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Improving Automated Clean Case Screening: Tier 3 eAdjudication Business Rule Refinement

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ABSTRACT: This report presents the rules of tests modifying the electronic adjudication (eAdjudication) business rules to attempt to reduce the rate of false alarms and to incorporate potential applications of natural language processing (NLP). eAdjudication is a tool used by the Federal Government to automatically grant favorable eligibility determinations to clean cases. Because the rules are quite conservative, eAdjudication frequently generates false alarms, incorrectly transferring clean cases to human adjudication rather than granting a favorable determination. This report presents the results of tests to reduce this false alarm rate without increasing the risk of incorrect favorable determinations. In addition, preliminary NLP results are presented that reproduce certain business rules using the unstructured text contained within the background investigation. Results of the business rule testing suggest two potential modifications to reduce false alarms without increasing security risk. First, modifying the rule that selects only cases with a case seriousness code of "G" to include cases with case seriousness codes of "R" and "A" as well. Second, deactivating the rule that checks the results of the question on the Standard Form 86 about Selective Service registration. Making these changes reduced false alarms by 8.4%. In addition, NLP results show that criminal history can be predicted with some reliability using the unstructured text from the Report of Investigation. Future research should explore the possibility of including NLP or other avenues for increased complexity of business rules in order to further reduce the rate of false alarms.					
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PREFACE

The implementation of electronic adjudication (eAdjudication) introduced significant cost avoidance for DoD and the Executive Branch of the Federal Government as a whole. Although business rules have been implemented for the eAdjudication of Tier 3 investigations, those rules are necessarily conservative, and frequently transfer cases to human adjudication that are later favorably adjudicated. This report documents the results of testing to refine and update those business rules to allow for more correct favorable determinations, and explores the possibility of expanding eAdjudication capabilities through the application of natural language processing.

Eric L. Lang
Director, PERSEREC

EXECUTIVE SUMMARY

The process of adjudicating background investigations for suitability, security, and credentialing determinations requires substantial time, labor, and training. As a strategy to reduce the cost associated with adjudication, DoD implemented automated clean case screening through the electronic adjudication (eAdjudication) tool. The eAdjudication tool applies a set of business rules to results of background investigations to ensure that they are clean, allowing a substantial number of cases to automatically receive favorable determinations. Implementation of eAdjudication has substantially reduced the costs associated with adjudication of investigations (Youpa, Baweja, Vargheese, Nelson, & Reed, 2018). The Defense Personnel and Security Research Center (a division of the Office of People Analytics) has previously conducted work on the business rules for Tier 3 Investigations (see Youpa et al., 2018).

However, applying the existing business rules results in a substantial number of flagged cases that later receive favorable determinations when reviewed by a human adjudicator (i.e., false alarms). Reducing the rate of false alarms would improve the cost effectiveness of eAdjudication. Thus, in FY18, the Performance and Accountability Council's Research and Innovation Division funded the Defense Personnel and Security Research Center to explore possibilities for refining the business rules for Tier 3 investigations.

METHOD

To test possible modifications to the business rules, researchers used a set of 52,186 Tier 3 investigations that had been fully adjudicated. Using this sample, researchers ran the cases against the current operational set of eAdjudication business rules. They selected a subset of 11,495 cases as a convenience sample to improve the efficiency of the testing process. Using the results of the baseline rules, analysts modified the most common eAdjudication business rules resulting in failures to assess how they affected the rate of false alarms. After determining the most promising flags for modification, they applied those rule changes to the larger sample (of 52,186) to determine whether they resulted in a change in false alarms without increasing the rate of potential misses (i.e., incorrect favorable determinations).

RESULTS

Researchers tested a total of 12 potential modifications to the eAdjudication business rules. These modifications include potential changes or deactivation of rules associated with the case seriousness code, the Selective Service question on the Standard Form 86, the education and employment checks, and the rules governing the inclusion of supplemental investigative items (i.e., items that were added to the investigation in order to follow-up on information of potential concern). For all tests, analysts compared results for tests by deactivating the rule regarding case seriousness code, or broadening it to accept some additional values (specifically, cases with minor but not disqualifying issues—R and A codes). Results showed that deactivating the rule regarding the response to the Selective Service check on the Standard Form 86, and allowing R and A cases to pass

through the eAdjudication business rules decreased the rate of false alarms by 8.4% when applied to the full sample of 52,186 cases, and did not increase the rate of potential misses.

