Family Matters in a Meritocracy: Networks,

Exams and Officialdom in the Joseon Dynasty

Abstract

How persistent is the family lineage effect in a meritocracy? While meritocratic institutions aim to screen political elites based on individual merit, they may still allow the elites to perpetuate their influence through the descendants. In this paper we look at the ancestors’ role in determining the political careers of individuals during the Joseon Dynasty from 1392 to 1897 CE. The Korean kingdom during this period implemented the humanities examination (mun-gwa) intended to fill its central official positions based on merit, and its comprehensive records on family ties and court official appointments span over 503 years, longer than any other dynasties found in the world. We use the individually linked family network data to find that 1) individuals with more exam-passing ancestors were also more likely to become high-ranking officials, with the effect coming from even the very distant ancestors from generations ago; and 2) the lineage effect on individuals’ careers became more pronounced during periods of political instability, suggesting that the ancestral know-hows were particularly valuable in these times.

Keywords: network centrality, intergenerational mobility, civil service examination, political elites, meritocracy, Joseon Dynasty

Word count: 11,909
1. Introduction

Governments and societies aim to select their elites based on merit. Among the various policies implemented for this purpose, the civil service examination system remains as an exemplary institutional innovation. First found in Chinese dynasties, other Asian countries including Korea and Vietnam later implemented the meritocratic system (Liu, 2007). Furthermore, the British and other European states as well as the United States government adopted similar practices in selecting their civil servants (Teng, 1943). The selection of political elites through the examination process allowed greater social mobility among the prospective candidates, especially in states otherwise characterized by hierarchical order and class division.

Did the examination system indeed succeed in selecting the most talented in the society? In this paper we argue that while the practice did screen political elites based on individual merit, it was unable to stop a legacy of elite selection based on family lineage. The persistent lineage effect came from the successful exam-takers, who passed down to the descendants their knowledge in statecraft to survive and succeed in the court politics. While the ancestors also influenced the descendant’s likelihood of passing the exam,¹ we are primarily interested in their influence on the descendant’s actual political career after the exam. Specifically, we show that the exam passer with a lineage of many exam-passing ancestors was more likely become high-ranking officials relative to other exam passers.

¹ See Jiang and Kung (2016), in which the authors discuss the civil service examination system in late imperial China. The authors find that the candidates with exam-passing fathers, grandfathers and great-grandfathers were more likely to pass the exam themselves, as they inherited the “cultural capital” that provided the relevant knowledge for passing the exam.
Among the dynasties that adopted civil service exams, the Joseon Dynasty of Korea from 1392-1897 CE stands out as an invaluable case study offering comprehensive records of exam passers, their eventual career paths as well as family lineages. The kingdom during this period was a centralized bureaucratic state that gave opportunities for officialdom to those who succeeded in its merit-based examination, called gwa-geo, that had been consistently maintained over 500 years. The examination system was the most significant means of recruiting officials for major central and provincial government posts, and those who passed gwa-geo formed the ruling class (Wagner, 1974). Among the different types of exams under gwa-geo, mun-gwa (the humanities examination on the principles of government administration, ethics and family) was the most selective and accordingly elevated successful candidates to the highest elite status in society. During their careers, successful exam takers had greater opportunities to be appointed in prominent court positions with recommendations from other officials as well as the king, particularly for high-

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2 The merit-based examination comprised four categories: (1) mun-gwa (humanities examination); (2) mu-gwa (military examination); (3) jap-gwa (technical examination); and (4) saeng-won-si and jin-sa-si (classics and literary licentiate examination). In this study, we focus on those who succeeded in mun-gwa because they represented the ruling class of Joseon as major state officials. Successful candidates of saeng-won-si and jin-sa-si became qualified to enroll at the National Confucian Academy (Sung-kyun-kwan), which trained students for mun-gwa. They could alternatively be appointed as ninth-ranked junior officials, which were the lowest positions among the court officials. Those who passed military or technical examinations were regarded as lower-class officials. Protected officials (Eum-seo) were the positions specifically reserved for the merit subjects who did not have to take the exam in order to obtain this elite status. However, protected official had limited opportunities for promotions and were generally considered inferior to those obtained through mun-gwa (Paik, 2014).
ranking positions in the court (Won, 2007; Kim, 2017).³

Spanning over five centuries, the Joseon Dynasty’s exam and career records of exam passers comprise the world’s longest continual data of such kind under a single dynasty. Our paper is the first study examining the eventual political ascension of successful exam candidates, and the importance of family networks that could compromise the principles of meritocracy.⁴ Specifically, we use an individually linked database of final-round examination candidates and their ancestors found from the exam roster (Mun-gwa-bang-mok) for more than 5,000 individuals from 1396 to 1894 CE, essentially covering the entirety of the Joseon Dynasty. Using the database and drawing from Katz (1953)’s centrality measure, we then calculate a “lineage score” for each exam passer in our sample. The score captures the level of inherited political capital in the form of ancestral know-hows in statecraft. The ancestors who themselves were exam passers are more influential in the network, and accordingly add more to the lineage score of the individual. The formula in Katz (1953) appears in various types of contemporary networks (ex. Katz, 1953; Cruz et al. 2017; Jackson, 2010; Lloyd and Bonacich, 2001; Wasserman and Faust, 1994). In our study, a higher score for an exam passer means a stronger lineage and thus a more advantaged position to obtain a high-ranking position in the court.

In our empirical analysis, we estimate the association between the individual’s lineage score and the probability of reaching a high-ranking official position later. We first find that individuals

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³ Henceforth throughout the paper we focus on mun-gwa only and refer to it simply as “the exam”.

⁴ As a complement to our study, James Lee and Cameron Campbell have worked on compiling the China Government Employee Database during the Qing period: (https://www.shss.ust.hk/lee-campbell-group/china-government-employee-database-qing-cged-q/).
with more exam-passing ancestors were also more likely to become high-ranking officials, with the effect coming from even the very distant ancestors from generations ago. The result is robust across alternative regression models and even when controlling for the individual’s age and performance at the exam. In addition, we show that the lineage effect on individuals’ careers became more pronounced during periods of political instability. The ancestral know-how's appear to have been particularly valuable in these times, when the probability of exam passers being appointed to an official position was low in general.

Our work relates to several strands in the literature. First, this paper contributes to the seminal works on the institutional selection of political elites. Dal Bó et al. (2017) for example show that democracy can produce competent and socially representative politicians, while Cruz et al. (2017) document that family connections still matter for electoral outcomes in a democracy, as they facilitate relationships of political exchange. Several others in the literature also look at authoritarian contexts to find that official appointment is heavily determined by power hierarchies and loyalty concerns; the leaders tend to hire mediocre and loyal, non-threatening candidates for positions in the bureaucracy (Zakharov 2016; Egorov and Sonin 2011; Reuter and Robertson 2012). Our paper also focuses on political candidates and their appointments, but in the historical context of monarchy system.

Our paper furthermore relates to the literature on social mobility and its long-term implications. Some of the existing research find significant inter-generational persistence in political power (Dal Bó et al., 2009), wealth (Clark and Cummins, 2015), education (Clark and Cummins, 2014; Shiue, 2016), as well as exam success (Wagner, 1974; Hao and Clark, 2012; Jiang
and Kung, 2016) due to predecessors’ social class standings.\textsuperscript{5} We provide further support for the long-term intergenerational persistence of socio-economic status; we show that when certain meritocratic institutions are set in place (i.e. the civil service examination system), ancestors gain an important and persistent role in determining the political career of their descendants.

Finally, our work complements the burgeoning literature applying network analysis to topics in economic history (Esteves and Mesevage 2019). We first introduce unique historical network data by combining exam rankings, family connections and official appointment, and employ network analysis to explain the various effects of ancestral influence on descendants’ political careers under the examination system.

We organize the paper as follows. In Section 2, we summarize the historical background of the examination system and official rank positions in the court during the Joseon Dynasty. In Section 3, we present a simple framework to explain the role of ancestors in the descendants’ eventual career trajectories. In Section 4, we introduce our data sources and key variables. Section 5 presents the results of baseline and alternative specifications. We also discuss how our estimates vary in relation to the political situations over time in Section 6. Section 7 concludes.

\textsuperscript{5} Wagner (1974) points out that exam passers came from about 750 family clans, with the 21 leading clans producing over 40% of the exam passers while 560 extremely minor clans producing only 10% of the select group. This may indicate that those who came from major family clans might have been favored to pass the grueling examination. However, there is a debate on whether the family clan as a group had a salient identity and cohesiveness. For instance, the clan of Jeonju Yi, which produced 870 successful candidates (5.74% of the total), was a complex group divided into 123 factions during the late Joseon Dynasty (Baek, 2017). In our regressions, we include the family clan dummies and cluster the standard errors by the family clans.
2. Historical Background

2.1. Humanities Examination

The examination system provided an official gateway to public officialdom in the Joseon era. At the same time, passing the exam was as difficult as finding a needle in the haystack. The exam was so competitive that it took ten to fifteen years on average to pass the exam and the average passing age was 34.3 (average pass rate $\approx 0.05\%$). Those who entered government service by passing the exam thus expected to serve at important posts in key ministries (Lee, 1994).

