoring any latter ones. This will reduce the amount of connections from 698 found in the connections.csv to only 372.

⁸¹Raj P. M., Mohan, and Srinivasa 2018a, pp. 14-15.

Self loops occur when one node has—for some reason or another—a connection to itself.⁸² Similarly to the parallel edges, they cause bias to the node degrees. In this graph a self loop can be found at least on the node with id 5 and id 90. In the case of id 5: Gustaf Axelsson Baner, his relatives are "Father 4, Father-in-law 217, Brother 9, Sons 5, 7, 8, 10, Sons-in-law 152 and 197", and similarly with id 90: Johan Göransson Gyllenstierna his family reads "Maternal Grandfather 184, Brother 90". These self loops are most likely caused by a typo in the dataset, because it is reasonable to assume that none is a son or brother to themselves.

Gephi does have a switch whether or not self loops are allowed in the graph, and it can automatically remove them based on the preference. The self loops are present in the test run graph alongside with the ghost nodes, yet those will be removed from the subsequent analysis. To highlight the ghosts they are colored gray, and the four nodes referred as an example here are colored red in the test run graph.

The last step in the preparation of the network analysis is the selection of the layout algorithm. For the test run an algorithm called Yifan Hu was used with default configurations except parameter theta set to 2.0. Then layout option "noOverlap" was chosen to separate possibly overlapping nodes, and some further manual placement of the nodes was done to make the graph more readable. The outcome was visually somewhat dense network in the middle and mostly unconnected isolated nodes around it.

2.3 Fitting Modern Model on a Historical Time Period

Every model is an approximation.

All models are wrong; some models are useful.

(Box et al. 2005, prefix)

George Box with his colleagues have collected aphorisms depicting statistics and model building to the prefix of their book. Those aphorisms emphasize the ambiguous nature of (statistical) models. A graph is elementally a generalizing and simplifying model of complex social networks within the Swedish Council of the Realm. Yet, when building any kinds of (computational) models, decisions between the complexity and abstraction must be made. In fact besides too simplifying models, too complex or overfitted ones are a problem on their own.⁸³ Due that, one of the most important question is what factors to include and and what to exclude. Yet, a more existential question is what we can even know about historical social networks.

As I am working with pre-collected data, many of the significant choices have been made by the authors of the dataset, Hakanen and Koskinen, and by the scholars their work is leaning on. Thus, it is important to understand the limitations of the data

⁸²Raj P. M., Mohan, and Srinivasa 2018a, p. 13.

⁸³TODO

and model. The data—and consequently the graph—is able to give an abstraction of the officially recorded family links inside the Council of the Realm. However, with the data in question, it is not possible to know about the messy every day relationships, friendships, informal discussions, intentions, emotions or disputes these 257 men have had.

In essence historical data has its limitations, and when it comes to the study of early modern period, the scholars are working with a finite body of source material. As mentioned in the section 1.4 the national order of keeping records of the parish population was given in 1686. And, source material concerning lower social estates like peasants and groups like women or marginalized people are even harder to find. This means that the scholars must combine separate bodies existing sources to form interpretations.⁸⁴

Also the early modern high society was ruled by (adult) men, and source material left by women or different age groups like children is lacking.⁸⁵ Noblewomen held unofficial and invisible power. They formed social relationships, wrote letters and negotiated marriages in the gatherings and festivities.⁸⁶ The law of Sweden also granted the right of inheritance for women, which meant that they sometimes held massive fortunes.⁸⁷ Aristocratic women are also included in the contemporary lineage diagrams as seen later in Figure 4, which in itself means that they held meaning and status recognized in the social realm. Therefore building a graph including noblewomen or a graph depicting noblemen with their clients would be an achievable task in the future.

As discussed in the beginning of this section (2) networks were not explicitly part of the early modern social or political theory. However, did the contemporaries understand their social relations—families and friendships—as networks is a more complex question. And it probably cannot ever be answered undisputedly. Still, when applying a modern model to historical context, it is important to remember that we are operating on modern time with modern understanding, and be aware of the possible anachronisms.

Early modern Sweden was a hierarchical and unequal society. The social order was divided into four estates: the Nobles, the Clergy, the Burghers and the Peasants, which all had their own privileges and duties. Most of the privileges belonged to the Nobles while the Peasants had practically none. Even though the ideal of the society was static—everything and everyone had its own place—social mobility amongst the estates did happen.⁸⁸

The social structure was justified by the Lutheran theology and religion. According to Lutheran doctrine, God had chosen the monarch to hold the Divine power and justice on Earth, as God did in the Kingdom of Heaven. The disrespect of the monarch became a taboo, and an unexpiated sin would doom the whole community to face the God's wrath.

⁸⁴Fagerlund 1999, p. 218.

⁸⁵Lappalainen 2013, p. 158; 2013, pp. 40-41.

⁸⁶Hakanen, Haikari, and Koskinen 2020, pp. 140-142; Lappalainen 2013, pp. 40-41.

⁸⁷Lahtinen 2020, p. 43; Lappalainen 2013, p. 40.

⁸⁸Karonen 2009a, pp. 21-23, Karonen and Hakanen 2017, pp. 21-22.

A consensus and harmony were seen as ideals in the political sphere.⁸⁹

Historian Mirkka Lappalainen describes the mentality and circumstances in the early modern Norden vividly in her monograph on the famine and mortality crises of Finland in 1690's, *Jumalan vihan ruoska*. During the time period Northern Europe went through "the Little Ice Age", when the average temperature dropped. The cooling of the average temperature meant instability and extremes in the weather patterns, like arctic winters, chilly summers, continuous rainfall or drought. Europe was also torn by wars of religious and/or political origins. The society heavily dependent on the agriculture was vulnerable to these circumstances, and generally the mentality was to be prepared for the apocalypse and the End of the Earth as prophesied in the Bible. The contemporary *Baroque* art with the *Vanitas* paintings of skulls and blown out candles symbolized the feeling of lingering doom.⁹⁰

Sometimes explanations for the bad weather, crop failures and losses in war were looked from the unexpiated sins and even witchcraft. The volatile circumstances contributed to the spread of the witch hunts in Europe.⁹¹ These reactions and rationalizations can be understood in their context, overall life was uncertain and contingent.

Facing the death was commonplace and more present in the culture. In fact the kingdom of Sweden went through five significant crop failures or full-blown famines during the time period from 1520 to 1680. These crises happened in the late 1590's, from 1601 to 1603, between 1633 and 1634, from 1650 to 1652 and in 1675. The crises caused havoc locally, and sometimes throughout the land. Especially in Finland the year 1601 (*olkivuosi* "the year of straws") has been reported of being one of the most severe famines in the early modern period.⁹² Aristocrats did not starve to death, but they were not safe either, they faced the consequences of these crises in the form of spreading epidemics.⁹³ And if the crop failures in 1601 was not enough, it was the same year duke Charles unleashed his outrage upon his enemies.

The quest for changelessness and harmony—the immutable order of the Cosmos—was emphasized in the uncertain times.⁹⁴ For instance, a widely known manuscript from early modern period *Hortus Regius* ("the Royal Guarden") can be used to illustrate the worldview of the early modern nobility. *Hortus Regius* is digitized and freely available on the internet making it easy to approach.⁹⁵ The book was given to queen Christina by a diplomat Shering Rosenhane (1609-1663) in circa 1645. It consists of delicately illustrated

⁸⁹Karonen 2009a, pp. 24-28, 2014, pp. 161-163.

⁹⁰Lappalainen 2012, pp. 23-25.

⁹¹Lappalainen 2012, pp. 23-29.

⁹²Drike, Olsson, and Svensson 2015, pp. 9-11.

⁹³Lappalainen 2013, p. 159.

⁹⁴Hakanen, Haikari, and Koskinen 2020, p. 150.

⁹⁵In 2025: Internet Archive: <https://archive.org/details/urn-nbn-se-kb-digark-4937173-mode/1up> Library of Congress: https://www.loc.gov/resource/gdcwdl.wdl_17187/?st=gallery.



Figure 4: Lineage of the house of Vasa from the *Hortus Regius* or "Queen Christina's Genealogical Tree with Political Emblems".(Rosenhane and Holsteyn (artist) 1645)

political emblems⁹⁶ and noble family trees leading to queen Christina.⁹⁷ The manuscript has been widely used by scholars of early modern Norden.