DISCUSSION

1. Stakeholders should modify the eAdjudication business rules to deactivate the rule associated with the Selective Service question on the Standard Form 86, and allow case seriousness codes of R or A as permissible results.
2. The government should continue to explore natural language processing (NLP) capabilities to increase flexibility in the eAdjudication business rule engine. Results here indicate that a few additional modifications to the existing Tier 3 eAdjudication business rules will substantially decrease the false alarm rate, and greater rule complexity will increase the cost savings associated with eAdjudication. The promising results presented in Appendix A suggest that NLP is a good avenue for such increased complexity.
3. Future efforts should explore the possibility of expanding the eAdjudication business rules to include additional case types (e.g., Tier 5 cases). This might include applications of some of the NLP capabilities developed here.
4. Testing should always begin with the production version of the business rules and the code for the most current Java environment.

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INTRODUCTION

In the context of personnel security and suitability vetting, adjudication refers to the process of determining whether an individual meets the criteria for access to sensitive or classified information, suitability for employment in the civil service, or access to controlled facilities. The adjudication process is labor-intensive, challenging, and complex, and requires significant resources. In order to mitigate these demands, DoD implemented an automated process for approving clean cases (i.e., cases that contain no adjudicatively relevant derogatory information) known as electronic adjudication (eAdjudication). The eAdjudication tool has been successfully applied to Tier 3 (T3) (i.e., the background investigation for eligibility to access Secret level classified information) and Tier 3 reinvestigations (T3R) (i.e., the reinvestigation for continued eligibility to access Secret information) case types, and has resulted in significant cost avoidance for DoD (Youpa, Baweja, Vargheese, Nelson, & Reed, 2018) through elimination of the need for human review of clean cases and transferring only cases deemed to contain derogatory information to human adjudicators for review.

Although eAdjudication has a discernible impact on adjudicator workload, the process remains extremely conservative, resulting in a high number of false alarms; that is, cases that are subsequently favorably adjudicated by human adjudicators. Furthermore, eAdjudication lacks the ability to process the unstructured text (e.g., paragraphs of prose) that makes up a large portion of the investigative case file. In FY17, the Performance Accountability Council's Research and Innovation division funded the Defense Personnel and Security Research Center (PERSEREC), a division of the Office of People Analytics, to conduct a study exploring potential modifications to the eAdjudication business rules to reduce false alarms. Additionally, this study explored natural language processing (NLP) technologies in order to determine how such techniques could be leveraged within the context of eAdjudication. Appendix A provides more information about the background and results of this effort.

BACKGROUND

The eAdjudication process was originally developed to automatically adjudicate clean National Agency Checks with Law and Credit cases (the type of background investigation that preceded T3 for eligibility to access Secret information). Later, eAdjudication was expanded to include the T3, T3R, and Tier 1 (the investigation used for low-risk, non-sensitive positions) case types (Youpa et al., 2018). eAdjudication applies a set of Extensible Markup Language¹ business rules to the files that result from the investigation—particularly, the Standard Form 86 (SF-86; Electronic Questionnaires for Investigations Process version) and the Case Closing Transmittal portion of the Office of Personnel Management Report of Investigation (ROI). If all results on the SF-86 and the Case Closing Transmittal are permissible, the case is considered “clean” and it receives a

¹ Extensible Markup Language is a way of annotating documents that is both machine and human readable, and structures documents in a particular way. Extensible Markup Language is customizable depending on the document.

favorable determination; if results are not permissible, the eAdjudication process forwards the case for human adjudication. In short, eAdjudication checks the results of the investigation as recorded in the ROI to ensure that the case does not include derogatory information. Any potential derogatory information is sent to a human for review.

As mentioned, the eAdjudication process is extremely conservative. In other words, the process frequently sends cases to human adjudication that ultimately are favorably adjudicated (i.e., false alarms). This is reasonable, as the risk associated with improperly granting a clearance (i.e., a potential miss) is quite high. That is, a risk to national security would arise if an individual who is potentially unreliable or untrustworthy received eligibility to access classified information. However, the consequence of this conservative design is that many results are classified as false alarms (approximately 45% for T3 and 30% for T3R cases; Youpa et al., 2018). Thus, there remains substantial room for improvement in the business rule engine to reduce the rate of false alarms. The primary goal of this study is to explore potential modifications to the T3 business rules in order to reduce the rate of false alarms without increasing risk to national security.

CURRENT STUDY

The purpose of this study was to identify potential changes to eAdjudication in order to minimize the number of the cases that require human adjudication. In particular, the primary goal was to test modifications to the T3 eAdjudication business rules that would increase the number of cases that correctly pass eAdjudication without passing cases that should fail.

METHOD

The eAdjudication business rule modification testing consisted of two primary parts: testing proposed modifications to the current eAdjudication business rules, and testing potential applications of NLP for eAdjudication. The sections below describe the sample and the methods for each part of the study.

