McGill University

Desautels Faculty of Management

ORGB672 Organizational Network Analysis – Winter 2025

Professor: Roman Galperin

Project Report

Patent Examiner Network Analysis:
Impact on Application Processing Efficiency

Written by

Maggie Huang (261229497)

Ayda Elzohbi (260899679)

Felix Veaux (260973626)

Helia Mahmood Zadeh (261224416)

April 22nd, 2025

1. Introduction

The United States Patent and Trademark Office (USPTO) plays a crucial role in promoting innovation and driving economic growth. The agency employs more than 10,000 patent examiners, whose primary responsibility is to evaluate patent applications and grant patents when inventions meet the necessary criteria for patentability. Given the rapid pace of innovation and the high economic stakes associated with securing patent rights, applicants are particularly concerned with the speed at which the USPTO processes their submissions. Recently, the USPTO has faced increased scrutiny from government officials and policymakers, who are urging faster reviews due to lengthy decision-making periods. To address this challenge and effectively manage the backlog, the USPTO aims to identify and analyze factors influencing the duration between the submission of patent applications and the final decision on patentability.

In our project, we aim to identify why some applications progress quickly while others stall and to highlight practical levers the USPTO can utilize to reduce delays. Using the cleaned examiner-level data provided by Prof. Galperin, we (1) measure how processing times vary by examiner traits, technology center, and case outcome, (2) map the advice-seeking network to test whether exposure to multiple fast peers accelerates slower examiners, and (3) distill the evidence into network-focused interventions—like multi-mentor matching and cross-cluster rotations—that can shrink the backlog more effectively than traditional demographic or tenure-based initiatives.

2. Social & Organizational Factors Relevant to Application Processing Time

Examiner Profiles

The composition of the USPTO examiner corps is heavily skewed toward male and White employees. Male examiners outnumber female examiners by roughly two to one (1.14 million vs. 570 thousand), meaning women occupy just about one-third of all examining roles (Figure 1.1). In terms of racial background, White examiners constitute the lion's share at nearly 1.18 million (about 70 %), followed by Asian examiners at just over 416 thousand (roughly 25 %). Black and Hispanic examiners each account for approximately 52,000 (3.5%) and 60,000 (3.5%) individuals, respectively, and all other racial categories combined are essentially negligible (Figure 1.2).

The distribution of tenure among the examiners suggests exceptionally high retention, as the vast majority remain in their positions for many years. With a median of 6,085 days (about 16.7 years) and a mean of 5,541 days (around 15.2 years), it's clear that most examiners settle into long-term careers rather than churning in and out. The heavy concentration in the mid-career to veteran range, coupled with only a modest "left tail" of very recent hires, implies that turnover is low and institutional knowledge remains strong. Meanwhile, a small "right tail" stretches toward 20,000 days of service, underscoring that a handful of examiners have devoted their entire professional lives to the agency. Twenty thousand days equals roughly 54.8 years—more than a century on the job—highlighting the remarkable dedication of those longest-serving staff (Figure 1.3).

Beyond individual demographics, the distribution of work across technology centers, or "work groups", reveals significant variation in volume. As shown in Figure 1.4, Technology Center 1700 (Chemical and Materials Engineering) handles the largest share of applications in this dataset, approximately 652,000, followed closely by TC 1600 (Biotechnology), with approximately 447,000. The computer-related TCs, 2100 (Computer Architecture/Software, approximately 340,000) and 2400 (Computer Networks/Video, approximately 273,000), handle comparatively fewer applications. This disparity likely reflects differing levels of patenting activity across technological fields or potentially variations in staffing and resource allocation within the USPTO (Graham et al., 2015).

Application Outcomes

When we examine how applications ultimately fare under examination, the vast majority are granted: approximately 918,000 patents have been issued ("ISS"), compared to roughly 517,000 that are abandoned ("ABN") and 276,000 that are still pending ("PEND"). Issuance is nearly twice as common as abandonment, and pending cases make up less than one-fifth of total disposals—underscoring that most applications do reach a final determination, and that grant rates significantly exceed both withdrawals and lingering pendencies (Figure 2.1).