In *Pohjoinen suurvalta* Petri Karonen interprets the drawing of a building and scale found in *Hortus Regius* as a metaphor to the structure of the kingdom. The building consists of four floors on top of each other. Each floor represents each estate. Next to the building is a scale with a crown on one side and the symbols of the four estates on the other. When the crown and the symbols are both present, the scale is in equilibrium. The hierarchical structure of the building with the scale were symbols of the ideal static, harmonious and immutable world order.⁹⁸

When it comes to the subject of this work, the more relevant parts of the manuscript are the family trees. In *Hortus Regius* there are nine genealogy charts depicting royal families in Europe at the time. The charts are drawn as trees with filigree leaves, and beautiful backgrounds and animals such as lions, horses and deer beside them. The orna-

⁹⁶Instructions, virtues, metaphors

⁹⁷"Hortus Regius" or Queen Christina's Genealogical Tree with Political Emblems."; Blennow 2023, p. 271.

⁹⁸Karonen 2014, pp. 162-165.

ments probably holding meaningful symbolism.⁹⁹ Figure 4 is a portrayal of the patrilineal tree of queen Christina and also the Vasa dynasty.

Gustavus Vasa "Gustavus I Rex" is found on the trunk of the tree. His children—including the female descendants—and their families are depicted as the branches. Gustavus Vasa's son and Christina's grandfather king Charles IX "Carolus IX Rex" and Christina's father Gustavus Adolphus "Gustavus Adolphus Rex" can be found near the treetop. Christina herself "Christina Regina" is on the top of the tree with a crown.

Interestingly, some political picks are easy to spot on the genealogy chart of Vasa dynasty. The branch of Gustavus Vasa's son king Eric XIV (1533-1577) "Ericus 14 Rex(TODO check)" is broken violently leaving behind just a sharp cutting. In fact Eric was dethroned by his brother duke John (1537-1592, future king John III) and later poisoned.¹⁰⁰ Yet, no mention of Eric's two children with his wife of ignoble birth Karin Månsdotter can be found either. These political choices are understandable when thinking the family tree in its context.

As a matter of fact, genealogy charts were of a high value to the aristocracy on the early modern timeperiod. Family trees were to prove the noble birth and blood, and therefore to legitimate the high status and rank (the position signed by God). The charts have been so valuable that in some cases they have been enhanced or even forged.¹⁰¹ Family trees were politics. For example the long religious and civil wars forced the French noble families to reassess and redraw their affiliations with one another, and further with the monarchs in the latter half of the 16th century. While some European noble houses went so far, that they constructed a genealogy charts with biblical, Roman or Trojan heroes as their early ancestry, generally the practice of genealogy took a more critical and evidence-based stance towards the end of the 17th century.¹⁰²

Ideally the aristocratic blood, possessions, position and wealth were inherited through patrilineal path, from father to son, but due the high child mortality in the early modern time, many families were left without legal inheritors. In fact many ennobled family lines died down during the 17th century.¹⁰³ Possibly due the harsh realities of life's contingency and high child mortality, aristocrats in the early modern Sweden took the matrilineal heritage into account, and women were granted of inheritance of landed property.¹⁰⁴ As an analogue, the *Hortus Regius* has a delicate drawing of queen Christina's matrilineal heritages.¹⁰⁵

Marriage was the another way of inheriting and uniting property and social status.

⁹⁹Rosenhane and Holsteyn (artist) 1645.

¹⁰⁰Melin, Johansson, and Hedenborg 2006, pp. 118-124.

¹⁰¹Friedrich 2018, pp. 192-197; Hakanen, Haikari, and Koskinen 2020, p. 150; Lappalainen 2013, p. 158.

¹⁰²Friedrich 2018, pp. 192-197.

¹⁰³Lappalainen 2013, pp. 158-160.

¹⁰⁴Lahtinen 2020, p. 43; Lappalainen 2013, p. 40.

¹⁰⁵Rosenhane and Holsteyn (artist) 1645.

According to Mirkka Lappalainen the noble marriages in the early modern period were mostly a mix of social opportunism with a genuine companionship and attraction between the spouses. The ideal of marriage was a harmonious companionship, and it was considered barbaric to force marriage, therefore forced marriages were of an exception. A rise in the social hierarchy through marriage was easier for women, and especially girls were tried to be married off to a suitor with a higher rank.¹⁰⁶

In the early modern Sweden divorce was not practically an option. Yet, because common illnesses like flu and states like pregnancy and childbirth could easily turn deadly, many marriages—happy or not—ended as Death did the couple apart. Usually aristocrats who lived till their 50s and 60s, had been married and widowed approximately two to three times during their lives. The marriages and remarriages formed large stepfamilies and larger family networks.¹⁰⁷

While marrying a cousin in the early modern Sweden was not illegal, it was considered weird and undesirable, the family networks were generally larger but more sparse. Instead of tightly knit network of one dynasty, the networks included plethora of notable families.¹⁰⁸ Mirkka Lappalainen approximates that in the 16th century the Swedish political elite consisted of around 20 families.¹⁰⁹ As marriages are an integral part of inheritance in the early modern Sweden the family links through marriage are not distinguished from the ones through blood in the Councillors of the Realm dataset or the graph depicting it.¹¹⁰

Outside of marriage, but related through blood, the illegitimate children were an anomaly in the early modern society. Premarital and extramarital affairs were forbidden in the Swedish law and morale of the time. The law enforcement was however directed at the common people. Upper nobility was practically above of the law, and the scandals were taken care of discretely in private. While we do have evidence of a number of illegitimate children, many nobles were in fact deeply religious, and did not have affairs outside of the Holy Matrimony.¹¹¹

Illegitimate children are found in the Councillors dataset. For example Tore Jönsson Tre Rosor (id 231, died 1532) had his illegitimate son Jacob Turesson Rosengren (id 175, died 1571) in the council. Carl Carlsson Gyllenhielm (id 81, 1574-1650) was the illegitimate son of Charles IX, and Gustaf Gustafsson af Vasaborg (id 241, 1616-1653) was the illegitimate son of Gustav II Adolf.¹¹²

As marriages, alliances and the art of genealogy were of a high value in the early modern culture, a compelling question is whether or not those family trees can be understood

¹⁰⁶Lappalainen 2013, pp. 33-42.

¹⁰⁷Lappalainen 2013, pp. 35-42.

¹⁰⁸Lappalainen 2013, p. 40.

¹⁰⁹Lappalainen 2009, p. 55.

¹¹⁰Hakanen and Koskinen 2017a.

¹¹¹Lappalainen 2013, pp. 36-37.

¹¹²Hakanen and Koskinen 2017a.

as networks. To get an intuitive opinion I have had unofficial discussions with my friends and colleagues about the subject matter and most of them have counted family trees as networks without doubt. Family trees also fit the mathematical criteria of a graph with nodes (persons) and directed edges (inheritance). Formally $G(V, E)$ where V means the vertices and E means the edges of graph G.¹¹³

Some text books have depicted family trees as examples of simple networks.¹¹⁴ While some scholars explicitly describe family trees as (sparse) graphs.¹¹⁵ Obviously, in early modern times family trees have not been used in the sense of network analysis or as analytical tools, as we know them today, but the contemporaries may have still been more familiar with the idea of network thinking than we may think.

2.4 The Script

For the conclusive analysis, I did some improvements to the Python script. The script is available in GitHub¹¹⁶ and can be found in Appendix A. The viable version of the script is largely based on the test run script, however I added the functionality and did some refactoring; adjustments to make the code more slick.

The script reads and prints data in exactly same format as the previous one. The input data must be formatted similarly to the example of Table 2 in the .csv format. However, the name of the input file is given as a command line parameter. The new functionality is that also the timerange of the network can be delimited with command line parameters. As a side-effect of the timerange functionality, the "ghost" nodes discussed in Chapter 1.4 are removed automatically.

The format of the command is as follows:

```
python data_sifter.py Councillors_of_the_Realm1523-1680.csv
```

This produces the network from the original time period given in the dataset. And, for example, command "python data_sifter.py <dataset.csv> prior 1650" and "python data_sifter.py <dataset.csv> post 1590" limits the networks to councillors and their relatives appointed before 1650 or after 1590. Lastly the command "python data_sifter.py <dataset.csv> 1540 1620" delimits the network to councillors and their relatives appointed between 1540 and 1620.

When it comes to the script and the graph, I made some simplifications. The types of the relationships, such as brother, grandfather or brother-in-law, are not taken into account. Each relationship is taken from the dataset by the Id number and marked as an undirected edge with weight standard 1.0. This means that the graph does not

¹¹³Raj P. M., Mohan, and Srinivasa 2018b, p. vii.