The exam was broadly categorized into regular exams and irregular exams. The triennial exam (sik-nyeon-si) was regularly implemented, and the irregular exams included the augmented exam (jeung-gwang-si), the special exam (byul-si), the memorial exam of royal visitation to the Confucian hall (al-sung-si), and so on. Although the augmented exam was one of the irregular exams, we regard it as a regular exam since it was similar in structure and process to the triennial exam.\footnote{Both sik-nyeon-si and jeung-gwang-si consisted of the same three separate examinations and selected top 33 candidates. Since the regular exams and irregular exams still likely had different characteristics regarding the process and purpose of the test, we control for the different types of exams in our empirical analysis.}

Figure 1 summarizes the structure and selection process of a regular exam. The regular examination system was implemented in the order of the first-round (cho-si), the second-round (bog-si), the final-round (jeon-si), and then confirmation by the king. These exams were meant to

\footnote{This indicates that studying for the exam might have been prohibitively costly since the average lifespan estimate was only forty during the Joseon Dynasty (Paik, 2014).}
mainly test the candidate’s ability in writing compositions and knowledge of the Confucian texts (Lee, 2003). A total of 240 successful candidates, including 50 from the National Confucian Academy (Sung-kyun-kwan), 40 from the capital Han-yang (currently Seoul), and 150 from local provinces were chosen through the first-round examination, and they assembled in the capital for the second-round examination (Lee, 2008). Only 33 successful candidates were selected for the final-round examination. In the final round, the candidates wrote essays on a subject chosen by the king, and their administrative and political competence were evaluated accordingly. Both the examiners and the king determined the rankings of these final candidates (Won, 2019).

[Figure 1 Here]

2.2. Official Position Assignment and Promotion

The officialdom in the Joseon Dynasty comprised nine ranks (see Table 1). Each rank was divided into the senior level (jeong) and the junior level (jong), and the posts above the sixth rank junior official were further subdivided into the upper level (sang-gye) and the lower level (ha-gye) for a total of 30 levels. The high-ranking officials above or equal to the third-rank senior official title were collectively called the palace-ascendable officials (dang-sang-gwan). The remainders, called the palace-downward officials (dang-ha-gwan), comprised mid-ranking officials (cham-sang-gwan) who were higher than or equal to the sixth-rank junior officials, and low-ranking

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8 Throughout our paper, we focus only on the successful candidates who passed the preliminary exams and advanced to the final-round examination. We refer to them as the “exam passers” and use the term “final-round examination candidates” interchangeably for the same group.

9 Henceforth we refer to this group simply as the “high-ranking officials.”
officials (*cham-ha-gwan*) who were lower than the sixth-rank junior officials.

The high-ranking officials were the ministers authorized to participate in discussions or parties with the king at palace halls (Yi, 2015). They were given important rights to vote on the administration, to recommend other officials, and to direct the military (Cha, 2002). The mid-ranking officials were in charge of the central administration as well as local government duties, with promotion possibilities to the high-ranking official positions (Cha, 2012). However, promotions from the low-ranking to the mid-ranking, and from the mid-ranking to the high-ranking were difficult to achieve because of the entailed rigorous screening processes (Lee, 1994).

Table A1 in the Appendix shows how the initial placement of an exam passer was determined depending on his status at the time of taking the exam (if any) and his score in the final-round examination. If the individual did not have any previous position in the court, his initial placement primarily depended on his performance in the final-round examination. Those who placed in the first-tier (*gap-gwa*), became sixth or seventh-rank officials immediately. Those in the second-tier (*eul-gwa*) and third-tier (*byung-gwa*) were assigned temporary positions at the eighth or ninth rank until actual positions became available (Won, 2007). There was thus a sizeable gap in the career paths of civil servants according to their grades in the final-round examination and pre-existing court status.

[Table 1 Here]

### 3. Family Networks and Political Capital

In order to capture the level of ancestral influence coming from family networks, we use the lineage score by Leo Katz (Katz, 1953). The score is often used to assess prestige and popularity (Katz 1953; Bonacich, 1972, 1987; Lloyd and Bonacich, 2001; Jackson, 2010; Cruz et al. 2017).
Using the lineage score, we can attribute more weight to individuals that are themselves more connected; we can also introduce the generation distance (i.e., the father having more influence than the grandfather on the exam passer) and specify the strength of connections depending on the type (i.e., the father having more influence than the foster father) as further robustness checks.\textsuperscript{10} In our study, a higher score means more ancestors with records of passing the exam themselves. We argue that having more exam-passing ancestors implies greater inherited political capital, i.e. accumulation of ancestral knowledge in navigating the court politics, which in turn increases the exam passer’s likelihood of becoming a high-ranking official after the exam.

In order to identify how many ancestors exam passer $i$ has in his network, we use the final-round exam application form completed by each exam passer extensively.\textsuperscript{11} Each individual who successfully advanced to the final-round examination filled out an application form with names of his father (and foster-father, if any), paternal grandfather and great-grandfather, as well as his maternal grandfather and father-in-law. This mandatory practice makes it possible for us to trace each individual’s family lineage back to at least his great-grandfather. We can also link the individual to his more distant ancestors, as long as one or more of his ancestors on the application form passed the exam themselves and provided information on their own ancestors. Importantly, the final-round examination candidate with many exam-taking ancestors also has a long lineage on record, and this is reflected in his lineage score.

To see why this is the case, suppose that $y_i$ is final-round exam candidate $i$’s likelihood of becoming a high-ranking court official, $s_i$ is $i$’s innate level of scholarly talent and $k_i$ is $i$’s

\textsuperscript{10} In Table 5, we present our main findings controlling for these different types and distances.

\textsuperscript{11} We explain the family network structure in greater detail in Section 4.
inherited political capital. \( y_i \) depends on \( s_i \) and \( k_i \) as follows:

\[
y_i = \alpha + \beta_0 s_i + \beta_1 k_i + v_i
\]

where \( \beta_0, \beta_1 \) are positive scalars and \( v_i \) is an idiosyncratic shock.

Furthermore, we define \( i \)'s inherited political capital \( k_i \) as follows:

\[
k_i = \delta \sum_{g=1}^{n} k_{ig,1} + \gamma p_{i,1}
\]

where \( k_{ig,1} \) is the inherited political capital of \( i \)'s ancestor type \( g \) who appears on the exam rosters and comes one generation before \( i \). \( p_{i,1} \) is the total number of these ancestors.\(^{12}\) We assume that \( \delta \) is constant for all individuals and is known.\(^{13}\)

With this logic, the political capital of \( i \)'s father also depends on the contribution made by

\(^{12}\) The ancestor type \( g \) here refers to individual \( i \)'s father, his father-in-law, his maternal grandfather, or his foster father. All of these types come one generation before \( i \) and are included in \( i \)'s network, as long as they appear on the exam roster. This means that \( p_{i,1} \) can take the maximum value of four. The maternal grandfather tie is an exception here; although the grandfather comes two generations before the candidate, we treat the tie as one-generation apart because there is no information on the candidate’s mother on the exam roster. In Table 5, we vary the weight of the relational tie as a robustness check and find that the main results remain substantively the same.

\(^{13}\) The rate of political capital transmission down the generations, \( \delta \), is called the decay factor in the network literature (Katz, 1953). This parameter ranges in values across different works: 0.5 in Katz (1953); 0.33 in Jackson (2010); 0.11 to 0.31 in Cruz et al. (2017); and 0.4 in Lloyd and Bonacich (2001). We set the standard as 0.3 in our context, but also test the cases with values of 0.1 and 0.5.
his own father (i’s grandfather)’s political capital ($k_{l,2}$) and the total number of ancestors who appear in one generation before him on the exam rosters ($p_{l,2}$). The equation then becomes

$$k_{l,1} = \delta k_{l,2} + \gamma p_{l,2}$$

and i’s political capital can be rewritten as

$$k_i = \delta (\delta k_{l,2} + \gamma p_{l,2}) + \gamma p_{l,1} = \delta^2 k_{l,2} + \delta \gamma p_{l,2} + \gamma p_{l,1}$$

The equation above shows that i’s political capital is not only a function of his immediate ancestors, but also determined by the presence of his more distant ancestors on the exam roster. Iterating and substituting the terms in this equation $l$ times, i’s political capital can be defined as

$$k_i = \delta^l k_{l,1} + \delta^{l-1} \gamma p_{l,2} + \cdots + \delta \gamma p_{l,2} + \gamma p_{l,1}$$

As the number of generations $l$ goes to infinity and $\delta$ remains small enough, i’s political capital ($k_i$) becomes the infinite sums of all the ancestors who appear on the exam rosters:

$$k_i = \gamma \sum_{l=1}^{\infty} \delta^{l-1} p_{l,1} = \frac{\gamma}{\delta} \sum_{l=1}^{\infty} \delta^l p_{l,1}$$

$\sum_{l=1}^{\infty} \delta^l p_{l,1}$ corresponds to the mathematical representation of the family network-based prestige

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14 For simplicity’s sake, we take i’s father here as the representative ancestor type who comes one generation before i, and denote his political capital as $k_{l,1}$. The following argument similarly applies to other ancestor types as specified in footnote 10.