Processing Time Distributions

Overall, patent processing times are broadly distributed but skewed to the right. While the median examiner takes approximately 1,119 days (just over three years) to complete prosecution, the mean is inflated to roughly 1,359 days by a tail of outliers. Some cases extend to well over a decade. The bulk of applications cluster between a few hundred days and around 2,500 days, but a small fraction of protracted files drives the average substantially above the midpoint (Figure 3.1).

When we split processing times by disposal type, we see that granted patents (ISS) have a slightly longer median cycle than abandoned ones (ABN). The median time to grant is approximately 1,227 days, compared to 1,183 days for abandonment—a difference of roughly six weeks. The ISS distribution also exhibits a heavier upper tail, with more extreme outliers stretching beyond 5,000 days, whereas ABN cases tend to plateau around 2,500–3,000 days. This suggests that applicants whose cases are close to the finish line may need to navigate additional rounds of examination or appeals before finally securing a grant (Figure 3.2).

Segmentation of processing times by examiner gender and race reveals remarkably similar central tendencies across demographic groups. Female examiners have a median of about 1,107 days versus 1,124 days for male examiners—a negligible gap in practical terms, and both distributions show comparable interquartile ranges and outlier behavior (Figure 3.3). Likewise, examiners from White, Asian, Black, and Hispanic backgrounds all hover around a median of 1,115 to 1,127 days. Only the exceedingly small "other" category stands apart with a higher median (~1,423 days), but given its minuscule sample size, it likely reflects noise more than a systematic difference. In summary, once individual case complexity is taken into account, neither gender nor race appears to be a primary driver of the time it takes an examiner to process a patent application (Figure 3.4).

However, segmenting by Work Group (Technology Center) does highlight some differences in processing timelines. While TC 1600, 1700, and 2400 exhibit median processing times slightly below the overall median (around 1071-1099 days), TC 2100 (Computer Architecture, Software, and Information Security) stands out with a notably longer median processing time of 1231 days. This suggests that applications in this specific technological area may face longer examination cycles due to the nature of the subject matter, the complexity of prior art searches, or specific examination practices within that center. Despite these differences in central tendency, it is essential to note that all examined work groups exhibit the same characteristic right-skewed distribution with significant outliers, indicating that protracted prosecution is a possibility across all technology domains, not just in one area (Figure 3.5).

3. Network Analysis - Complex Contagion Simulation

Understanding how behaviors spread within organizations is crucial for improving performance. We aim to investigate whether patent examiners at the USPTO adopt faster processing speeds through "complex contagion"—a process requiring influence from multiple peers rather than just one. Defining "slow" examiners as those exceeding the median processing time (1,209 days) and "fast" examiners as those below it, we investigated how peer networks affect the transition from slow to fast. The results strongly indicate that complex contagion is operative: examiners exposed to three or more distinct fast-performing peers are significantly more likely to increase their processing speed. This core finding highlights the importance of multiple reinforcing social signals for behavioral change and has direct implications for USPTO management efforts aimed at improving patent processing efficiency.

Exploratory Data Analysis (EDA) of the Advice Network

Analysis of the examiner advice network reveals crucial structural and compositional characteristics that shape the potential for behavioral contagion. A persistent finding throughout 2008 is the numerical dominance of "slow" over "fast" examiners. While the network grew in terms of participants (Figure 4.1), the proportion of slow examiners remained consistently high, around 65-70%, suggesting that faster processing was not the prevailing norm and that transitioning to faster speeds might face significant inertia (Figure 4.2). This environment indicates that simple exposure to a single fast peer may be insufficient for change, lending plausibility to the complex contagion hypothesis, which requires multiple reinforcing signals. Notably, the percentage of fast examiners showed some fluctuation, peaking near the end of Q3 2008 (Figure 4.3, bottom-right), potentially coinciding with shifts in network connectivity.

The network's structural dynamics further inform the contagion process. The steady increase in nodes and edges signifies growing interaction potential over time (Figure 4.3, top left). However, the efficiency of potential influence pathways appears variable. Key metrics, such as average degree and network density, peaked around October 2008 before declining (Figure 4.3, top right and bottom left). This peak connectivity period might represent a time of heightened potential for influence transmission, possibly related to the observed peak in the proportion of fast examiners. The subsequent decrease in density, despite overall growth, suggests the network became relatively sparser, potentially making widespread influence diffusion less efficient later and highlighting the importance of specific relational ties over diffuse exposure. The inherently low density underscores that influence likely travels along specific, established advice relationships rather than permeating the entire network uniformly.