¹¹⁴See e. g. Huhtamäki and Parviainen 2013, p. 247.

¹¹⁵Batagelj and Mrvar 2008.

¹¹⁶<https://github.com/Heidi-Suurkaulio/mastersthesis/tree/main/PythonScript>

Table 6: Example of the test dataset

Name;	Id;	Appointed;	Family
A;	1;	1000;	example 11
B;	2;	1000;	3, 4

separate blood relations, the relationships formed through marriages or illegitimate blood relations. As in the previous research, the family ties in general are mentioned to have been valuable, this graph depicts family ties as an abstraction.¹¹⁷

The second simplification is that only the years of appointments are taken into account, but the years of death are not. Most of the time the position of the councillor was a lifelong.¹¹⁸ So, the graph can not give a defined picture of the amount of the councillors active during a certain timeperiod. Basically the graph represents the family network of councillors appointed during certain timeperiod, and answers the question: *Who were appointed to the Council and to which degree they were related to each other?* The script could be further develop into regognizing the type of the relationship and taking the years of death—the obvious end to the position—into account.

2.4.1 Testing the Script

Before anything else the script had to be tested. Testing is one of the most important—yet daunting—task in programming. Due the size and complexity of the Councillors dataset, the Python script is hard and ambiguous to test with the original data. To test the logic and behavior of the script I crated a small test dataset with simple dummy data. The test dataset is intentionally so small that it is readable by human. With the script the test dataset is available in GitHub.¹¹⁹

The test dataset consist of 12 entries with values for name, id number, (year of) appointment and family links. The names are represented by capital alphabets from A to L, and ids are sequential numbers from 1 to 12. The values in appointment-column are numbers between 1000 and 1299, and there are intentionally four entries within every range of 100. The family links are represented by numbers found in the ids except one which should be excluded by the script if everything works as planned.

When run with default setting the test dataset should produce 13 connections excluding the connection to the non-existent id 30, as it does. Giving the range 1000-1999, 1100-1199 and 1200-1299 as arguments divides the dataset in the groups of four as intended. Lastly giving the "prior 1150" and "post 1138" as arguments reduces the amount of entries and connections as expected. With the small test dataset the algorithm should work as intended. Inconveniently, the accuracy of the connections still has to be checked

¹¹⁷See subsection 2.3.

¹¹⁸Hakanen and Koskinen 2017b, TODO.

¹¹⁹<https://github.com/Heidi-Suurkaulio/mastersthesis/tree/main/PythonScript>

manually.

The graph consisting of 257 nodes is way too complex for a human eyes and brain to inspect thoroughly. Therefore I compared parts of the connections in the largest graph with the connections in the dataset. This means that samples of the actual graph is checked by human.

Lastly, to roughly review the results the script gives with the original dataset, I used some simple R script with R's ready-made functions to do some duplicate checking on the number of nodes. For the number prior to year 1600 the R script gave 111, and post year 1601 the R script gave 146. These are the R script gave the expected results.

Table 7: Absolute amount in different ranks (Data by Hakanen and Koskinen 2017a, statistics by author)

Commoner	Ennobled	Estate unknown	Unknown	Ancient nobility	
5	8	7	1	236	= 257

Table 8: Proportional amount in different ranks

Commoner	Ennobled	Estate unknown	Unknown	Ancient nobility	
1.9	3.1	2.7	0.3	91.8	$\approx \%$

3 Family Ties Between 1523 and 1680

During the time period between 1523 and 1680 there were 257 men active in the Council of the Realm. As discussed earlier in subsection 1.3 the council consisted mostly of men with noble background. To quantify this: according to the dataset 236 of the 257 councillors (91.8%) were part of the ancient nobility (*uradel*), and only approximately 5% were of unknown or ignoble background, most of the time bishops or other clerics.

The kingdom of Sweden was ruled by nine monarchs: Gustavus Vasa (1523-1560), Eric XIV (1560-1568), John III (1568-1592), Sigismund (1592-1599), Charles IX (1599-1611), Gustavus Adolphus (1611-1632), Christina (1644-1654), Carl X Gustav (1654-1660) and Carles XI (1672-1697), and two regnants from 1632 to 1644 and from 1660 to 1672 during the time period.¹²⁰ The amount of councillors appointed by each monarch¹²¹ or regnant varied from none to 56. Yet, 13 councillors present in the dataset had been appointed before the reign of Gustavus Vasa.

The monarchs who appointed the most councillors were Gustavus Vasa (56) and queen Christina (45). The large number of councillors appointed by Gustavus Vasa may be explained by the sheer length of his reign. He ruled Sweden for 37 years, whereas all of the other monarchs ruled less than 20 years. Also the religious Reformation was performed during his reign. The bishops and clerics that lost their position in the Council were replaced by noblemen chosen by the king.¹²² As queen Christina ruled only for ten years, the exceptionally high number on her reign is interesting. Therefore, her reign will be discussed in greater detail in subsection 3.3.

However, the king who appointed no new councillors was the son of king John III: Sigismund (1566-1632). He was both the king of Poland and Sweden forming a personal union between the two countries. Why king Sigismud did not appoint any new councillors?

Sigismund was the son of king John III and his wife Catarina Jagellonica (1526-1583).

¹²⁰Lappalainen 2013, p. 11.

¹²¹Calculated with a R script. To avoid the script dublicating the years that the monarch changed, the beginning of each reign is adjusted, the actual year + 1. E. g. Eric XIV's reign is calculated 1561-1568, the actual being 1560-1668. This may cause slight inaccuracy.

¹²²Karonen 2014, TODO.

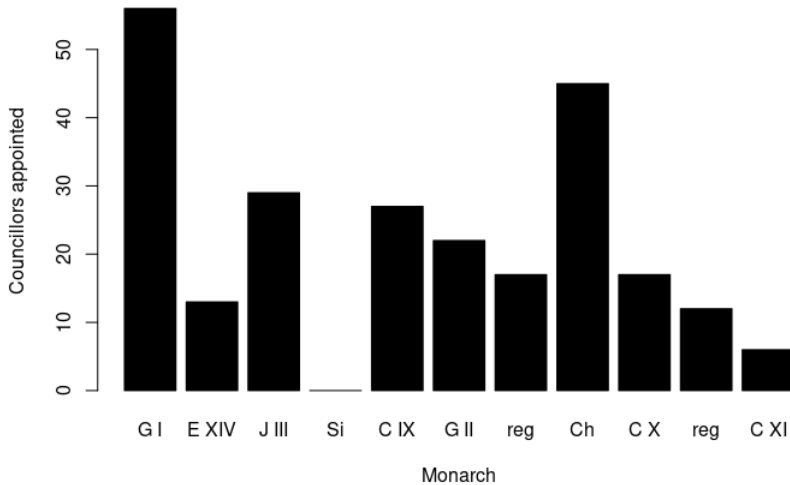


Figure 5: Number of councillors appointed by each monarch or regnant from 1523 to 1680. (Data by Hakanen and Koskinen 2017a, figure by author) From left to right G I: Gustavus I Vasa (1523-1560), E XIV: Eric XIV (1560-1568), J III: John III (1568-1592), Si: Sigismund (1592-1599), C IX: Charles IX (1599-1611), G II: Gustavus Adolphus (1611-1632), reg: regnant (1632-1644), Ch: Christina (1644-1654), C X: Carl X Gustav (1654-1660), reg: regnant (1660-1672) and C XI: Carles XI (1672-1697).

Catarina Jagellonica was a descendant of the European royalty, remarkably she was the sister of the king of Poland, and a daughter of Milan princess Bona Sforza (1494-1557)¹²³. Sigismund was born in 20th of June 1566 while his parents were imprisoned by John's brother king Eric XIV in the Gripsholm castle. Due his mother's position and faith, Sigismund was raised as a Catholic.¹²⁴

Sigismund was elected to be the king of Poland in 1587. After his father's death in 1593 Sigismund also inherited the throne of Sweden. Sigismund's enforcement of the Catholic faith caused fear and suspicion amongst his Swedish subjects, and the interactions between the parties have been described as suddenly antagonistic. The tense situation culminated in a civil war won by the duke Charles in 1599 (or 1604), as Sigismund lost his kingship of Sweden in 1599.¹²⁵ Even though he was not particularly popular in Poland either, Sigismund remained the king till his death in 1632. The Polish crown was inherited by his oldest son Vladislav.¹²⁶

It seems that the answer on why Sigismund appointed no councillors lies in the overall mistrust between the king and his subjects. Sigismund was not a particularly popular king amongst the Swedish nobility, and vice versa, he did not trust his councils in Sweden.