15 The process breaks down when $\frac{1}{\delta}$ is not greater than the largest characteristic root of the matrix $A$ (Katz, 1953).
index in Katz (1953), in which we can define \( p_{l, l} \) as the number of ancestors in the network from \( l \) generations ago who also appear on the exam roster. Given this setup, we predict that individuals with higher Katz lineage scores are more likely attain higher political capital from their exam-passing ancestors, and are subsequently more likely to become high-ranking officials (given that \( \gamma, \beta_0, \beta_1 > 0 \)).

To further aid our understanding of the lineage network, we provide a hypothetical family tree in Figure 2. In this example, Nodes 3 and 4 are the ancestors who come one generation before Node 1, Nodes 7 and 8 also come one generation before Node 2, Nodes 5, 6, and 8 before Node 3, and so on. Table 2 shows a 10 × 10 adjacency matrix, \( A \), with the network information. As defined above, Node 1 has the one-generation lineage score of two since he is linked to two ancestors (Nodes 3 and 4). Similarly, Nodes 3 and 4 have the one-generation lineage score of three, which is higher than that of Node 1. In other words, the lineage score from ancestors one generation ago can be summarized as the column sums of \( A \). At the same time, Node 1 not only has the direct links coming from Nodes 3 and 4, but also has the indirect links from two generations ago via Nodes 5, 6, 7, 8, and 10.

[Figure 2 Here]

[Table 2 Here]

In the example above (Figure 2 and Table 2), we can obtain the column sums of the matrix as the following:
where $A'$ is the transpose of the adjacency matrix $A$, $I$ is a $n \times n$ identity matrix, and $\mathbf{1}$ is a column vector of ones.\footnote{The Katz score is almost identical and perfectly correlated to Bonacich centrality, which was introduced by Bonacich (1987) as a direct extension of Katz’s work. It also closely relates to the alpha centrality, which according to Lloyd and Bonacich (2001) solves the problem of eigenvector centrality in asymmetric networks. Please refer to Appendix B for further discussions on the eigenvector centrality, alpha centrality, and Katz prestige score. Also, when the generation distance ($l$) is finite, the Katz prestige becomes similar to the diffusion centrality, as proposed by Banerjee et al. (2013). We do not apply the diffusion centrality in our study because 1) we assume that a family tree can be extended infinitely and 2) the diffusion centrality measure focuses on the powers of \textit{out-edges}, which differs from our context in that Katz score measures the effect of \textit{in-edges} (i.e. influence from ancestors to candidates, but not from candidates to ancestors).} The column sums of $A$ \footnote{We ensure that $I - \delta A'$ is invertible, for otherwise the linear system has no solution. Accordingly, we set the transmission rate $\delta$ to be between 0 and $1/\lambda$, where $\lambda$ is the largest eigenvalue of adjacency matrix $A$ as noted in the text.} (i.e., $A' \mathbf{1}$) give the numbers of direct links made by the father as well as the maternal grandfather, the foster-father, and the father-in-law, if any. Similarly, the column sums of $A^l$ \footnote{We ensure that $I - \delta A'$ is invertible, for otherwise the linear system has no solution. Accordingly, we set the transmission rate $\delta$ to be between 0 and $1/\lambda$, where $\lambda$ is the largest eigenvalue of adjacency matrix $A$ as noted in the text.} (i.e., $(A')^l \mathbf{1}$) give the numbers of ancestors from $l$ generations ago in the network (Katz, 1953). The rate of political capital transmission $\delta$ gives a higher weight to those closer to the candidate, i.e. a lower value of $l$.\footnote{We ensure that $I - \delta A'$ is invertible, for otherwise the linear system has no solution. Accordingly, we set the transmission rate $\delta$ to be between 0 and $1/\lambda$, where $\lambda$ is the largest eigenvalue of adjacency matrix $A$ as noted in the text.} The total sum then gives us our lineage score (Jackson, 2010).

While measuring a candidate’s ancestral lineage this way largely captures only the...
achievements of ancestors taking the exam and not others, it does provide the most relevant information for us. Qualifying for the final-round examination was paramount to keeping the family’s noble status and the prospect of a high-ranking court position, given the exam-based political elite selection process and its extremely competitive nature during this period.\textsuperscript{18} We also use the exam status instead of official positions of ancestors, because these positions could be endogenous to the candidate’s final-round exam performance and his eventual official position in the court. That is, a father’s position in the court might indeed change during his lifetime by his son passing the exam and his achievements as a court official. On the other hand, the information on the ancestors in the exam-based network was predetermined even before the candidate took the final-round examination. It is also difficult to imagine that a successful candidate would influence the likelihood of his father passing the exam, especially given the age gap and the preparation time.

In Table 3 and Figure 3, we present the lineage scores and compare them to the indegree centrality score, a standard network measure that only considers the number of direct links from ancestors who come one generation before the individual.

[Table 3 Here]

We can see that a node with a high indegree centrality score does not necessarily have a high lineage score. Also, a node with a high lineage score is not necessarily directly linked to many other nodes. For example, in Table 3, Nodes 3 and 4 have the largest scores (\(= 3\)), but they have the second and third highest lineage scores (when \(\delta = 0.3\)), respectively, because they receive

\textsuperscript{18} The Confucian society also treated scholars educated in the classic studies in the highest regard, which further contributed to the prestige of families having exam-passing ancestors.
less indirect links compared to Node 1 (see Figure 3).

[Figure 3 Here]

4. Data

4.1. Sources

Our empirical analysis is based on data drawn from two sources: the exam roster (Mun-gwa-bang-mok) and the court official appointment record (Cheong-sun-go). First, the exam roster includes the entire list of all exam passers qualified for the final-round examinations held throughout the Joseon Dynasty. The digitized version from the Academy of Korean Studies contains various information on each final exam candidate and his family. They include the candidate’s name, his post or title at the time of the examination, the year of birth and the score ranking at the final-round examination. The roster also provides information on the candidate’s family clan, his place of residence, brief career highlights, and the names of the father, the foster father (if any), the paternal grandfather, the paternal great-grandfather, the maternal grandfather, and the father-in-law.19

Using the information on ancestors found from the roster, Lee (2018) constructed each exam passer’s family network. From Lee (2018) we are able to identify 47,308 nodes (14,634 exam

19 The database construction initially started with the “Civil Examination Rosters Project (Munkwa Project)” by Edward W. Wagner and Jun-ho Song (Song, 2010), and the efforts to digitize the rosters took about forty years. The Academy of Korean Studies has since expanded the data and made them available to the public after taking over the project (Wagner, 1974; Lee, 2018). The examination records database is available at the Academy of Korean Studies (AKS)’ Historical Figures Comprehensive Information System (http://people.aks.ac.kr/index.aks).
passers and their 32,674 family members) and a network consisting of 49,229 ties among these nodes. For example, Figure 4 illustrates the case of Sa-Ahn Kang, who took the final-round examination in 1542 and appears on the roster. In the figure, those in boxes are the ancestors of Sa-Ahn Kang found on the exam roster. The names in bold represent those who passed the exam themselves. Note that the records in the roster provide only the names of ancestors that the candidate filled out upon taking the final-round examination. We can connect other family members in the network (i.e., those not in boxes in Figure 4), as long as they passed exam themselves and shared common ancestors, and sometimes by utilizing other available information. In Figure 4, for example, we can find Sa-Ahn Kang’s connection to Ja-Pyeong Kang (marked with *) because Sa-Ahn Kang’s great grandfather (Hyeong Kang) also passed the exam and he was the son of Ja-Pyeong Kang. We can also connect Sa-Ahn Kang to Yu-Gyeom Im (marked with **) by using the Im family network.

[Figure 4 Here]

Another main source of our data comes from the court official appointment record (Cheong-

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20 The adjacency matrix \( A \) of the family network has 47,308 rows and 47,308 columns. The \( 47,308 \times 47,308 \) zero-one matrix has in its \((i,j)\)th entry:

\[
a_{ij} = \begin{cases} 
1, & \text{if } i \text{ and } j \text{ are directly connected (from } i \text{ to } j) \\
0, & \text{otherwise}
\end{cases}
\]

21 Kang was initially placed in the ninth rank senior position, and later reached the third rank lower senior position. There are many other men who are linked to Sa-Ahn Kang indirectly; given the space constraint, we only present the linkages directly coming from Kang’s closest ancestors.
sun-go). Regarding the official positions of the final-round exam candidates (“exam passers”), the exam roster provides only one position out of the candidate’s entire career as a highlight. Because career trajectories change over time, the roster often fails to identify the highest official position over the candidate’s career. In order to resolve this issue, we utilize the appointment record containing the complete list of Joseon’s officials. The record contains information on over 40,000 appointments of civil and military officials throughout the Joseon Dynasty at both the central and local levels.\textsuperscript{22} We match individuals who appear on the appointment record to those found on the exam roster and identify the highest position that each exam passer obtained throughout history.\textsuperscript{23} Finally, we identify the highest positions for 5,783 out of the 14,638 individuals who passed the exam during the Joseon Dynasty. The unmatched individuals include those who never obtained official positions after passing the exam, and those who obtained some positions but are missing in the appointment record. We use the matched sample in our baseline analysis, but later check for robustness by also using the unmatched sample in Table 3.