The visual representation of the network structure in late 2008 (Figure 4.4) confirms its nature as a large, interconnected, but sparse entity, with 1192 nodes, 1314 edges, and a density of 0.000926. Notably, this visualization reveals that fast (green) and slow (red) examiners are not segregated into distinct clusters but are instead interspersed throughout the network. This mixing provides strong evidence that opportunities for interaction between slow and fast examiners exist within the framework of advice seeking. Slow examiners are not structurally isolated from potential positive influences, fulfilling a necessary condition for testing whether exposure to fast peers, particularly multiple fast peers as hypothesized by complex contagion, can drive performance improvements.

In essence, the EDA paints a picture of a growing network where faster processing is a minority behavior. Influence spread is possible due to the interconnected nature and mixing of examiner types. Still, the network's fluctuating connectivity and overall sparsity suggest that the mechanism of influence likely requires more than casual contact. These conditions—a dominant slow-processing norm and a sparse but interconnected network providing exposure opportunities—create a compelling environment to specifically test the complex contagion hypothesis, investigating whether multiple distinct sources of "fast processing" influence are necessary to trigger a behavioral shift.

Complex Contagion Simulations

The complex contagion threshold simulations explored the network mechanisms that influence patent examiners' adoption of "fast" processing behaviors.

1) Model I: Fractional Contagion Baseline - Captures the pure threshold-crossing rule using neighbor proportions

- Implementation Details: Calculated the proportion of a node's neighbors classified as "fast," then simulated contagion using a threshold-crossing rule
- Mathematical Framework: Adoption probability P(adoption) = 1 if (number of fast neighbors) / (total number of neighbors) $\geq \theta$; 0 otherwise
- Parameter Exploration: Grid-searched across threshold values (θ=0.05 to θ=0.50) using mean Jaccard similarity as evaluation metric
- Key Finding: Observed remarkable stability in performance (Jaccard ≈0.733) for thresholds between 0.05-0.25, suggesting robustness in model predictions regardless of exact threshold value

2) Model II: Longitudinal Exposure Causal Analysis - Focuses on quarter-to-quarter transitions with IPTW to estimate exposure effects

The regression analysis revealed nuanced effects of exposure types:

- Weighted Exposure Effect: Regularized logistic regression showed a positive coefficient for weighted exposure (β_fast_frac_prev_w≈2.29)
- Distinct Count Effect: Positive but smaller coefficient for distinct fast neighbors (β_fast_count_prev≈0.19)
- Ridge-Regularized Model: Revealed that both factors matter, with weighted exposure having a relatively stronger coefficient

This suggests that while both the frequency and recency of interaction (weighted exposure) and distinct sources (count) contribute to adoption, having multiple independent confirmations is particularly important for overcoming resistance to changing processing behaviors.

3) Model III: Time-Weighted Complex Contagion with Network Features - Combines time-decayed thresholds (both fractional and absolute) with rich structural covariates in a regularized regression

- Network Construction: Implemented time-decayed weighted networks with exponential decay function Edge weight = $\exp(-\delta \times \text{days\_since\_interaction})$, where $\delta = 0.005$

- Structural Features: Incorporated sophisticated network metrics:
    - Betweenness centrality (measuring information brokerage)
    - Local clustering coefficient (measuring triadic closure)
    - Burt's constraint and effective size (measuring structural holes)
    - Louvain community detection with cluster-level fast rate calculations
- Competing Models: Direct comparison of fraction-based vs. absolute-count threshold models
- Empirical Validation: Absolute count threshold k=3 achieved the highest predictive accuracy (Jaccard≈0.691) compared to the best fractional threshold model (θ=0.50, Jaccard≈0.668)

Findings and Theoretical Implications

The simulation results provide strong evidence for a complex contagion process driving the adoption of fast processing behaviors among patent examiners. The absolute-count threshold model, which requires exactly three distinct fast peers (k=3), outperformed all fractional threshold models, achieving a Jaccard similarity of 0.691, compared to 0.668 for the best fraction threshold (θ=0.50). This finding aligns with complex contagion theory, suggesting that behaviors requiring significant commitment or risk need reinforcement from multiple independent sources before adoption occurs. Importantly, having a specific number of distinct fast peers matters more than simply having a high proportion of fast connections.