¹²³For more info see e. g. Güttnar 2020.

¹²⁴Lappalainen 2009, p. 27, 47.

¹²⁵Lappalainen 2009, pp. 49-52, 78-81, 100-111, 259-267. Östergren 2003/2006.

¹²⁶Östergren 2003/2006.

All of the councillors active between 1523 and 1680 are represented in a graph of 257 nodes and 362 edges, with self loops and parallel edges removed. The number of edges exceeds the number of nodes which means that theoretically all of the nodes could be linked to one another. Although, the edges are not distributed that way. Some of the nodes are linked to more than one other node, but some isolated nodes are indeed present. The average degree of the graph is $2.817 \approx 2.8$ meaning that councillors typically had 2 or 3 direct relations to another members of the Council.

The graph density is 0.011. In the mathematical definition the graph is sparse (scale from 0 to 1). However, interpretation in practical sense is not that straightforward. Having a completely dense social network, meaning that every node is directly linked to each other, is almost impossible. In this context it would mean, that each councillor is a direct relative through blood or marriage to each other, which would be weird to say at least. Further, taking the dimension of time into account, the mathematical interpretation would be even more nonsensical: how a nobleman appointed to the council in the 1670's could be directly linked to a bishop died in 1530's.

The question whether or not the councillors were highly linked to each other is more of a qualitative one. In the context of early modern institution, how we define a highly linked or even nepotistic institution? Probably the graph density has more explanatory value as a parameter to be compared between graphs collected from other contemporary communities.

Even so, the proportion of the nodes with at least one connection in the graph is $224/257 \approx 0.8715$ Which means that between 1520 and 1680 the probability of a councillor being related to someone else in the Council is $\approx 87\%$. In that sense the councillors can be considered highly networked.

Another interesting finding are the nodes with the highest and lowest degree. Maybe the most eclectic and fascinating group is the isolated nodes. There are 33 isolated nodes meaning that 33 councillors did not have any family ties within the Council. Some of them are members of the nobility with family ties to councillors active prior the beginning year of the dataset, so the connections are excluded from this graph. These are for example: Ture Bengtsson Lilliesparre (127) or Nils Olofsson Vinge (242). Yet, some of the isolated nodes represent bishops and clerics like Magnus Sommar (186) or Ingemar Petri (162) present in the Council before the religious Reformation.

Besides that, the isolated nodes also reveal something about the international relationships during the time period. For example a teacher from France Dionysius Beurraeus (id 12, 1507-1567) or a Scottish baron Robert Douglas (id 58, 1611-1662) can be found. Dionysius Beurraeus came to Sweden invited by Conrad von Pyhy (id 168, circa 1500-1553) in 1543. Due his knowledge in mathematics and medicine Beurraeus took part in the upbringing and teaching Gustav Vasa's sons in the Swedish court. He became close with the king Eric XIV and was appointed to the Council in 1562. However, his life ended

dramatically only five years later, in 1567 in the violent outburst of the unstable king. The act of violence is called *Sturemorden* (murder of Sture family).¹²⁷

As discussed in the end of subsection 1.4, it is hard to say for sure, whether or not Robert Douglas (id 58) was in fact a member of the Council, but regardless of his official position as a councillor, he held a significant standing amongst the Swedish aristocracy in the mid-17 century. Also the famous German born chancellor Conrad von Pyhy (id 168) is represented as an isolated node. During his stay in Sweden von Pyhy had a significant impact on the politics of Gustavus Vasa.¹²⁸ This means that as a merited foreigner one could make their way up to the Swedish Council of the Realm.

On the contrary, the nodes with the highest degree (≥ 5) are of councillors who are part of the old well established aristocratic families like De la Gardie, Oxentierna, Gyllenstierna, Bielke, Stenbock, Sparre and Ribbing. Also Finnish families of Horn and Kurck can be found.¹²⁹ That in itself ties to the previously known fact that the aristocratic families had a remarkable stance in the negotiations and politics of the Swedish kingdom.

To focus more on the temporal dimension of the graph, I decided to divide the dataset in half. As seen in Figure 1 the most intuitive point to do the division is between years 1600 and 1601. By year 1601 duke Charles had won the civil war against king Sigismund and he practically decimated the Council of the Realm while eliminating the noblemen loyal to the former king. However, by 1602 he had to appoint 15 new councillors in order to manage the growing number of tasks in diplomacy and administration.¹³⁰ By coincidence, year 1601 also divides the time range of the dataset almost in half. The first graph depicts the network prior to year 1600 and the latter one post year 1601, so both of these represent the family ties accumulated approximately for 80 years.

3.1 Prior to Year 1600

The graph depicts the family links within the Council during most of the 16th century. It consists of 111 nodes and 92 edges. In this case the number of edges subceeds the number of nodes meaning that at least some isolated nodes must be present.

The average degree in this graph is $1.658 \approx 1.7$, meaning that typically councillors were directly related to one or two other members. The number is smaller than in the larger graph. However, it can be partly explained by the shorter time range, simply the family networks had not have enough time to accumulate. Thereafter, the closest comparison is the graph of councillors family ties post 1601, which will be discussed later.

The graph density is 0.015, although, comparing that to the larger graph is not that

¹²⁷Landberg 1924.

¹²⁸Karonen 2014, pp. 81-83.

¹²⁹TODO

¹³⁰See subsection 1.3

straightforward. The amount of nodes having at least one connection is $85/111 \approx 0.765$ meaning that the probability of councillors to be linked at least one other member is $\approx 77\%$. That is 10 percentage points smaller than in the larger graph. Even though this prior to year 1600 graph is not directly comparable with the larger graph, it indicates that the family links in the 16th century were more sparse.

The amount of isolated nodes is significant: 26—whereas in the larger graph it was 33. The fact that all of the bishops and clerics must be present in this graph partly explains this. Limiting the time range also breaks some of the existing links, so for example, Pontus De la Gardie seems to be without any connections in that graph, even though his descendants were remarkably woven into the networks of Swedish aristocracy. Taking these factors into account, still the relatively high number of isolated nodes may suggest the relatively high number of incomers and larger social mobility in general.

The nodes with highest degree (≥ 4) were of the remarkable noble families such as Bielke and Stenbock, however the Bååt family is more apparent in this particular graph than in the larger one or any of the latter ones. Why did the family name disappear? According to Swedish *Riddarhuset*-website the family was extinct in the 17th century (extinct on the male line *Utdöd svärdssidan* in 24.12.1654 and extinct on the female line *Utdöd spinnssidan*¹³¹ in 1698 or 1699).¹³² It seems that the family was indeed in the process of dying down during the time period, as usually happened to the noble houses of the 17th century.¹³³

3.1.1 The Last Man Standing: Nils Gyllenstierna

The latter half of the 16th century and especially the turn of the 17th century was politically turbulent time in the kingdom of Sweden. The latter half of the 16th century being affected by the rivalry between the sons of Gustavus Vasa which culminated in the civil war during the 1590's. The battle between king Sigismund and duke Charles was won by duke Charles, who later directed his spite upon the Council of the Realm. Many of the councillors were executed or fled Sweden. Despite that the Council was almost fully devastated in 1601, one councillor was left behind: Nils Göransson Gyllenstierna (id 91, 1526-1601).

Due to these circumstances, Nils Gyllenstierna had an exceptional political career. He was a nobleman born in 1526 to a family with three generations of councillors. In his youth he studied in the university of Wittenberg. In autumn 1560 he was given the title of a chancellor and appointed to the Council of the Realm by Eric XIV, at the age of 35.¹³⁴

¹³¹Sword and "spinn" → spindle (tool for making yarn).

¹³²"Bååt - Adlig - Nr. 3".

¹³³See subsection 2.3

¹³⁴Andersson 1967/1969.

He did outlive the rivalries of the Gustavus Vasa's sons, yet only slightly. In year 1597 he was already elderly, ill and weak, but almost got executed by the command of Duke Charles.¹³⁵ He was mostly able to stay away from the heat of the conflicts between the Council and duke Charles, and in the late 1590's he declined the invitations to the Diet and the Council meetings, by claiming his old age.¹³⁶ When he died of natural causes in 1601 at the age of 75, he had served a total of 41 years in the Council.¹³⁷ Somehow he had been able to keep his position throughout all of the Gustavus Vasa's sons reigns. Retroactively it seems that his tactic was not to take sides, and not to be in the wrong place at the wrong time.