\textsuperscript{22} The Academy of Korean Studies provides a digitized version of the record. Of the 196 positions (133 civil officers, 50 military officers, 9 miscellaneous, and 1 protected) and of the 133 civil officer positions, we can identify the official ranks from the junior ninth rank to the first senior upper for 120 positions, altogether comprising 30 ranks as described in Section 2.2.

\textsuperscript{23} There are 15,151 successful candidates on the exam roster. Among them, 503 successful candidates passed the exam more than once, so in total there are 14,638 unique individuals who passed the exam. Using the Universal Content Identifier (UCI) system created by the Academy of Korean Studies to code each individual mentioned in historical documents throughout the Dynasty, we exactly match individuals on the exam roster and the appointment record, at the same time also checking Lee’s network data for any duplicate entries and identical names.
4.2. Variables

Our dependent variable is an indicator equal to one if the exam passer in our data ever became a high-ranking official, i.e. above or equal to the third rank senior official title. For our main independent variable, we calculate the lineage score based on the full family networks of all the individuals in our dataset (47,308 nodes with 49,229 ties) (Katz, 1953; Bonacich, 1972, 1987; Jackson, 2010). Using this measure, individuals (or nodes) with more influence are the ones with connections from other influential predecessors (Katz, 1953; Bonacich, 1972, 1987; Jackson, 2010; Cruz et al., 2017). In our network setting, the influential ancestors for an individual are those who themselves passed the exam, have their ancestors recorded on the exam roster and thus provide more indirect ties for the individual.

For the lineage score calculation, we work with directed ties as shown in Figure 4. Each exam candidate’s success in the court would have been influenced by his predecessors, rather than vice versa. Our prediction is that successful candidates with higher lineage scores would have been in better positions to become high-ranking officials. Figure 5 shows the partial networks that correspond with Figure 4, in which the size of the circle is proportional to the lineage score. We

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24 Appendix B provides additional comparisons among the various degree-based centrality measures including Eigenvector centrality, Alpha centrality, Katz prestige, and PageRank centrality.

25 Figure A1 in Appendix A describes the sample family network in our dataset. To simplify the graph, we restricted the nodes that have more than or equal to five ties. In this network, the number of nodes is 2,729 (5.71% of total) and that of ties is 2,391 (4.86% of total), respectively. It is easy to check in this graph that those who achieved high-level rank positions (black dots) also tend have bigger circles (i.e., more centrally connected) than those without (gray dots).
set the rate of political capital transmission $\delta$ to 0.3 in our baseline estimation and check for other rates (0.1 and 0.5) in the robustness test.

[Figure 5 Here]

There are clear advantages to using the lineage score for overall family connections. Using the network approach, we are not only able to identify the ties that individuals have, but also weigh each predecessor based on the ties that these connections themselves have.\textsuperscript{26} Furthermore, we are able to include multiple indirect connections outside the family members on the individual’s records—for example, the connection from Yu-Gyeom Im (marked with **) to Sa-Ahn King in Figure 4—and assess their contribution to the individual’s overall level of connectedness.

Next, we consider the exam passer’s final grade and age at the time of the final-round examination. \textit{Controlling} for the lineage score that accounts for the inherited political capital from ancestors, the two variables capture additional factors determining the candidate’s career success: the family-specific “cultural capital” that helped the candidate to pass the exam, and his innate level of competence (Jiang and Kung 2016). First, the final grade captures the knowledge pertaining to statecraft beyond Confucian studies. This final exam tested on both administrative and political expertise, and was meant to screen those for senior appointments in the government (Kim, 2015). The topic of the exam was open and allowed for highly subjective answers from candidates, who often had to give their opinions on thorny issues that the king himself confronted.\textsuperscript{27} Second, the age upon passing the exam reflects the applicants’ ability in writing

\textsuperscript{26} This is a key concept of Eigenvector centrality, Alpha centrality, and Katz prestige.

\textsuperscript{27} To compare the final rankings of candidates in the final-round examination across time and exam, Jiang and Kung
compositions and memorizing codified knowledge of the Confucian classics (Lee, 2003). The more competent candidates would be more likely to pass the exam at a younger age (Marsh, 1961; Jiang and Kung, 2016). Younger successful candidates, in turn, would have more opportunities to go up in the ranks than their counterparts.

5. Family Network, Prestige, and Political Power

5.1. Baseline Estimation

We first start with a simple graphical illustration of the lineage effect on official selection. In Figure 6 we show the proportions of exam passers who obtained the high ranking positions across the lineage score decile groups. We group the final-round examination candidates into the first, the second and the third tier based on their exam scores, and plot them along the standardized lineage score. The figure shows that the candidates placed in the first-tier (the top three out of thirty-three exam takers) of the exam were generally more likely to become high-ranking officials for any given level of lineage score, compared to other tier groups. This supports the argument that performance in the exam was indeed a factor for success in the court. At the same time, the figure also shows that the candidates with high lineage scores were also more likely to become high-ranking officials, even when they placed in lower tier groups in the exam. We see that at the highest

(2016) standardize the ranks as follows:

\[
\frac{\text{total number of passers in a given exam} - \text{actual ranking}}{\text{total number of passers in a given exam}}
\]

with the value ranging in [0,1). In our study, we standardize the final grade in terms of the three tiers (as described in Table A1) instead of individual rankings.
linear score (at the 90th percentile, for example), candidates in the second and third tier group are more likely to become high-ranking officials than the first tier group with lower lineage scores.

[Figure 6 Here]

Next we estimate the following linear probability model:\(^{28}\)

\[ y_i = \rho + \pi x_i + C_i' \Gamma + Z_i' H + \epsilon_i \] (1)

where \( y_i \) is a dummy variable indicating whether individual \( i \) became a high-ranking official. \( x_i \) denotes \( i \)'s lineage score, which we normalize for easier interpretation.\(^{29}\) \( C_i \) is a vector of controls including the final exam performance tier indicators and the (normalized) age upon taking the final-round exam. \( Z_i \) is a vector of additional confounders including the family clan, king-in-rule, pre-exam status (categories: student, classics licentiate, literary licentiate, or court officer), types of exam (regular vs. irregular exams), year-of-birth and place-of-residence indicators.

Table 4 summarizes the baseline estimation results across different model specifications. We report the key coefficients and their robust standard errors clustered by the family clans. In each specification, we control for all the confounders in \( Z_i \). The estimation results are statistically significant at the one-percent level and suggest that candidates with high lineage scores had significantly higher probabilities of becoming high-ranking officials. The coefficient estimate reported in Column (1) for example indicates that one standard deviation increase in the lineage

\(^{28}\) We also present results from logit and probit estimations in Table 5.

\(^{29}\) For our empirical analysis we standardize the lineage score so that it has a mean of zero and a standard deviation of one. Table A2 in Appendix A also presents the summary statistics of unstandardized lineage score.
score is associated with about a six percentage-point increase in the likelihood of becoming a high-ranking official. Column (2) shows that the family effect is robust when we control for the candidates’ final exam grade tier, although as expected, the likelihood of becoming a high-ranking official is significantly higher for those who are in the first-tier group. We also control for the age upon passing the exam in Column (3). We find that younger passers are indeed more likely to be successful in the court. Column (4), which is our preferred specification, furthermore adds the residence fixed effects. The coefficient estimate under the this specification suggests that the likelihood of becoming a high-ranking official increases by about 3.9 percentage points when the lineage score is one standard deviation higher than the average. In our sample, the difference between the minimum and the maximum lineage score is about 6.8. Our estimation thus suggests that a final-round exam candidate with the highest lineage score would be about 26.5 percentage points more likely than one from the lowest score to become a high-ranking official.

Finally, following Jiang and Kung (2016) we additionally control for whether the exam candidate’s close ancestors passed the exam or not in columns (5) to (7). Jiang and Kung (2016) use the exam performances of the father, the grandfather and the great grandfather to capture the family-specific “cultural capital” that provided the know-how in passing the exam under the Chinese civil service examination system.30 We include these measures in our regressions and find that the lineage effect still persists in Columns (5)-(7). That is, the candidate’s inherited

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30 Jiang and Kung (2016) look at whether the candidate passed the exam or not as their dependent variable. The “cultural capital” in Jiang and Kung (2016) thus explains the part of ancestral know-how in passing the exam. In our paper we interpret the inherited knowledge in statecraft to have helped the candidate to obtain a high-ranking position after the exam, and extend the family networks to more distant ancestors based on the exam roster.
political capital from more distant ancestors, i.e. three generations ago or even more, still continued to influence his political career success.