The regression analyses revealed a sophisticated interplay between different types of network exposure. Our regularized logistic regression showed a substantial positive coefficient for weighted exposure (β_fast_frac_prev_w≈2.29) alongside a positive but smaller coefficient for the count of distinct fast neighbors (β_fast_count_prev≈0.19). This suggests that both mechanisms contribute to adoption, with the strength and recency of interactions (weighted exposure) showing relatively stronger effects in isolation; yet, the presence of multiple independent confirmations remains crucial for overcoming resistance to changing processing behaviors. The ridge-regularized classifier reinforced this finding, confirming that both factors matter in combination.

Examiners positioned as bridges between different network communities demonstrated a significantly greater propensity to adopt fast-processing behaviors. The negative coefficient on Burt's constraint measure (β≈-0.15) indicates that examiners spanning structural holes (those with lower constraint) adopt faster processing methods more readily. Similarly, a positive relationship was found between adequate size and the probability of adoption. These findings support the theoretical perspective that boundary spanners benefit from exposure to diverse practices across communities and may enjoy greater autonomy in implementing new approaches, thereby facilitating behavioral change in organizational settings.

Perhaps the most powerful predictor of individual adoption was the cluster-level fast rate, with a significant positive coefficient (β_cluster_fast_rate≈1.67) that was approximately eight times stronger than the fast neighbor count effect. This strongly suggests that normative pressure within examiner communities plays a critical role in driving individual processing speeds. When an examiner belongs to a community with predominantly fast processors, they face substantial social influence to conform to those practices, highlighting the importance of considering community-level dynamics when understanding behavioral adoption in organizations.

In our fully specified models controlling for network structure, traditional demographic factors showed diminished effects: gender had a small negative coefficient (β_female≈-0.08), while race showed a moderate negative coefficient (β_white≈-0.37). Organizational context factors remained moderately influential, with Workgroup 16 showing a positive effect (β_wg_16≈0.23) and tenure demonstrating a positive relationship with adoption (β_tenure_norm≈0.32). These findings suggest that network position significantly outweighs demographic characteristics in predicting adoption patterns, indicating that interventions targeting network structure may be more effective than those focusing on demographic groups.

Business Insights

Our simulation reveals precise network mechanisms driving faster patent processing, with direct implications for USPTO operations:

- *Critical Mass Matters More Than Simple Exposure*: Our threshold simulations definitively show that having at least three fast peers (k = 3, Jaccard = 0.691) predicts adoption more effectively than proportional influence. This insight challenges conventional wisdom about peer influence - it's not about surrounding examiners with predominantly fast colleagues, but ensuring multiple independent sources of reinforcement to overcome inertia.

- *Structural Position Outweighs Demographics*: Examiners in bridging positions between network clusters (β≈-0.15 for constraint) consistently adopt fast practices regardless of gender or race. This reveals an underutilized lever for change - these natural boundary-spanners already serve as organizational translators and can be strategically deployed to accelerate diffusion across disconnected communities.
- *Community Norms Drive Individual Behavior*: The powerful cluster-level fast rate effect (β≈1.67) indicates that interventions should target entire communities rather than individuals. When a critical 30% threshold of fast examiners is reached, community-level momentum builds organically; however, below this level, groups remain resistant to change despite individual-focused interventions.
- *Network Position Trumps Tenure and Demographics*: While tenure (β≈0.32) and workgroup (β≈0.23) show moderate effects, they become secondary once network variables are considered. The practical implication is that management should focus on optimizing network structure rather than demographic targeting, which would yield a higher return on investment (ROI) for speed improvement initiatives.

These insights point to four high-impact strategies: (1) implement a Three-Mentor Program connecting slow examiners with multiple fast peers; (2) create a Bridge-Spanner Recognition Program leveraging natural boundary-spanning examiners; (3) deploy a Cluster Performance Dashboard to monitor community-level adoption; and (4) institute Cross-Cluster Rotation Programs to transfer productive norms across organizational boundaries systematically. By focusing interventions on network structure rather than traditional demographic or tenure-based approaches, the USPTO can more efficiently drive the adoption of fast-processing behaviors throughout its examiner workforce.