Nils Göransson Gyllenstierna (id 91) had a significant amount of councillors directly related to him. His father Göran Eriksson Gyllenstierna (id 88, 1498-1575) and son Jöran Nilsson Gyllenstierna (id 86, 1575-1618) were in the Council. His father-in-law Axel Eriksson Bielke (id 13, circa 1500-1559) was a councillor. He had also four sons-in-law in the Council. Overall, he had seven direct connections, and several indirect ones. The degree of the node representing him was seven, and the node was amongst the 8.17% which had degree of ≥ 7 . If the indirect connections are counted to the distance of three¹³⁸, the indirect connections consists of 72 nodes. Meaning $\approx 28\%$ of the dataset's councillors are within three connections from Nils Göransson Gyllenstierna.

The last councillor to be executed in Sweden was Hogenskild Nilsson Bielke (id 16). He was born in 1538, and appointed to the Council by king Eric XIV in 1562 at the age of 24.¹³⁹ In his youth he studied in Finnish town of Turku and later in famous European universities, and was influenced by the teachings of the Finnish reformer Mikael Agricola. In 1569 he married Anna Sture (1541-1595) the daughter of Svante Stensson Sture(id 217, 1517-1567).¹⁴⁰ Due his exceptional education has been described as the spokesperson of the old nobility.¹⁴¹

In year 1600 he became suspected of treason by duke Charles and was imprisoned in Linköping. The legal process took five years, but consequently he was sentenced to death of high treason, and executed in 3rd of June 1605 at the age of 67.¹⁴² All in all, he had served in the Council of the Realm for 36 years (being inactive for two years between 1590-1591).¹⁴³

Hogenskild Nilsson Bielke does not seem to have had a firm network of related councillors behind him, that does not mean that he did not have a network of supporters

¹³⁵Lappalainen 2009, pp. 205-206.

¹³⁶Andersson 1967/1969.

¹³⁷Hakanen and Koskinen 2017a.

¹³⁸Meaning that the node's neighbors, neighbors' neighbors and neighbors' neighbors' neighbors are counted. See section 2.1.

¹³⁹Hakanen and Koskinen 2017b, p. 58. 2017a.

¹⁴⁰Berg 1924.

¹⁴¹Lappalainen 2009, p. 55.

¹⁴²Berg 1924.

¹⁴³Hakanen and Koskinen 2017a.

Table 9: Number of edges needed for different densities of network. The observed numbers are bolded

Density	Amount of possible edges		
	32 896 (all)	6 105 (prior to 1600)	10 585 (post 1601)
0.011	361.9	67.2	116.4
0.015	493.5	91.6	158.8
0.0174	572.4	106.2	184.2

and allies, which he most likely had. His only direct connection on the graph was to his father-in-law Svante Stensson Sture (id 217). In fact, Svante Stensson Sture with his two sons Nils and Erik Sture were tragically killed—directly or indirectly—on the hands of Eric XIV in 1567. Besides Svante Sture and his sons, the violent act of *Sturemorden* claimed at least three more victims, Abraham Gustavsson Stenbock, Ivar Ivarsson Liljeörn and Eric’s own teacher Dionysius Beurraeus (id 12). Svante Sturesson Sture was buried together with his two sons.¹⁴⁴ This means that both Hogenskild Nilsson Bielke and Svante Stensson Sture were put to death by Gustav Vasa’s sons.

3.2 Post Duke Charles’ Revenge

Practically, this graph begins from the year 1602 when duke Charles had to appoint 15 new councillors and the Council of the Realm was re-established. The graph consists of 146 nodes and 184 edges, now the number of edges exceeds the number of nodes. After 1601 (or 1602) the average degree of node is $2.251 \approx 2.3$, larger than the 1.7 prior to 1600. Also, visually the graph seems more dense.

The number of isolated nodes is significantly lower: 16, compared to the 26 prior to 1600 or the 33 in the whole time period. Again it still must be remembered that limiting the time range cuts some family ties present in the dataset. Subsequently, the proportion of nodes with at least one edge is $130/146 \approx 0.89$, thereby, the probability of councillor having at least one direct relation in the Council was now $\approx 89\%$. That is 12 percentage points greater than the 77% in the 16th century, and two percentage points greater than the 87% from the whole time period.

Also the density of this graph is the largest: 0.017. In prior to 1600 it was 0.015 and from the whole time period 0.011. To make the densities comparable to some degree, the amount of edges needed for different densities is counted in Table 9. Still, the scale of the larger graph makes it hard to compare with the other graphs, so, I will focus on the two smaller ones. The graph prior to 1600 would need ≈ 14 more edges to have the density of 0.017, whereas in the graph post 1601 the difference between the density of 0.015 and 0.017 is ≈ 26 . This behaviour is explained in the subsection 2.1. So, even though the time scale is similar (80 years), the density and the absolute amount of edges is different.

¹⁴⁴Samuelson 2013/2019.

This means that it can be argued that the post 1601 graph is more dense than the one prior to 1600.

One interesting isolated node is one representing Johan Adler Salvius (id 2, 1590-1652). Johan Salvius was of merchant background, he was orphaned and raised by the Bishop of Strängnäs. He got the chance to study in the European universities and therefore landed a position in the Svea Royal Court (*Svea hovrätt*). As a skilled officer he was noticed by king Gustav II Adolph, who later hired him as a diplomat. He was part of the Swedish delegation in the peace treaties of Westphalia in 1648, that ended the Thirty Years War in Europe.¹⁴⁵

He was ennobled in 1629, and appointed to the Council of the Realm in 1648 by queen Christina despite the opposition provoked by his ignoble birth. To gain financial stability he had married a wealthy elderly widow in his youth. Nevertheless, the elderly lady happened to outlive her husband. Due to this Johan Adler Salvius left no direct heirs, and the dispute over the inheritance of his massive property lasted until the 19th century.¹⁴⁶

All in all, 17th century has been called in the previous literature "the Age of the Aristocracy", and the presented data seems to confirm the trend.¹⁴⁷ It seems that the family affiliations became more prominent in the Council of the Realm, and important in general, during the 17th century. Similarly, the amount of incomers decreased, which implies the slowdown of social mobility.

3.3 In the Court of Queen Christina

Queen Christina (1626-1689) was the daughter of the king Gustavus Adolphus and queen consort Maria Eleonora of Brandenburg (1599-1655). She inherited the throne at the age of 6, after her father's sudden death in the battlefield in November 1632. Before she was declared an adult at the age of 18 in 1644, the kingdom was ruled by a regnant.¹⁴⁸ The reign and especially the personal life of queen Christina are fascinating chapters in the Swedish history, and she is the most researched monarch in the European history.¹⁴⁹

During the time of Christina's birth the future of the inheritance of the Swedish throne was at stake. Cristina's grandfather Charles IX had claimed the crown from his nephew Sigismund in 1599 (or 1604) and left it to his son Gustav II Adolph.¹⁵⁰ In the case of Gustav II Adolph's death the chance of Sigismund reclaiming the kingdom was high. Gustav II Adolph needed a son. Due to a series of misfortunes his and Maria Eleonora's only

¹⁴⁵Marjomaa 2000.

¹⁴⁶Marjomaa 2000.

¹⁴⁷Hakanen and Haikari 2020.

¹⁴⁸Lappalainen 2014, pp. 188-189, 288-289.

¹⁴⁹Mäkelä-Alitalo and Setälä 2000, For more information see e.g. Peter Englund *Silvermasken: en kort biografi över drottning Kristina* finnish version *Kuningatar Kristiina*, or Marie-Louise Rodén *Drottning Christina: en biografi*.