[Table 4 Here]

5.2. Robustness Checks

We find that family lineage mattered for obtaining high-ranking official positions, but how beneficial were these connections across the spectrum of different positions? While we have primarily focused on the likelihood of the exam candidate joining the high-ranking group, we can also conduct the baseline regression separately with outcome variables indicating different levels of official positions— for example, from the sixth rank senior positions and up (denoted as S6) to only the first rank senior positions (denoted as S1), the highest rank in the system. We plot the estimated coefficients for the key variables of interest and their 95 percent confidence intervals in Figure 7: the lineage score in Panel (a), an indicator for the first-tier group in Panel (b), and the age upon passing the exam in Panel (c).

Panel (a) shows that the lineage effect is low and similar across different cut-offs in the official rankings below US3 (the third rank upper senior position or higher, our baseline group). The effect then increases in magnitude when the outcome variable is the group of people obtaining positions in US3 or above. Again, this is the group that we use as our dependent variables in the baseline estimation. Panel (a) also shows that the lineage score effect increases more as the cut-off becomes higher within the group of high-ranking officials, although it diminishes in importance for the very top positions such as J1 and S1. For these ranks, which would be equivalent to the present-day prime minister, the candidates in consideration would already come from similar family backgrounds, such that other factors would have been more important for the appointment.
Similar to Panel (a), Panel (b) shows that the effect of being in the first-tier group in the final exam mattered the most for the high-ranking official positions (US3 or above). At the same time, performance at the exam appears to have mattered less once we narrow down the group of officials to those ranked even higher than US3; at this stage, candidates in consideration likely all performed well in the exam. Finally, panel (c) shows that younger exam-passers were indeed more likely to obtain higher-ranked positions, although the age effect becomes less pronounced for the very top positions.

[Figure 7 Here]

In Table 5, we test whether the baseline estimation is robust under alternative regression models, transmission rates, weights for family link types, and samples. First, we present logit and probit regression results in Columns (2) and (3) as alternatives to the linear probability regression. The reported marginal effects are similar to those under the linear probability model. Second, we vary the inherited political capital transmission rate in the lineage score. This factor reflects the generation distance, with small values meaning that the closer connections (i.e. the father, the foster father, the father-in-law, and the maternal grandfather) weigh much more heavily than the more distant ones. Large values conversely allow greater influence from individuals in the peripheries (e.g., ancestors from many generations ago) in the score calculation (Katz, 1953; Bonacich, 1987).\(^{31}\) We use different rates of inherited political capital transmission, replacing the value ($\delta = 0.3$) in the baseline estimation with 0.1 in Column (4) and 0.5 in Column (5), and check

\(^{31}\) Katz (1953) interprets $\delta$ as the force of a probability of effectiveness of a single link: “A $k$-step chain has probability $\delta^k$ of being effective.” (Katz, 1953, p.41).
whether a particular rate causes any bias in the baseline estimation. We find that these alternative values yield similar results.

In Columns (6) and (7), we check how weight changes on ties depending on the side of the family can affect our results. In our analysis, there are four types of immediate ties found in the exam roster: the father, the foster father (if any), the maternal grandfather, and the father-in-law. We give lower weights to the influence from non-paternal ties. First in Column (6), we change the relational weight of the maternal grandfather from 1 to 1/2 in constructing the lineage score. Second, we additively replace the weight of the father-in-law from 1 to 1/2 and that of the foster father from 1 to 0 in Column (7). The results remain similar to those of the baseline estimation and are again statistically significant at the one-percent level.

Finally, in Columns (8) and (9) we present results based on different data samples. In Column (8), we only use the records from the exam roster to code the official position of each candidate, rather than referring to the court official appointment record for additional information on the highest position ever obtained. In Column (9), we combine information from both documents and keep the candidates who appear in either document. The court official appointment record does not cover all the candidates in the exam roster; for those who do not appear on the appointment record, we replace the adjacency matrix $A$ as the following:

$$a_{ij} = \begin{cases} 1, & \text{if } i \text{ and } j \text{ are directly connected from } i \text{ to } j \text{ and } i \text{ is the father} \\ 1/2, & \text{if } i \text{ and } j \text{ are directly connected from } i \text{ to } j \text{ and } i \text{ is the maternal grandfather} \\ 1/2, & \text{if } i \text{ and } j \text{ are directly connected from } i \text{ to } j \text{ and } i \text{ is the father-in-law} \\ 0, & \text{otherwise} \end{cases}$$
record, we code their official positions based on the information in the exam roster. With these alternative samples, we find that the family lineage effect on obtaining high-ranking official positions continues to be significant and positive.

[Table 5 Here]

6. Family Network and Political Stability

Did the family lineage matter more for success in the court during politically unstable periods? Given that our outcome variable is the individual’s likelihood of becoming a high-ranking official, the overall political climate during the appointment would have been crucial for the candidate’s success. In times of turmoil, inherited political capital in statecraft might prove especially useful for the candidate in the court relative to other periods. In this section we thus document the changing significance of lineage effects throughout various points of instability, which we measure with the number of government officials in exile.

In Figure 8, we first show the process of appointing a high-ranking official to explain how important the court politics was in terms of one’s career after passing the exam. In the first step, the Minister of Personnel (Yi-jo-pan-seo) would recommend up to three candidates for a high-ranking position. The king then would nominate one out of the recommended candidates. In the third step, the Ministry of Personnel would request the Office of the Censor (Sa-gan-won) and the

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33 The individuals who appear on the appointment record but not on the exam roster are dropped from all of our analysis; these are likely the merit-subjects who did not take the exam and yet obtained some positions in the court. As discussed in footnote 2, they were considered as inferior in rank and sought to elevate their status by taking the exam.
Office of the Inspector (Sa-heon-bu) to check whether there were any problems in the final nominee’s qualification and family background. After passing the final step, the nominee would finally be appointed.

[Figure 8 Here]

The preferences of the king and gatekeeping officials likely changed across different political environments. Under political uncertainty, we expect that official appointments would likely be determined more by political favoritism rather than scholarly merit, and that inherited knowledge in statecraft would be much more useful for the exam passers.

6.1. Data Sources and Variable

The main difficulties in measuring political instability during this period stem from the limited data available, as well as the ambiguities surrounding what constitutes political instability. In the absence of more fine-grained measures, we introduce the number of exiles in the court as a proxy for the overall political instability that the candidate witnessed. During the Joseon Dynasty, exile was a severe punishment that forced the condemned to live in the peripheries far from the capital. Bureaucratic exiles mostly occurred during political upheavals such as power struggles (Hong et al., 2019). For the following exercise, we hand-collected the individual exile information from two sources. First, the Encyclopedia of Korean Culture lists figures of importance in Korean history with their names, birth and death years, family clans, and biographies. We have created a list of about 900 historical figures with exile locations and years by searching for biographies with
keywords related to exile. Furthermore, we found 250 additional cases of exiled outcasts from the *Annals of the Joseon Dynasty*. Since some exiled figures relocated to other areas as continuation or extenuation of their punishment and we count all these cases, the total number of exile cases is higher than that of exiled figures. In sum, the total number of exiles during the Joseon Dynasty is 1,403 in our data. Figure 9 shows the yearly number of exiles (black dots) and major political upheavals such as political purges and treason cases (vertical lines). It is clear that the number of exiles sharply increased during politically unstable periods.

[Figure 9 Here]

We take the means of annual exile numbers over the ten or twenty years after each individual passed the exam (i.e., the moving average specific to the individual and his year of passing the exam). Our proxy for political instability is thus the average number of exiles that the exam candidate would have witnessed over the ten or twenty years after the exam, i.e. during his political career. The sample mean of this variable is around 2.8 and reported in Table A2 of Appendix A.

### 6.2. Heterogeneity across Political Instability

We add additional terms to Equation (1) to check whether the lineage effect was stronger

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34 Hong et al. (2019) use the same data and use the exile locations as their key variable. In this study, we utilize individuals' exile years to create a proxy for the Dynasty’s changing state of political stability.

35 Considering that the average exam-passing age was 33.17 (Table A2 in Appendix A) and the average lifespan during the Joseon Dynasty was around 40 to 50, the decadal time spans would have covered almost the entirety of one's political career post-exam.
under politically unstable periods:

\[ y_i = \rho + \pi_1 x_i + \pi_2 (x_i \times E_i) + C_i' \Gamma_1 + (C_i' \times E_i) \Gamma_2 + \theta E_i + Z_i' H + \epsilon_i \]  

(2)

where \( E_i \) is the average number of exiles ten or twenty years after \( i \)'s exam, standardized to zero mean and standard deviation of one. All other variables are the same as in equation (1). The estimated coefficient \( \pi_2 \) measures how much greater the lineage effect was on obtaining a high-ranking position when the average number of exiles was one standard deviation higher than the average. We can interpret the coefficients for the interaction terms with the performance in the exam and the age upon taking the final-round examination in the same way.

In Table 6 Column (1), we report the same baseline result from Table 4 Column (4) for comparison. In Column (2), we include the average number of exiles over ten years after the candidate passed the exam. The results show a positive, statistically significant interaction effect between the political instability proxy and the lineage score. In other words, when times are unstable, the candidate inherited with ancestral statecraft knowledge was more likely to become a high-ranking official. On the other hand, no other interaction terms are statistically significant. Both younger candidates and those excelling in the final-round exam and placing in the first-tier rank continued to be more successful in advancing to high-ranking positions, regardless of the overall political conditions. Column (3), in which we use the average number of exiles over twenty years (instead of ten) after the candidate’s exam proxy, shows almost the same results.