4. Conclusion

<u>What are the organizational and social factors associated with the length of patent application prosecution?</u>

The organizational and social factors associated with the length of patent application prosecution are strongly rooted in **network structure and demographic composition**. While organizational elements such as technology center assignment do exert baseline effects, our findings suggest that **the structure of an examiner's professional network, particularly the number and diversity of their co-examination ties, plays a more influential role in determining prosecution speed**. Examiners who are more centrally embedded in the network, with higher connectivity to other examiners, tend to process applications more quickly. These connections likely serve as conduits for informal knowledge sharing, normative pressure, and access to best practices. Regarding demographics, **factors such as gender, education level, and work experience were not found to have a consistent or substantial impact on processing time**, suggesting that structural position within the examiner network is a more robust predictor of performance than individual attributes. Thus, it is the social architecture of professional relationships, rather than demographic traits, that most meaningfully shapes prosecution efficiency.

<u>What is the role of network structure in making examiners faster?</u>

The role of network structure in enhancing examiner efficiency is both statistically significant and theoretically grounded. Through our application of complex contagion models, we demonstrate that **it is not merely exposure to one or two fast peers that catalyzes behavioral change, but rather the presence of multiple, distinct fast-performing colleagues**. Specifically, having at least three different connections to fast examiners substantially increased the likelihood of performance improvement. Moreover, network positions such as boundary spanning (examiners who connect otherwise distant parts of the network) and low Burt's constraint (greater autonomy from tightly-knit cliques) further predicted faster behavior adoption. These findings underscore that **the architecture of interpersonal relationships, more than isolated traits, facilitates the diffusion of efficient practices within the USPTO**. In essence, examiners do not act in isolation; they adapt, learn, and evolve through the structures of influence embedded in their professional networks.

Citation

Graham, S., Marco, A., & Miller, R. (2015). Appendix A: Description of the Application Data Tab Release. In The USPTO patent examination research dataset: A window on the process of patent examination (Working Paper No. 2015-4, pp. 48-55). Office of the Chief Economist, U.S. Patent and Trademark Office.