¹⁵⁰See subsection 1.3

child surviving infancy was a girl: Christina. Christina was declared to be the rightful heir to the throne, and she was educated as a future ruler.¹⁵¹

Although educated and skilled monarch, she provoked the Council of the Realm many times during her reign. Politics aside, she was not considered as a skilled ruler when it came to the economics, and she has said to spent fortunes on the lavish lifestyle on the court with her inner circle. Also her atypical behavior further fueled questions and rumors surrounding her persona.¹⁵²

She started preparing the abdication of the throne in the early 1650's, however, was forced to postpone the process by years. Officially she abdicated the throne in 6th of June 1654 in favor of her cousin Carl X Gustav (1622-1660), and left Sweden in 10th of June the same year. In 1655 she officially converted to Catholicism, and changed her name to Maria Christina Alexandra. She moved to Rome where she lived the rest of her life.¹⁵³

She came back to Stockholm accompanied by Italian court and a Catholic monk in 1660, and tried to reclaim the right to the inheritance of the Swedish throne. This caused concern amongst the monarch and the Council, who demanded her to reassure her renouncement of the crown. She left Sweden in 1661 and never returned. In Rome she was known for her support for the arts, theater and opera. She died in Rome in 1689. Queen Christina left behind an ambivalent legacy, particularly in Sweden she was heavily criticized on her choices.¹⁵⁴

In the early years of her reign she had to acquire the authority over the Council of the Realm. Due that Christina's father was frequently away from Sweden and the long period of the interregnum, the power of the Council had grown remarkably when Christina was enthroned. Contrary to the previous monarchs, she was forced to go for the Council to get counsel, yet, the situation did not stay that way for long.¹⁵⁵ In the words of Hakanen and Koskinen:

Christina played the high nobility at their own social network game rather than enter into open warfare with them. That is, she quickly created a large group of loyal supporters around her ...

(Hakanen and Koskinen 2017b, p. 64)

Furthermore, she appointed many new councillors to dilute the power of the original Council. By the year 1654 she had appointed 45 new councillors.¹⁵⁶

As queen Christina notoriously appointed councillors to dilute the power of the old Council, did she favor any age group, perhaps young educated noblemen? To give an

¹⁵¹Lappalainen 2014, pp. 185-189.

¹⁵²Mäkelä-Alitalo and Setälä 2000.

¹⁵³Mäkelä-Alitalo and Setälä 2000.

¹⁵⁴Mäkelä-Alitalo and Setälä 2000.

¹⁵⁵Hakanen and Koskinen 2017b, p. 64.

¹⁵⁶Hakanen and Koskinen 2017b, p. 64.

Table 10: Summary statistics on the councillors ages of appointment from the whole dataset (including the reign of Christina). NA meaning a missing value. N = 257 - 57 (Data from Hakanen and Koskinen 2017a, statistics by author)

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
22.0	33.0	38.0	39.6	45.0	74.0	57

Table 11: Summary statistics on the ages of appointment from the councillors appointed by queen Christina. N = 45 - 1 (Data from Hakanen and Koskinen 2017a, statistics by author)

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
25.00	32.75	37.00	39.36	45.75	61.00	1

indicative answer to this question, I calculated the summary statistics on the age distribution on the councillors appointed by Christina, and the same statistics on the age distribution from the whole dataset. As we can see from the Tables 10 and 11 the councillors appointed by Christina were the same age-range as the councillors appointed by all of the monarchs. In fact, the distributions seems fairly similar. However, in the whole dataset N (the number of observations excluding missing values) is 200, whereas in the part appointed by Christina N is 44, meaning that the distributions are not fully comparable.

Typically the councillors were appointed in their late 30's (median 38, mean 39.6), also the councillors appointed by Christina were of similar age (median 37, mean 39.36). Overall, the youngest councillors appointed were only the age of 22 years. They were Sten Eriksson Lewenhaupt (Leijonhufvud) (id 118, 1518-1568), Per d.ä. Joakimsson Brahe (id 40, 1520-1590) and Gustaf Axelsson Baner (id 5, 1547-1600). The youngest councillors appointed by Christina were 25 years old Magnus Gabriel Jacobsson De la Gardie (id 56, 1622-1686) and Henrik Fransson von Thurn (id 221, 1628-1656).

The oldest councillor to be appointed was Måns Svensson Some (id 187, 1495-1571). He was appointed in the age of 74, and served only two years in the Council before his death in 1571. The oldest councillor appointed by Christina was Konrad Falkenberg (id 61, 1591-1654) in the age of 61. He was appointed in 1652, and coincidentally also he died two years after his appointment in 1654.

The network of councillors appointed by queen Christina is displayed in Figure 6. As queen Christina's reign lasted for only ten years the graph is not comparable to the other larger graphs, despite that, it is interesting in its own right. The graph consist of 45 councillors, all of them which must have been close to queen Christina in one way or another.

Overall, the graph seems more like a list, but, an interestingly clustered pattern can be found in the middle of the network. Eight councillors: Karl Mauritz Johansson Lewenhaupt (id 125, 1620-1666), Gustaf Adolf Johansson Lewenhaupt (id 126, 1619-1656), Gustaf Otto Gustafsson Stenbock (id 207, 1614-1685), Fredrik Gustafssonare Stenbock



Figure 6: A graph of councillors appointed by queen Christina between 1644 and 1654.(Data by Hakanen and Koskinen 2017a, graph by author)

(id 204, 1607-1642), Erik Gustafssonall Stenbock (id 202, 1612-1659), Bengt Gabrielsson Oxenstierna af Korsholm och Wasa (id 148, 1623-1702), Gabriel Gabrielsson Oxenstierna af Korsholm och Wasa (id 154, 1619-1672) and Hans Claesson Wachtmeister (id 240, 1609-1652) are all related to each other directly or indirectly.

This tightly woven network seems to concentrate around the two brothers Gustaf Otto Gustafsson (id 207) and Erik Gustafsson Stenbock (id 202). They were part of the mighty Stenbock family. Their father was a councillor Gustaf Eriksson Stenbock (id 205, 1575-1629) who's father (id 203) and grandfather (id 206) were also in the Council. The brothers were councillors in the fourth generation.

Some other interesting individuals can be also found in the graph. Christina appointed his paternal half brother Gustaf Gustafsson af Vasaborg (id 241, 1616-1653)—Gustavus Adolphus' illegitimate son—to the Council on 5th of September 1646. Also the diplomat and nobleman Schering Johansson Rosenhane (id 177, 1609-1663) who gave queen Christina the *Hortus Regius* -manuscript was appointed to the Council by Christina on 30th of September 1650. Furthermore, Queen Christina is notoriously remembered on favoring the young Magnus Gabriel Jacobsson De la Gardie (id 56), so much so, that it caused dispute inside the Swedish court.¹⁵⁷ This indicates that family ties—even illegitimate—were of high value, but also mutual relationships had their place in the political sphere of early modern Sweden.

¹⁵⁷Mäkelä-Alitalo and Setälä 2000.

4 Conclusion

Can historical network analysis reveal new or unseen patterns in the affiliations between Swedish councillors of the Realm? Using network analysis can indeed reveal new patterns on the given dataset. Though, implemented on the highly researched topic of the early modern nobility, it seems to confirm the already known. This is not inherently a bad thing after all. Creating and testing a (new) model with a strong theoretical background is not redundant work, it is an integral part of the ground research.

How dense is the network (how linked the Council was in general)? The graphs depicting the councillors' family ties in the early modern period are highly linked for the most part. This, in accordance with the previous research, indicates that an individual's place in the society was determined by the family background. Yet, the density of the networks—depicting the importance of the family relations—changes with time. The graph of the 16th century is more sparse than the graph of the 17th century.

Are there any isolated nodes (councillors who have no relatives in the Council)? The isolated nodes or lack of thereof were probably one of the most revealing parts of the graphs. In the graph depicting the 16th century, the isolated nodes were somewhat common, but the amount decreased in the 17th century graph. In some cases the nodes were of incomers from abroad or of lower birth. Therefore they indicated both social and international mobility in the political sphere of early modern Sweden. The councillors represented by these nodes usually led interesting life stories.

Can the graph be visually divided into clear sub graphs (is there a certain groups or 'houses' of related councillors)? The graphs did not form visually separate subgraphs or components, which would indicate individual families or houses. Instead, the members well established and famous noble lines, such as Gyllenstierna, De la Gardie and Sparre, were represented as the nodes with the most connections. Following the previous research, it seems that the family networks were generally connected to each other, and most prominent houses were integrally interwoven into the network of the councillors of the Realm.

Dividing the graph between 16th and 17th centuries further revealed the processes within lineages. Comparing the two graphs was able to show the extinction of the Bååt family and the simultaneous rise of the de la Gardie family. The ancient Bååt family was prominent in the graph depicting the 16th century, however in the graph of the 17th century only two of the councillors carries the surname Bååt. On the contrary, in the graph of the 16th century Pontus de la Gardie is a single representative of the family, whereas in the 17th century de la Gardie is amongst the most networked houses.