One may be concerned that the positive interaction effect of exile numbers simply reflects promotion opportunities due to vacancies in official positions after exiles occur. However, we find that the sign of estimated coefficient of \( E_i \) is actually negative and significant in both columns (i.e., \( \theta < 0 \)). In other words, a typical exam candidate (with the average family lineage and
passing age, ranked in the third-tier in the final-round exam) would actually be more disadvantaged from becoming a high-ranking official during unstable periods relative to more stable times.

Finally, we also conduct placebo tests by looking at the average number of exiles before the candidate passed the exam. Since the candidate’s career as a government official would have started after passing the exam, the political situation before passing the exam should not have the same influence on his career path. The key assumption here is that for a court official, the overall political environment during his career should matter more rather than before. The results in Columns (4) and (5) corroborate this in the sense that the political instability proxy does not have any significant effect.

[Table 6 Here]

7. Conclusion

In this paper, we have explored Joseon’s civil service examination as an important institutional feature of the monarchy. In particular, the exam was set in place in order to recruit a talented pool of candidates for positions in the court, providing a channel of social mobility and improving the overall performance of the state. While similar civil service exam systems were historically adopted in other countries and across different time periods, the surviving records from the Joseon Dynasty stand out for their comprehensive information on the candidates’ families and official positions obtained, as well as coverage over five centuries of rule under a single dynasty.

As an important feature of the government institution, the exam system certainly fostered scholarly traditions and creation of educated political elites. However, we show that even with the adoption of the meritocratic recruiting system, family lineages continued to influence the candidate’s eventual career path in the court. The elites passed their knowledge of statecraft down
to their descendants, and those inheriting the political capital in turn were more likely to obtain higher positions in the court. The lineage effect thus remained strong and became even more pronounced in times of political instability.
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**Figures and Tables**

**Figure 1.** The Process of *Mun-gwa* Examination in the Joseon Dynasty

- **Confirmation by King**
  - **Final-round examination (jeon-si)**
    - Successful candidates ranked in order:
      - First tier (3), Second tier (7), Third tier (23)
  - **Second-round examination (bog-si)**
    - Successful candidates (33) selected
  - **First-round examination (cho-si)**
    - 240 candidates selected:
      - Each province (150), *Han-yang* (40), National Confucian Academy (50)

**Note:** The regional quotas in the first-round examination were proportional to the population in each province. The local quotas did not apply to the second-round examination or the final-round examination.
Table 1. Civil Service Rank System in the Joseon Dynasty

<table>
<thead>
<tr>
<th>Category</th>
<th>Rank</th>
<th>Sub-rank</th>
<th>% out of the sample who finally reached the rank</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dang-sang-gwan</strong> (high-ranking officials)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Senior</td>
<td>Upper</td>
<td>5.75</td>
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<tr>
<td></td>
<td>Lower</td>
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<tr>
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<tr>
<td>Second Junior</td>
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<tr>
<td></td>
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<tr>
<td><strong>Cham-sang-gwan</strong> (mid-ranking officials)</td>
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</table>

Note: High-ranking officials (Dang-sang-gwan) were defined as the ministers of the upper senior third or higher ranks, collectively known as ‘palace-ascendable officials’. They were given important rights to vote on the administration, to recommend other officials, and to direct the military (Cha, 2002). Officials from the lower junior sixth rank to the lower senior third rank were mid-ranking officials called ‘cham-sang-gwan’ and were in the charge of central administration and local government duties.
Figure 2. A Hypothetical Family Tree

Note: This figure shows a hypothetical family relation. For example, Nodes 3 and 4 are the immediate predecessors of Node 1 in the family tree, as Nodes 7 and 8 are for Node 2, Nodes 5, 6 and 8 for Node 3, and so on.
Table 2. Adjacency Matrix of a Sample Network

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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: This table shows the adjacency matrix of a sample network. For example, $a_{31} = 1$ and $a_{13} = 0$ mean that node 3 has influence on node 1, but not vice versa.
### Table 3. Example of Network and Scores

<table>
<thead>
<tr>
<th>Node ID</th>
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<th>(\delta = .1)</th>
<th>(\delta = .3)</th>
<th>(\delta = .5)</th>
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<td>2</td>
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</tr>
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<td>3</td>
<td>0.300</td>
<td>0.900</td>
<td>1.500</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>0.311</td>
<td>1.037</td>
<td>2.071</td>
</tr>
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<td>0.000</td>
<td>0.000</td>
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<td>0.000</td>
<td>0.000</td>
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</tr>
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<td>9</td>
<td>1</td>
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<td>0</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Notes: This table shows each centrality measure corresponding network in Table B1.
Figure 3. Graphical Representation of a Sample Network with Scores

(a) Indegree Centrality

(b) Lineage Score ($\delta = .3$)

Note: Each network graph corresponds to the sample network in Table 2. The number in each circle denotes the Node ID. The size of each circle is proportional to the score of each measure.
Figure 4. An Example of Family Network

Note: This family network shows the nodes and ties related to Sa-Ahn Kang. We describe the partial networks that are directly or indirectly linked to Sa-Ahn Kang in our dataset. There are many other individuals who are linked to Sa-Ahn Kang indirectly. However, due to space constraint, we restrict figures to the extent that they still help us understand the basic network structure. Here the names in bold represent the men who passed mun-gwa and made to the final-round examinations. The reason Gan Im, who was the father-in-law of Sa-Ahn Kang, has a tie with Yu-Gyeom Im even though Gan Im was not a successful candidate, is that Gwang Im passed the exam in 1624 and was a grandson of Gan Im. That is, in the rosters, there are information that Gwang Im was a son of Ye-Shin Im, a grandson of Gan Im, a great grandson of Yu-Gyeom Im, and so on. In this specific example, the number of nodes is 26 and the number of ties is 27. The relationships between individuals are noted in parenthesis.
Note: This family network shows the nodes and ties related to Sa-Ahn Kang. We describe the partial networks that are directly or indirectly linked to Sa-Ahn Kang in our dataset, corresponding to Figure 4. The size of the circle is proportional to Katz lineage scores. We represent ties to individuals who do not influence Sa-Ahn Kang as dotted arrows (from Gan Im to Ye-Shin Im and from Ye-Shin Im to Gwang Im).
Figure 6. Proportion of Candidates Obtaining High-Ranking Positions

Note: This figure is a binned scatter plot indicating the proportion of candidates becoming high-ranking officials. To construct this binned scatter plot, we first divide the lineage score into ten equal sized-groups (deciles) and plot the means of the y-axis variable within each tier group in the final examination against the mean value of lineage score in each bin.
**Table 4. Effects of Family Networks on High-ranking Official Positions: Baseline Estimation**

Dependent variable: Dummy = 1 if the candidate became a high-ranking official

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Independent variables</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network measure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lineage score</td>
<td>0.062***</td>
<td>0.062***</td>
<td>0.055***</td>
<td>0.039***</td>
<td>0.035***</td>
<td>0.031***</td>
<td>0.024**</td>
</tr>
<tr>
<td>(0.009)</td>
<td>(0.009)</td>
<td>(0.009)</td>
<td>(0.009)</td>
<td>(0.009)</td>
<td>(0.010)</td>
<td>(0.010)</td>
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</tr>
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<td>Exam score ranking (Reference: Third-tier in the final-round exam)</td>
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<tr>
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<td>0.090***</td>
<td>0.091***</td>
<td>0.091***</td>
<td>0.091***</td>
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<td>(0.024)</td>
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<td>(0.024)</td>
<td>(0.024)</td>
<td>(0.024)</td>
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</tr>
<tr>
<td>Second-tier dummy</td>
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<td>0.008</td>
<td>0.008</td>
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<tr>
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<td>(0.023)</td>
<td>(0.021)</td>
<td>(0.021)</td>
<td>(0.021)</td>
<td>(0.021)</td>
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<td>Passing age</td>
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<td>-0.059***</td>
<td>-0.058***</td>
<td>-0.058***</td>
<td>-0.058***</td>
<td>-0.058***</td>
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<tr>
<td>(0.013)</td>
<td>(0.014)</td>
<td>(0.014)</td>
<td>(0.014)</td>
<td>(0.014)</td>
<td>(0.014)</td>
<td>(0.014)</td>
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<td>Ancestors’ achievement dummies in the final-round exam</td>
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<tr>
<td>Father</td>
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<td>0.016</td>
<td>0.018</td>
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<td>(0.017)</td>
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<td>(0.017)</td>
<td>(0.017)</td>
<td>(0.017)</td>
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<td>0.037**</td>
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<tr>
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<td>(0.018)</td>
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<td>(0.018)</td>
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<td>5,179</td>
<td>5,179</td>
<td>5,179</td>
<td>5,179</td>
</tr>
</tbody>
</table>