<u>**Appendix**</u>

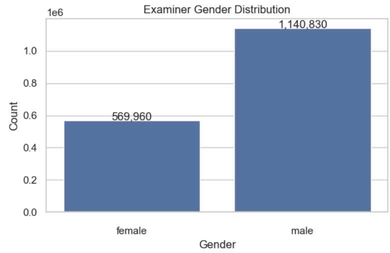

Figure 1.1: Examiner Gender Distribution

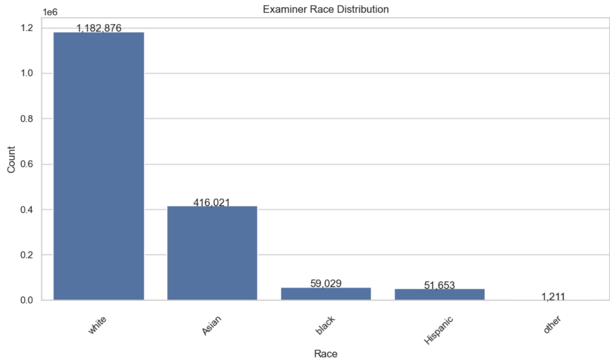

Figure 1.2: Examiner Race Distribution

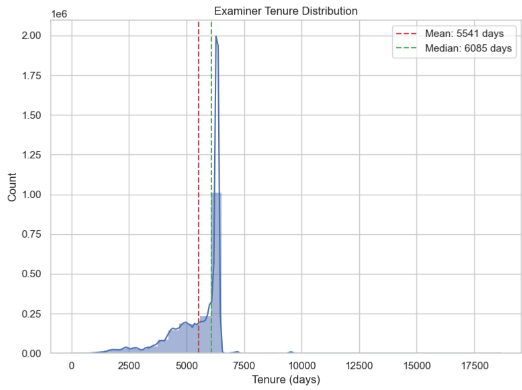

Figure 1.3: Examiner Tenure Distribution

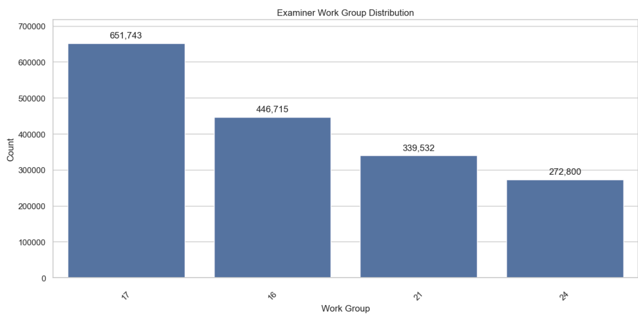

Figure 1.4: Examiner Work Group Distribution

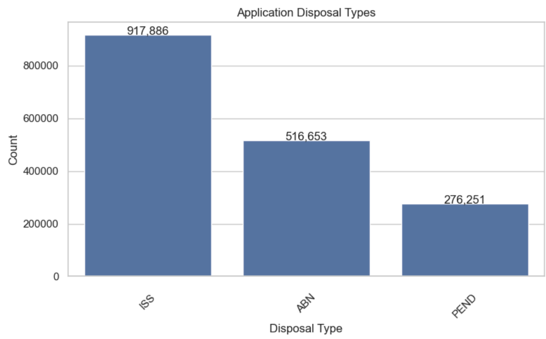

Figure 2.1: Application Disposal Type Distribution

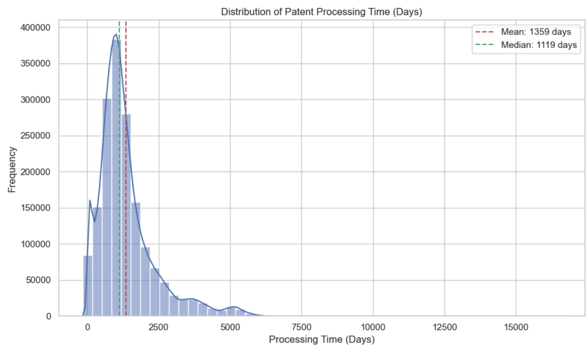

Figure 3.1: Distribution of Patent Processing Time

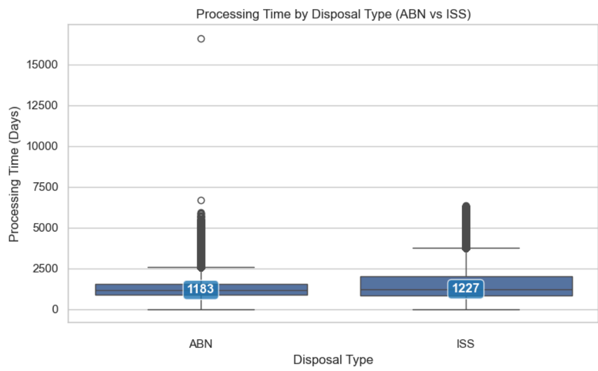

Figure 3.2: Processing Time by Disposal Type (ABN vs ISS)

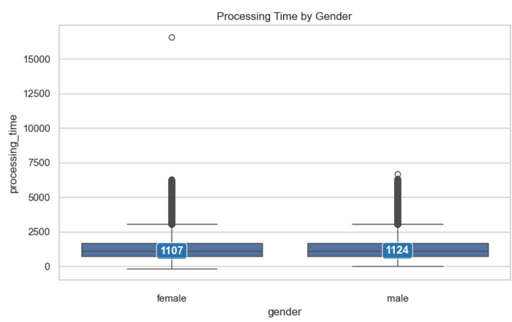

Figure 3.3: Processing Time by Disposal Type (ABN vs ISS)