To what extent can pre-processing the dataset for the network analysis be automated with a script? Collecting and creating network data manually from scratch is a daunting and time consuming task. To make process of building the graphs from already existing

data easier, I coded a small Python script to do the manual, error prone and dull work for me. Altogether, automatizing the process of extracting historical data is not that straightforward, and making a working code demanding in itself. As computer scientist James R. Parker put it in his book:

Here is a truth: nobody wants to run your program. What they want is to get their work done, or play their game, or send their email...The truth is that good code is invisible. It simply allows things to flow smoothly. Bad code is memorable. It interferes, makes people frustrated and angry.(Parker 2021, prefix p. XVI)

Automatically processing data that is not designed and collected to be automatically processed is hard. Scripts do not have an understanding of context. If the dataset or file names contain minor characters, such as dots or spaces, the script may crash. These detrimental small characters have to be manually replaced from the dataset or to be excluded from the processed data. Also the slightest changes in the spelling is able to corrupt the whole model.

For instance, working on a similar task for the *Shared Past, Different Interpretations*-project, I came across two different spellings of the same name in the dataset. This caused the script to create two nodes, of the one and same person to the graph. To make matters worse, the person was a highly central figure on the network, and the conflicting nodes discretely broke the whole model. With the help of alert colleague, and by a lucky coincidence, the error was spotted in time. Had that not happened, the graph would have remained inherently inaccurate. Usually it helps, if the programmer—or the working group—has at least conceptual understanding of the data.

What are the potential difficulties and pitfalls in the implementation and interpretation of historical network analysis in this specific dataset, and further in the field of early modern history? An important observation concerning the actual network analysis is, which statistics are usable in the context of historical social networks. For example, the graph density should tell us how interwoven the network was. Instead, as the number of possible nodes increases so rapidly with the size of the network, the density of two networks, with even a little difference in size, is almost impossible to compare. Furthermore, the mathematical definition of dense network would be odd in the context of larger social networks. On the other hand, the far simpler parameters, such as node degree or the ratio of isolated nodes from all nodes, are way more depicting.

While doing this work I made some simplifications on the data processing and model building. For instance, the calculated and reported numbers of edges are in fact the lower limit of the probable numbers. While limiting the time range of the graphs, some existing family links are excluded from the calculation, and, furthermore, some links were already excluded from the original dataset. This means that the actual networks were most likely

slightly more linked. This deviation or uncertainty could be further quantified with the methods of Bayesian statistics.

As computational network analysis seems to be a working method in the study of early modern history, it could be implemented in the study of wider social groups. Reconstructing social networks with noble women or the clients of the noblemen could be a feasible project. Also the *Swedish councillors of the Realm, 1523-1680* -dataset could be utilized in further research. For example creating a more complex statistical model on the age distributions of the councillors appointed by each monarch would be a doable and inspiring task in the future.

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A Python Script Used in Data Extraction

```
--author__ = "Heidi Suurkaulio"
--dependencies__ = ["sys", "pandas", "csv", "re"]
--version__ = "1.0"
--date__ = "01-05-2025"
--project__ = "https://github.com/Heidi-Suurkaulio/masterthesis"
--maintainer__ = "Heidi Suurkaulio"
--email__ = "heidisuur@gmail.com"

import sys
import pandas as pd
from csv import writer
import re

# testing that the filename is present
if len(sys.argv) < 2:
    print("Error: file name must be given in format .csv")
    sys.exit()

# reading the data
dataset_name = sys.argv[1]
dataset = pd.read_csv(dataset_name ,sep=";", index_col="Id")
dataset["Connections"] = None

# make sure the years of appointment are numeric type
dataset.update(pd.to_numeric(dataset['Appointed']))

# if start and end year or interval is given, limits the dataset on given parameters
if len(sys.argv) == 4:
    match sys.argv[2]:
        case "prior":
            # the year of appointment is the same or smaller than given
            end_year = int(sys.argv[3])
            dataset = dataset.loc[dataset['Appointed'] <= end_year]
        case "post":
            # the year of appointment is the same or greater than given
            start_year = int(sys.argv[3])
            dataset = dataset.loc[dataset['Appointed'] >= start_year]
        case default:
            # the year of appointment is greater than the first year given
            # the year of appointment is smaller than the last year given
            start_year = int(sys.argv[2])
            dataset = dataset.loc[dataset['Appointed'] >= start_year]
            end_year = int(sys.argv[3])
            dataset = dataset.loc[dataset['Appointed'] <= end_year]
```

```

# save the connections to the dataset
for index, ent in dataset.iterrows():
    st = ent.Family
    if isinstance(st, str):
        cons = re.findall(r'\b\d+\b', st)
        cons = list(map(int, cons)) # convert to integer
        dataset.at[index, "Connections"] = cons

# find current indexes
current_ids = dataset.index

# make a list of connections
printable = []
printable.append(['Source', 'Target', 'Type', 'Id', 'Weight'])
i = 0
for index, entr in dataset.iterrows():
    if isinstance(entr.Connections, list) and len(entr.Connections) > 0:
        for o in entr.Connections:
            if o in current_ids: # check if the id mentioned in connection is in dataset
                printable.append([index, o, "Undirected", i , "1.0"])
            i = i + 1

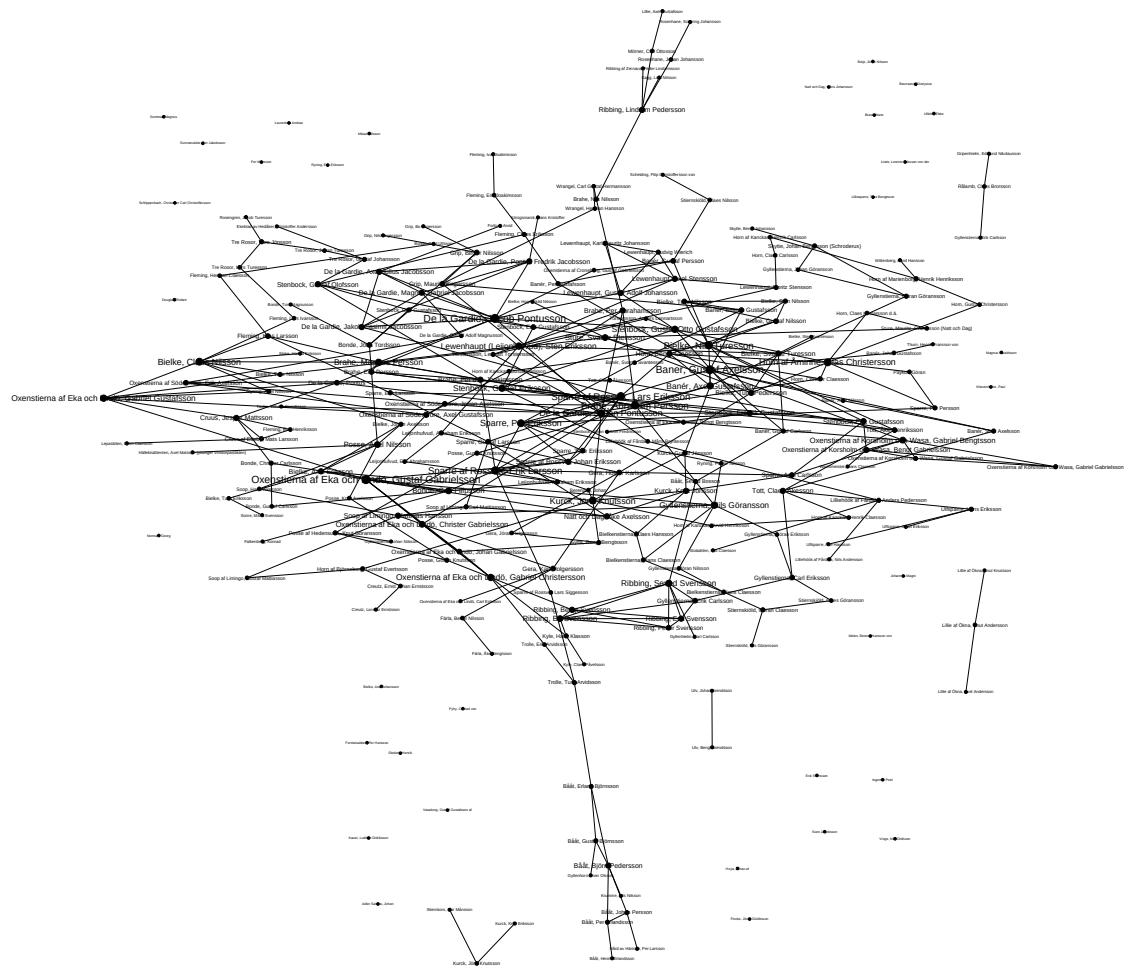
# print all
dataset.to_csv("councillors.csv", columns=["Name"], sep=";", header=["Label"])

with open("connections.csv", "w", newline='') as csvfile:
    wr = writer(csvfile)
    wr.writerows(printable)