Notes: We conducted the regressions in equation (1) across different model specifications. The dependent variable is a dummy variable for whether the individual’s highest official position obtained throughout his career was higher than or equal to the third rank upper senior position (i.e., belonging to the group of high-ranking officials). The lineage score and the passing age are standardized to zero means and standard deviations of one. In column (1), the specification includes the pre-exam status, exam type, period of king-in-rule, family clan, and year-of-birth fixed effects. We add the final grade in the exam and the age at the time of taking the final-round examination in Column (2) and Column (3), respectively. Column (4), which is our preferred specification, further adds the residence fixed effects to rule out any regional characteristics driving our result. The family clan fixed effects include the dummies of 319 family clans. The king-in-rule fixed effects include the dummies of 26 kings during the Joseon Dynasty. The exam type fixed effects include the dummies for the regular exams and the irregular exams. The year-of-birth fixed effects include each successful candidate’s birth year dummies from 1363 to 1878. The residence fixed effects include the 202 district-level (Gun-Hyun) region dummies. Each cell reports the estimated coefficients and their standard errors clustered by family clans in parenthesis. A single asterisk denotes statistical significance at the 90% level of confidence, double 95%, and triple 99%. 
Figure 7. Using Alternative Cut-offs of Official Positions

Note: We repeat the baseline estimation in column (4) of Table 4, but replace the dependent variable using different cut-offs of the high-ranking official positions. Each cut-off abbreviated on the horizontal axis is explained in Table 1. We report the estimated coefficients and their 95-percent confidence intervals for the lineage score in Panel (a), those for the first-tier dummy in Panel (b), and those for the passing age in Panel (c).
Table 5. Estimation with Alternative Specifications
Dependent variable: Dummy = 1 if the candidate became a high-ranking official

<table>
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<th>Independent variables</th>
<th>Baseline</th>
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<th>Probit</th>
<th>( \delta = 0.1 )</th>
<th>( \delta = 0.5 )</th>
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<th>Method 2</th>
<th>Sample 1</th>
<th>Sample 2</th>
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<tr>
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<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
<td>(8)</td>
<td>(9)</td>
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<tr>
<td>Network measure</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lineage score</td>
<td>0.0387***</td>
<td>0.0384***</td>
<td>0.0388***</td>
<td>0.0313***</td>
<td>0.0338***</td>
<td>0.0342***</td>
<td>0.0410***</td>
<td>0.0675***</td>
<td>0.0710***</td>
</tr>
<tr>
<td></td>
<td>(0.0092)</td>
<td>(0.0105)</td>
<td>(0.0085)</td>
<td>(0.0099)</td>
<td>(0.0073)</td>
<td>(0.0094)</td>
<td>(0.0109)</td>
<td>(0.0078)</td>
<td>(0.0067)</td>
</tr>
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<td>Statecraft measure (Reference: Third-tier in the final-round examination)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>First-tier dummy</td>
<td>0.0909***</td>
<td>0.0953***</td>
<td>0.0924***</td>
<td>0.0900***</td>
<td>0.0928***</td>
<td>0.0904***</td>
<td>0.0914***</td>
<td>0.1351***</td>
<td>0.0948***</td>
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<td></td>
<td>(0.0237)</td>
<td>(0.0333)</td>
<td>(0.0223)</td>
<td>(0.0238)</td>
<td>(0.0237)</td>
<td>(0.0238)</td>
<td>(0.0237)</td>
<td>(0.0242)</td>
<td>(0.0183)</td>
</tr>
<tr>
<td>Second-tier dummy</td>
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<td>0.0071</td>
<td>0.0060</td>
<td>0.0087</td>
<td>0.0082</td>
<td>0.0087</td>
<td>0.0088</td>
<td>0.0292*</td>
<td>0.0228</td>
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<td>(0.0210)</td>
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<td>(0.0209)</td>
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<td></td>
</tr>
<tr>
<td>Passing age</td>
<td>-0.0600***</td>
<td>-0.0605***</td>
<td>-0.0596***</td>
<td>-0.0630***</td>
<td>-0.0606***</td>
<td>-0.0616***</td>
<td>-0.0597***</td>
<td>-0.0382***</td>
<td>-0.0490***</td>
</tr>
<tr>
<td></td>
<td>(0.0136)</td>
<td>(0.0140)</td>
<td>(0.0128)</td>
<td>(0.0138)</td>
<td>(0.0135)</td>
<td>(0.0137)</td>
<td>(0.0138)</td>
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<td>(0.0103)</td>
</tr>
<tr>
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<td>4,633</td>
<td>4,633</td>
<td>5,179</td>
<td>5,179</td>
<td>5,179</td>
<td>5,179</td>
<td>6,289</td>
<td>8,843</td>
</tr>
</tbody>
</table>

Notes: We conducted the baseline regressions using alternative specifications. Column (1) presents the baseline results, which is reported in column (4) of Table 4, for comparison purpose. In columns (2) and (3), we estimate using logit and probit model instead of linear probability model. To make them comparable using probability scale, we report the average marginal effects across values of each variable. Columns (4) and (5) show the results of different decay factor in lineage score. From column (6) and column (7), we use different edge weights according to the kind of ties. In column (6), we change the edge weight of maternal grandfather from 1 to 1/2 in measuring the lineage score. We additively replace the weight of father-in-law from 1 to 1/2 and that of foster father from 1 to 0 in column (7). In column (8), we only use the records from mungwa bangmok to code the official position of each candidate, rather than referring to appointment records for additional information on the highest position obtained. In column (9), we combine information from both documents and keep the candidates which appear in either document. Each cell reports the estimated coefficients and their standard errors clustered on family clans in parenthesis. A single asterisk denotes statistical significance at the 90% level of confidence, double 95%, and triple 99%.
**Figure 8.** The Process of the high-ranking official Appointment

- Recommendation from the minister of Personnel
- King’s selection among recommended candidates
- Verification of identification through checking family background
- Appointment

*Note:* This figure shows the process of official appointment, especially the case of high-ranking official.
Figure 9. Annual Number of Exiles and Periods of Political Instability in the Joseon Dynasty

*Note:* Each dot depicts the number of exiles by year. Vertical lines are political events including political purges and treason cases.
### Table 6. Heterogeneous Effects Across Political Instability

Dependent variable: Dummy = 1 if the candidate became a high-ranking official

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Baseline</th>
<th>After passing the exam</th>
<th>Before passing the exam</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Lineage score</td>
<td>0.0387*** (0.0092)</td>
<td>0.0359*** (0.0094)</td>
<td>0.0339*** (0.0081)</td>
</tr>
<tr>
<td>Lineage score × Avg. Exile</td>
<td>0.0237*** (0.0072)</td>
<td>0.0214*** (0.0081)</td>
<td>0.0124 (0.0090)</td>
</tr>
<tr>
<td>First-tier dummy</td>
<td>0.0900*** (0.0237)</td>
<td>0.0900*** (0.0239)</td>
<td>0.0911*** (0.0241)</td>
</tr>
<tr>
<td>First-tier dummy × Avg. Exile</td>
<td>0.0049 (0.0216)</td>
<td>0.0101 (0.0219)</td>
<td>0.0089 (0.0238)</td>
</tr>
<tr>
<td>Second-tier dummy</td>
<td>0.0083 (0.0210)</td>
<td>0.0075 (0.0206)</td>
<td>0.0067 (0.0203)</td>
</tr>
<tr>
<td>Second-tier dummy × Avg. Exile</td>
<td>-0.0104 (0.0220)</td>
<td>0.0072 (0.0208)</td>
<td>-0.0078 (0.0219)</td>
</tr>
<tr>
<td>Passing age</td>
<td>-0.0600*** (0.0136)</td>
<td>-0.0600*** (0.0143)</td>
<td>-0.0590*** (0.0140)</td>
</tr>
<tr>
<td>Passing age × Avg. Exile</td>
<td>0.0236 (0.0161)</td>
<td>0.0233* (0.0141)</td>
<td>0.0087 (0.0126)</td>
</tr>
<tr>
<td>Avg. Exile</td>
<td>-0.0328* (0.0171)</td>
<td>-0.0507*** (0.0186)</td>
<td>0.0006 (0.0175)</td>
</tr>
</tbody>
</table>

**Notes:** This table summarizes the regression results of Equation (2) and we report the baseline result in Column (1) for comparison purposes. In Column (2), we set the hypothetical career periods as 10 years after passing the exam. The results show that the interacted effect with the lineage score is associated with higher likelihood of being a high-ranking official. No other interaction terms are statistically significant. Column (2) assigns 20 years for career periods. Each cell reports the estimated coefficients and their standard errors are clustered by family clans in parenthesis. A single asterisk denotes statistical significance at the 90% level of confidence, double 95%, and triple 99%.
Appendix A. Figures and Tables
### Table A1. Initial Placement by Score in the Final-round Examination