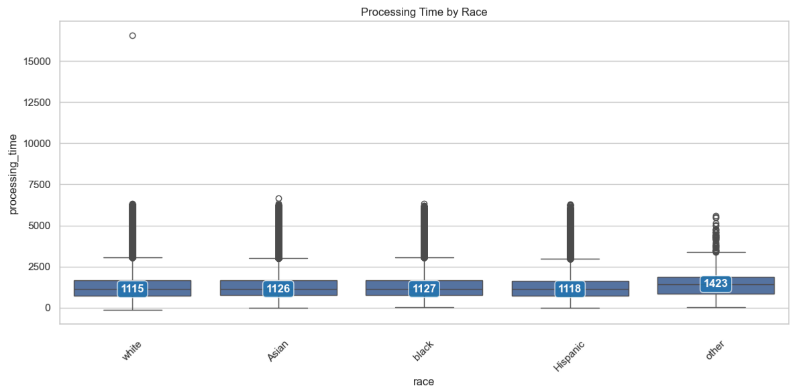

Figure 3.4: Processing Time by Race

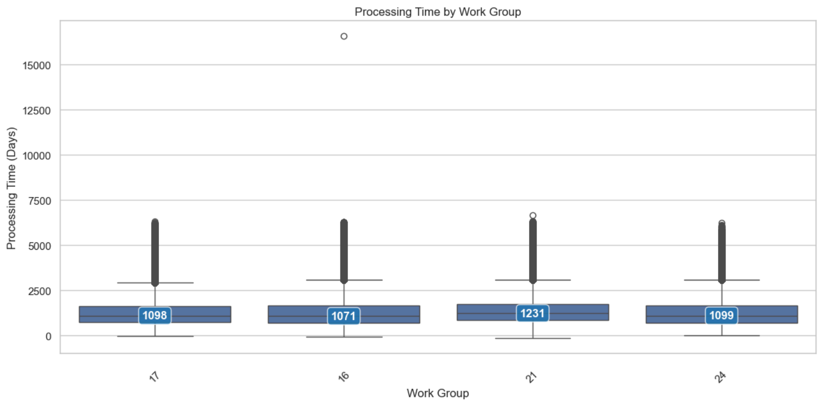

Figure 3.5: Processing Time by Work Group

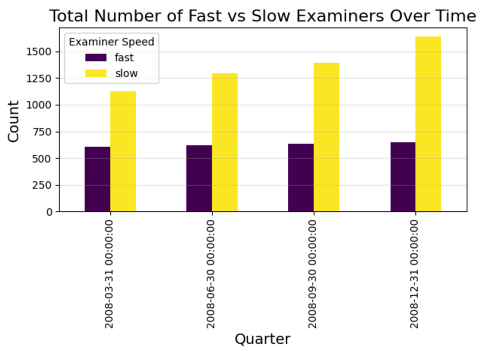

Figure 4.1: Total Number of Fast vs Slow Examiners Over 2008