SAMPLE

This study leveraged data from a previous effort that included 100,000 background investigations for Secret eligible cases completed between FY13 and FY17 (McEachern, D.R., Seneviratna, G.S., Zimmerman, R.A., James, K.M., Ortiz, X.B., Friedman, G.M., Beneda, J.G., & Chandler, C.J. (2018); see original report for more detail on this sample). Because the focus of this effort was T3 investigations, analysts selected only the 55,228 T3 cases out of the sample of 100,000. A small number of these cases ($N = 3,040$), at the time of this study (May 2018), had not progressed through final human adjudication or been given a current determination that could be classified as favorable or unfavorable (e.g., “Interim TS”, “Loss of Jurisdiction”); those cases were excluded from the study. As a result, the final sample size for comparison of results across eAdjudication and human adjudication was 52,186². Table 1 presents descriptive statistics for this sample.

² During the selection of a subset of cases for testing purposes (more detail provided in the section describing Business Rule Modifications), an additional $n = 2$ cases were removed by random selection, and were mistakenly not included in the larger sample, reducing the final sample from 52,188 to 52,186.

Table 1
Descriptive Statistics

Variable	N	%
Case Type		
Tier 3	52,186	100.00
Case Seriousness Code		
C	1,814	3.48
D	3,255	6.24
B	3,857	7.39
R	4,374	8.38
E	6,563	12.58
A	8,912	17.08
G	23,408	44.85
Closed Date		
Dec-15	8	0.02
Jan-16	14	0.03
Feb-16	49	0.09
Mar-16	37	0.07
Apr-16	49	0.09
May-16	43	0.08
Jun-16	55	0.11
Jul-16	38	0.07
Aug-16	10	0.02
Sep-16	352	0.67
Oct-16	5,561	10.66
Nov-16	8,553	16.39
Dec-16	16,104	30.86
Jan-17	17,992	34.48
Feb-17	1,847	3.54
Mar-17	1,473	2.82

Due to inconsistencies in the format of some of the files, there was a small amount of missing data for some of these variables, resulting in a slightly lower total sample shown in the Table for case seriousness code ($n = 52,183$) and investigation close date ($n = 52,186$).

PROCEDURE

Using the sample described above, proposed business rules changes were tested. The sections below describe the testing procedures.

Business Rule Modifications

To test, identify, and prioritize potential changes, the current business rules (i.e., the approved T3 business rules), called the *baseline* rules, were applied to the set of 52,186 cases. Results of the eAdjudication determination were compared with the results of the human determination and then classified the case results into *hits* (correct favorable determinations), *misses* (incorrect favorable determinations, or false negatives), *false alarms* (incorrect unfavorable determinations, or false positives), and *correct rejections* (correct unfavorable determinations), based upon the eAdjudication determination. In

addition, the eAdjudication rules generated a set of “flags”. These flags identified all of the associated security concerns or derogatory information identified by eAdjudication. For example, a flag would indicate if the business rule engine encountered a “Yes” when it expected a “No” in response to a question about credit counseling on the SF-86. The results of the baseline rules were explored in order to identify the business rules that most often caused cases to fail eAdjudication, and prioritize those rules as potential candidates for modification.³

First, the rate of hits, misses, false alarms, and correct rejections that resulted from the baseline rules was generated. Next, a series of business rule modifications were tested by altering the Extensible Markup Language and applying the revised rules to the same set of cases. Finally, analysts compared the results of the modified business rules to the results of the baseline rules to determine whether the modifications: 1) increased the proportion of hits without resulting in potential misses; and 2) decreased the proportion of false alarms.

In order to reduce the time required to test business rule modifications, a subset of the available cases was selected to perform initial testing. Because cases were stored in separate directories based on submission dates, researchers selected two directories for testing purposes (essentially a convenience sample). In addition, seven cases that failed human adjudication in a previous study were always included for testing purposes, allowing researchers to test whether modifications resulted in any changes to potential misses. Although this selection process was not entirely random, any recommended business rule changes were subsequently tested on the entire sample. Working with a subset of cases allowed for faster testing of potential business rule changes, because the eAdjudication process takes considerable time to run. The smaller subset sample consisted of 11,495 Tier 3 cases. After testing proposed changes on the subset, recommended changes were then tested on the entire sample.

³ During the course of the study, researchers received an updated version of the baseline rules that incorporated an additional investigative item, the Military Discharge (MILD) check. However, the sample of investigations used here did not contain that check. Thus, for the purposes of the rule testing here, that rule was deactivated. In addition, the updated business rule file contained cross-checks between the e-QIP and the ROI that were not supported by the version of the eAdjudication software that PERSEREC was able to access. Consequently, those cross-checking rules also had to be deactivated due to lacking the eAdjudication software to support their operation. Appendix A provides a full list of the necessary changes (including a description of the rules).

RESULTS

This section presents results first for the T3 eAdjudication business rules as they currently exist (i.e., as the rules are operationalized in the eAdjudication software). These results are referred to as the *baseline* results. Subsequent sections describe the results of tests of changes to the baseline rules. The tests are presented individually and summarized in Table 16.