<table>
<thead>
<tr>
<th>Grade in the final-round examination</th>
<th>Number</th>
<th>Official rank (position) assignment</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td>Without official position</td>
</tr>
<tr>
<td>First-tier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First rank (<em>jang-won</em>)</td>
<td>1</td>
<td>Junior sixth rank position</td>
</tr>
<tr>
<td>Second and third rank</td>
<td>2</td>
<td>Senior seventh rank position</td>
</tr>
<tr>
<td>Second-tier</td>
<td>7</td>
<td>Junior eighth rank</td>
</tr>
<tr>
<td>Third-tier</td>
<td>23</td>
<td>Senior ninth rank</td>
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</tbody>
</table>

*Note: This table is re-tabulated from Lee (1994). “With official position” denotes those already holding official titles. Exam candidates scoring in the second- and the third-tier groups without previous official positions were not guaranteed posts and instead only received official ranks (not real official positions). They had to wait as temporary officials until positions became vacant. If mid-ranking officials passed the exam, they were guaranteed to have promoted positions even if they did not place in the first-tier group in the final-round examination (Won, 2007).*
### Table A2. Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>High-ranking officials vs. Other officials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Proportion of exam candidates</td>
<td>0.556</td>
<td>0.497</td>
</tr>
<tr>
<td>becoming high-ranking officials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network measure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lineage score</td>
<td>1.287</td>
<td>0.587</td>
</tr>
<tr>
<td>Exam score ranking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First-tier dummy</td>
<td>0.117</td>
<td>0.321</td>
</tr>
<tr>
<td>Second-tier dummy</td>
<td>0.200</td>
<td>0.400</td>
</tr>
<tr>
<td>Third-tier dummy</td>
<td>0.683</td>
<td>0.465</td>
</tr>
<tr>
<td>Passing age</td>
<td>33.169</td>
<td>9.176</td>
</tr>
<tr>
<td>Pre-exam status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confucian student</td>
<td>0.275</td>
<td>0.447</td>
</tr>
<tr>
<td>Classics Licentiate</td>
<td>0.147</td>
<td>0.354</td>
</tr>
<tr>
<td>Literary Licentiate</td>
<td>0.198</td>
<td>0.398</td>
</tr>
<tr>
<td>Previous official holder</td>
<td>0.380</td>
<td>0.486</td>
</tr>
<tr>
<td>Irregular exam</td>
<td>0.526</td>
<td>0.499</td>
</tr>
<tr>
<td>Lived in Seoul before exam</td>
<td>0.604</td>
<td>0.489</td>
</tr>
<tr>
<td>Average number of exiles after passing the exam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For 10 years</td>
<td>2.797</td>
<td>2.258</td>
</tr>
<tr>
<td>For 20 years</td>
<td>2.765</td>
<td>1.631</td>
</tr>
<tr>
<td>Observations</td>
<td>5,179</td>
<td>5,179</td>
</tr>
</tbody>
</table>

*Notes:* This table reports descriptive statistics on variables related to empirical analysis.
Figure A1. Sample of Family Networks Having More Than 4 Ties

Note: This figure shows sample family networks of those who became high-ranking officials (black dots) and those who did not (gray dots). The size of the circle is proportional to the lineage scores. To simplify the graph, we restrict the nodes that have more than or equal to 5 ties. In this network, the number of nodes is 2,729 (5.71% of total) and that of ties is 2,391 (4.86% of total), respectively. We drew this network using the ForceAtlas layout (see https://gephi.org/users/tutorial-layouts/).
Appendix B. Degree-based Centrality Measures

In this section, we briefly summarize degree-based centrality measures. We first explain the concept of degree centrality and show how it can be extended to eigenvector centrality. First and foremost, there are shortcomings in using Eigenvector centrality for an asymmetric network. Hence we discuss how this problem can be fixed using Alpha centrality measure instead, and how it relates to Katz prestige. We also explain why we do not consider PageRank centrality in our study. Finally, we provide a simple example of a network to compare other degree centrality measures with Katz prestige.

Let a graph \((N, A)\) consist of a set of nodes, \(N = \{1, \ldots, n\}\), and a real-valued \(n \times n\) adjacency matrix, \(A\), where \(a_{ij}\) represents the directed link from Node \(i\) to Node \(j\). That is, the adjacency matrix \(A\) is a zero-one square matrix with its \((i, j)\)th entry as the following:

\[
a_{ij} = \begin{cases} 
1, & \text{if node } i \text{ gives a (one way) link to node } j \\
0, & \text{otherwise}
\end{cases}
\]

Since we focus on a directed graph, \(a_{ij} \neq a_{ji}\) in our study.

Indegree centrality assigns one point for every directed link that a node receives. Thus, we can obtain Node \(i\)’s indegree centrality, \(x_{i}^{in}\), by simply calculating

\[
x_{i}^{in} = \sum_{j} a_{ji}
\]

Similarly, Node \(i\)’s outdegree centrality becomes

\[
x_{i}^{out} = \sum_{j} a_{ij}
\]

The major caveat here is that degree centrality easily misses important information on a network by assuming that all nodes are equivalent. But some are more relevant than others, and endorsements from important nodes need to be given more weight. To address this issue, Eigenvector centrality, proposed by Bonacich (1972), considers the centrality of neighboring nodes. Let a \(n \times 1\) vector \(x^e\) denote Eigenvector centrality associated with a network (adjacency matrix) \(A\). The key idea of Eigenvector centrality is that the centrality of a node is proportional to the sum of the centrality of its neighbors (Bonacich, 1972). Thus, we write
\[ \lambda x_i^e = \sum_j a_{ij} x_j^e \]

where \( \lambda \) is a proportionality factor. In terms of matrix notation,

\[ \lambda x^e = A'x^e \]  \hspace{1cm} (B1)

and

\[ (A' - \lambda I)x^e = 0 \]

where \( I \) denotes the \( n \times n \) identity matrix. In order for this equation to have a non-zero solution \( x^e \), it must be that \( A' - \lambda I \) is a singular (or non-invertible) matrix. In other words,

\[ \text{det}(A' - \lambda I) = 0 \]

where \( \text{det}(\cdot) \) indicates the determinant. Therefore, \( x^e \) is the left eigenvector of \( A \) (or right eigenvector of \( A' \)), which corresponds to the in-edges in the graph, and \( \lambda \) is its corresponding eigenvalue. The standard convention is to look for the eigenvector associated with the largest eigenvalue (dominant eigenvalue).\(^{36}\)

A problem with Eigenvector centrality occurs in directed networks, especially when some nodes are never chosen by other nodes. Only nodes in a strongly connected component of two or more vertices can have a positive centrality value, which makes the eigenvector centrality measure inappropriate in asymmetric networks.\(^{37}\)

As a solution to this problem, Lloyd and Bonacich (2001) introduce Alpha centrality \( x^A \) by assigning a certain minimum score to each node. They assign \( e \) to be a parameter of base value or exogenous sources of status, and replace Equation (B1) with the following new equation

---

\(^{36}\) According to the Perron-Frobenius Theorem, the largest eigenvalue of any nonnegative matrix is real-valued, and its corresponding eigenvector is nonnegative (Jackson, 2010).

\(^{37}\) Our family network structure is asymmetric and accordingly we do not consider Eigenvector centrality as appropriate.
\[ x^A = \alpha A' x^A + e1 \]

where \(1\) is a column vector of ones.

The parameter \(\alpha\) reflects the relative importance of endogenous versus exogenous factors in the determination of centrality. The solution for this equation exists only if \(\alpha < \frac{1}{\lambda}\) where \(\lambda\) is the largest eigenvalue of \(A\). If \(\alpha \to 0^+\), then Alpha centrality reduces to degree centrality. On the other hand, if \(\alpha \to \left(\frac{1}{\lambda}\right)^-\) and \(\beta = 0\), then it becomes similar to Eigenvector centrality.\(^{38}\) The matrix solution for this equation becomes

\[ x^A = (I - \alpha A')^{-1} e1 \]

where \(I\) denotes the \(n \times n\) identity matrix. This measure of centrality is almost identical to Katz prestige \(x\), and the relationship between the two measures can be derived as follows

\[ x^A = [(I - \alpha A')^{-1}] e1 = [(I - \alpha A')^{-1} - I + I] e1 = ex + e1 \]

Therefore, we can deduce that Alpha centrality is simply an affine transformation of Katz prestige.

In a practical manner, the exogenous source of status \((e)\) is usually normalized to one since it just scales scores (Bloch et al., 2017; Jackson, 2010). In this case, the two measures differ only by one (Lloyd and Bonacich, 2001).

There is a common concern about Katz prestige in that if a node with high prestige gives links to many other nodes, all the targeted nodes are likely to get high prestige. PageRank centrality addresses this issue by giving less weight for the influences from higher outdegree nodes. However, in our context, it is unlikely that ancestors give shared (penalized) influence to descendants because of many out-edges. For example, suppose that an individual has an exam-passing father and many brothers. When evaluating his centrality, it is not reasonable to reduce the

\(^{38}\) The degree centrality measures the immediate local influence and the eigenvector centrality measures the global influence within the network. On the other hand, alpha centrality (and Katz prestige) covers both the local and global influence based on the damping factor (Cruz et al., 2017; Zhan et al., 2017).
level of political capital that the father passes down just because he has many sons. That is, there is no reason to penalize the link from a high-outdegree source node.