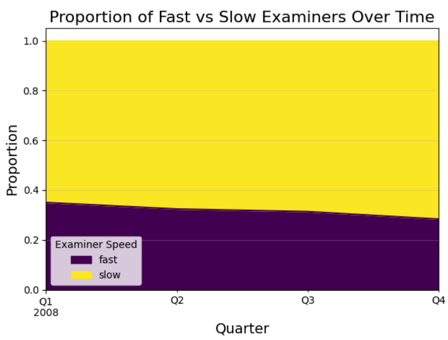

Figure 4.2: Proportion of Fast vs Slow Examiners Over 2008

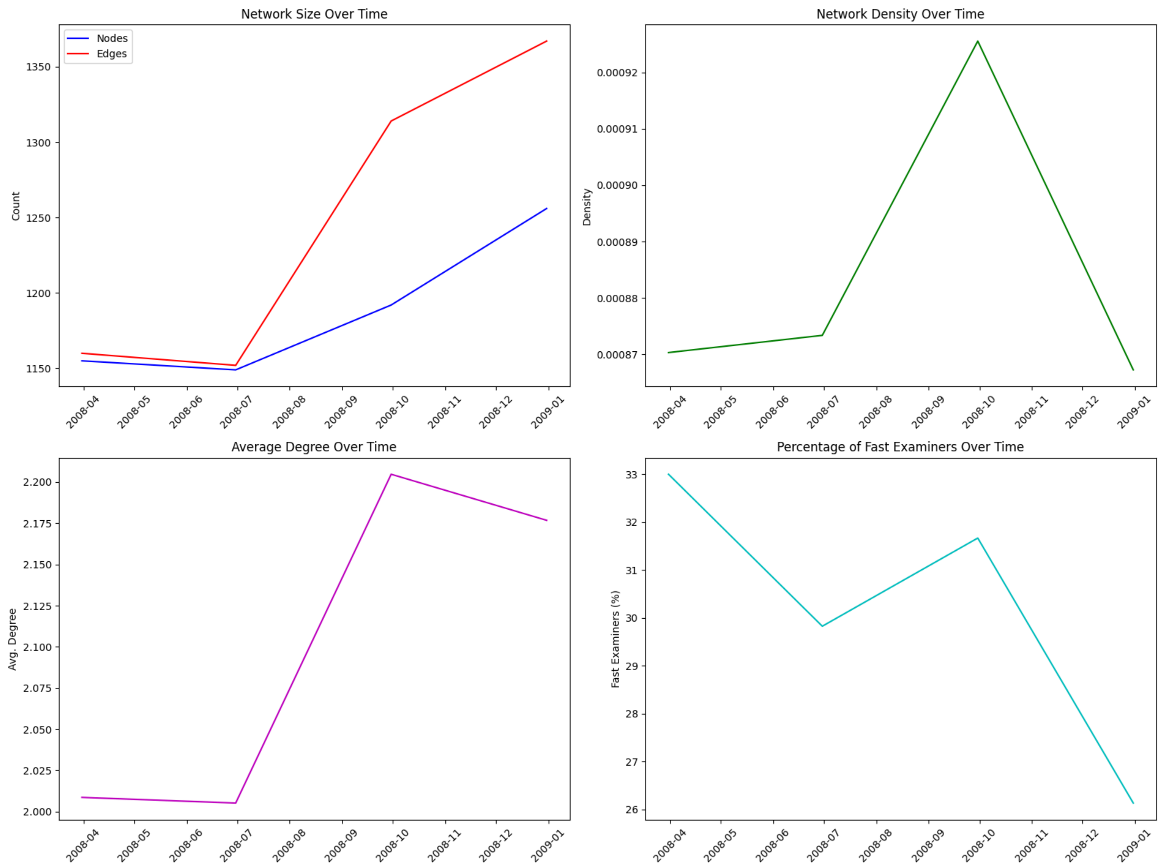

Figure 4.3: Network Structure and Percentage of Fast Examiners Over 2008

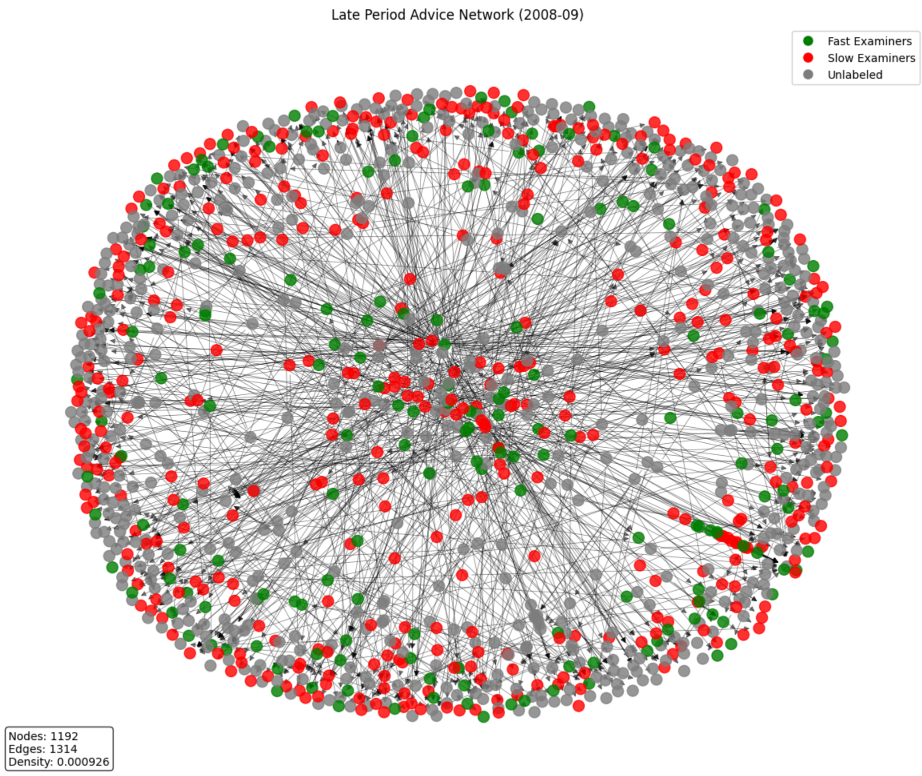

Figure 4.4: Advice Network in September 2008