```

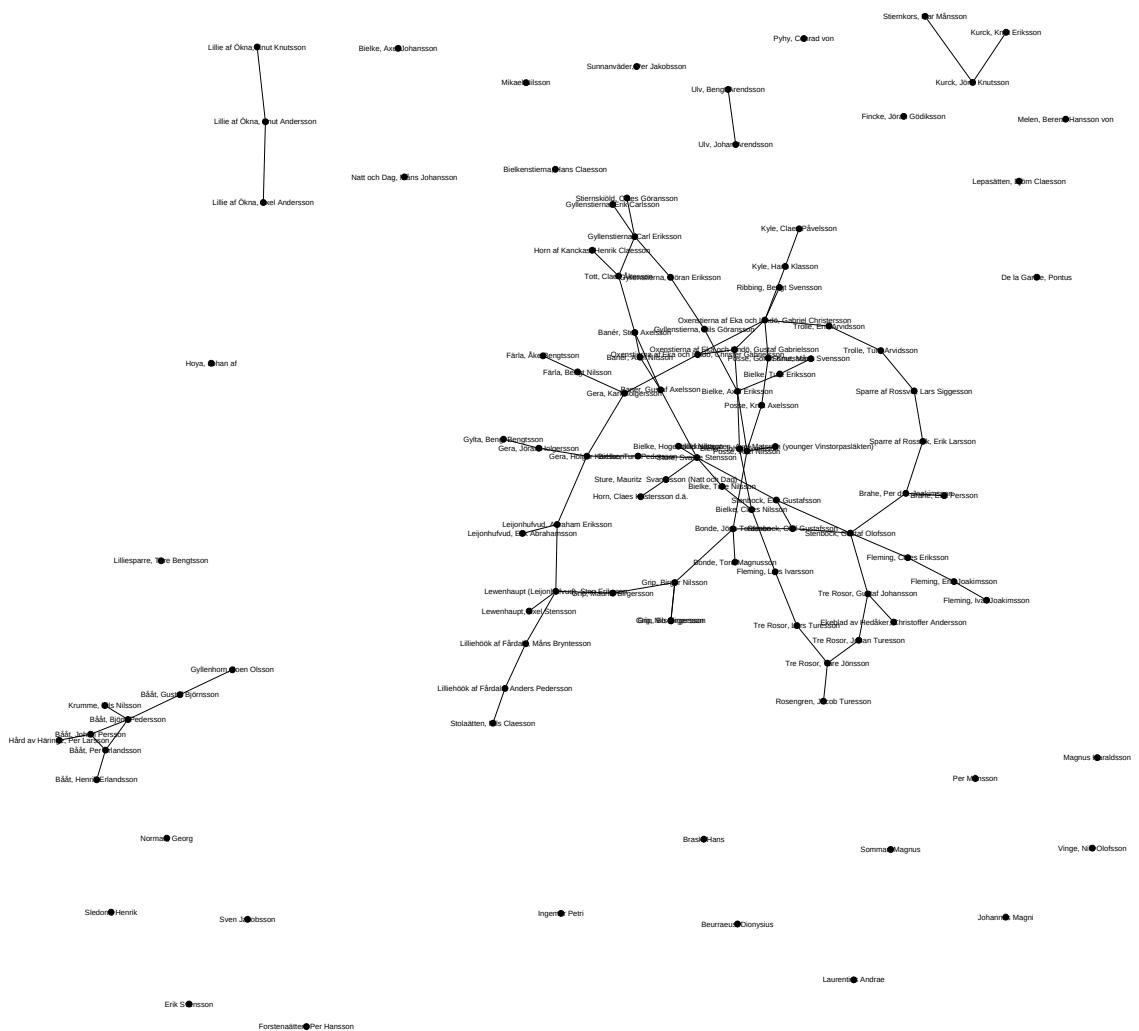
Downloadable version with instructions available in <https://github.com/Heidi-Suurkaulio/mastersthesis/tree/main/PythonScript>

B Graph 1523-1680



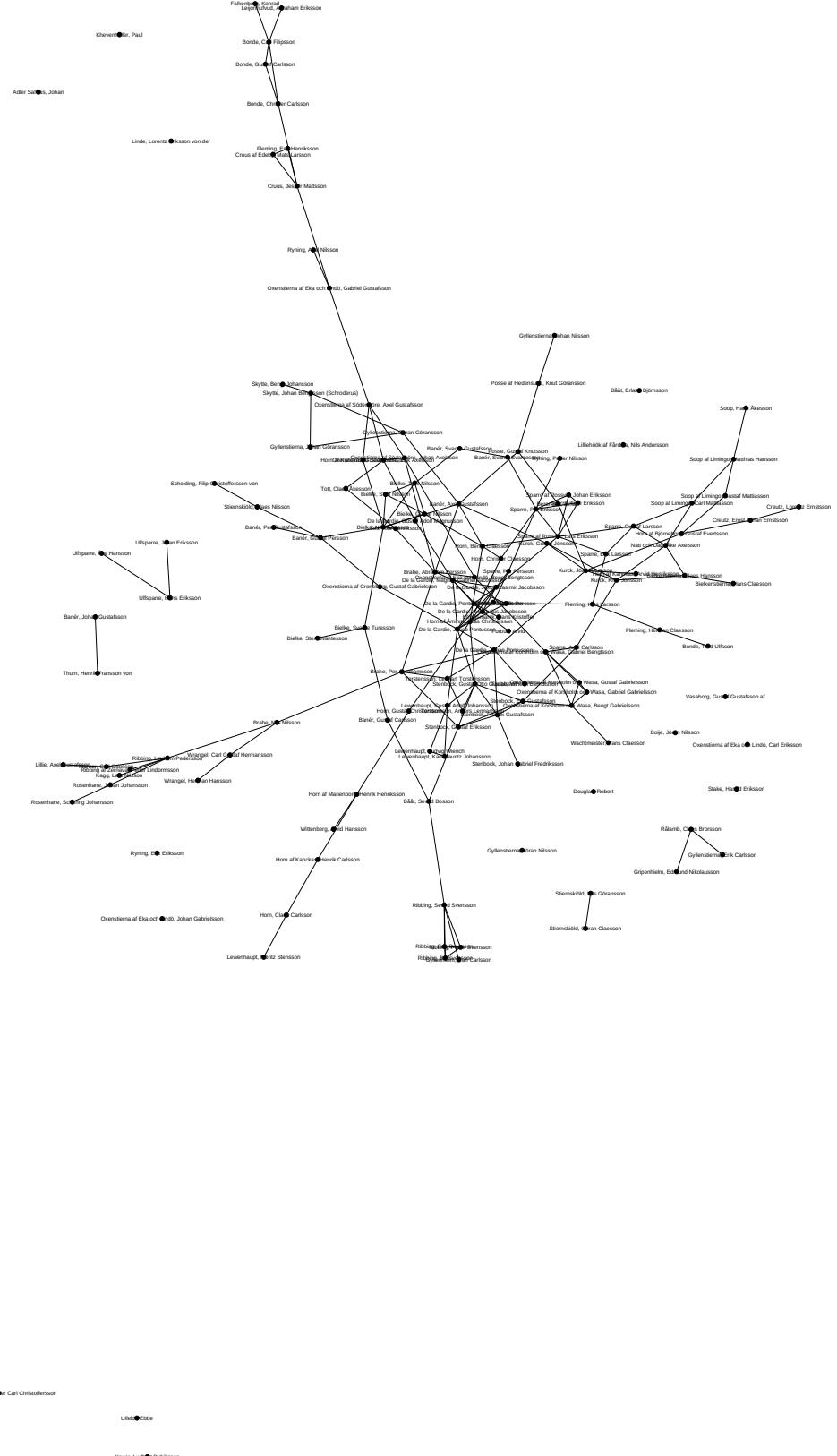
Higher resolution available in: <https://github.com/Heidi-Suurkaulio/mastersthesis/tree/main/GephiProjects>

C Graph Prior 1600



Higher resolution available in: <https://github.com/Heidi-Suurkaulio/mastersthesis/tree/main/GephiProjects>

D Graph Post 1601



Higher resolution available in: <https://github.com/Heidi-Suurkaulio/mastersthesis/tree/main/GephiProjects>