TIER 3 BUSINESS RULES: BASELINE RESULTS

Table 2 shows the cross-tabulation between the human adjudication and eAdjudication results. The table demonstrates that the current business rules for T3 cases are extremely conservative (i.e., only 29.2% passed eAdjudication). In addition, they result in no potential misses, but they do result in a large percentage of false alarms.

Table 2
All T3 Cases: Baseline Results ($n = 52,186$)

Human Adjudication		
eAdjudication	Favorable	Unfavorable
Favorable	Hits: 15,226 (29.2%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 36,953 (70.8%)	Correct Rejections: 7 (0.01%)

Table 3 presents the most common 25 flags (Appendix B shows the full results for all flags). This table provides detailed information about the flags that caused failures (most of which were false alarms, i.e., were mitigated by human adjudicators), and therefore which rules might be good candidates for potential modification. Each row represents a single eAdjudication flag, with the column labeled “Frequency” showing the number of cases that failed due to that particular flag. The sets of columns to the right (labeled Reason 1, 2, or 3) show the description associated with that flag—that is, specifically why that flag resulted in the failure of the case.

The first rule a case must pass and the most common reason for failure was the case seriousness code ($n = 28,777$ cases; i.e., 55% of cases failed this rule/did not have a case seriousness code of G). The Office of Personnel Management assigns this code to each case to indicate the seriousness of the derogatory information uncovered during the course of the investigation. Cases are classified as G cases (indicating no issues), R (no actionable issues), A (potentially actionable issues but not disqualifying), and so on. Other common reasons for failure included the presence of supplemental investigative items (i.e., items that were added to the investigation in order to follow-up on information of potential concern), credit (CRED), employment (EMPL), or education (EDUC) check results not being permissible values, or the response to the question about Selective Service registration on the SF-86 not being a permissible value.

Table 3
eAdjudication Flags for Baseline T3 Rules

			Reason 1		Reason 2		Reason 3	
eAdjudication Rule Code	Frequency	Rule Description	N	Description	N	Description	N	Description
ADJ_CHECK_400	28,777	Case Seriousness Code must be "G"	8,912	Case Seriousness Code was "A"	6,563	Case Seriousness Code was "E"	4,374	Case Seriousness Code was "R"
ADJ_CHECK_440	18,145	Removes cases with supplemental investigative items	2,859	Case contained "TESI" Item	1,534	Case contained "SIMM" item	964	Case contained "SIMM" item twice
ADJ_CHECK_429	18,144	Removes cases with select item codes (e.g., OUTS, STPA, SIMM)	2,870 ⁴	Case contained "TESI" Item	1,535	Case contained "SIMM" item	964	Case contained "SIMM" item twice
ADJ_CHECK_411	10,785	CRED Result Check	10,387	Result was "IS"	338	Result was "NR"	223	Result was "IS" twice
ADJ_CHECK_490	9,078	EMPL Result Check	3,531	Inquiry Result was "DN"	1,310	Inquiry Result was "IS"	917	2 Inquiry Results were "DN"
ADJ_CHECK_402	7,614	SIIF Result Check	3,803	Result was "NI"	1,017	Result was "IS"	535	Results were "IS" and "NI"
ADJ_CHECK_491	6,857	EDUC Result Check	2,295	Result was "DN"	1,691	Result was "UD"	1,444	Result was "IS"
ADJ_CHECK_014	6,677	Selective Service Registration Check (SF-86) response should be "Yes"	6,306	Response was "No"	230	"Cannot get past"	138	Response was "I don't know"
ADJ_CHECK_036	5,780	Relative citizenship must be U.S.	852	Relative citizenship was "Mexico"	700	2 Relative citizenships were "Mexico"	168	3 Relative citizenships were "Mexico"
ADJ_CHECK_061	4,234	Subject should have no police record in the past 7 years (SF-	4,234	Response was "Yes"	--	--	--	--

⁴ Note that this number differs slightly from the corresponding flag for ADJ_CHECK_440, and the same is true for the "SIMM" item. This is likely due to slight differences in the functionality of the rule. That is, some supplemental investigative items might not be explicitly excluded by ADJ_CHECK_429, resulting in a slightly different number of failures for the two rules.

			Reason 1		Reason 2		Reason 3	
eAdjudication Rule Code	Frequency	Rule Description	N	Description	N	Description	N	Description
		86 response should be "No")						
ADJ_CHECK_064	3,570	Subject should never have used any drugs illegally	3,570	Response was "Yes"	--	--	--	--
ADJ_CHECK_488	3,346	LAWE Result Check	773	Result was "IS" for Method = "R"	669	Result was "IS" for Method = "R" and Method = "I"	354	Result was "IS" for Method = "R" and Method = "I"
ADJ_CHECK_414	3,290	MILR Result Check	1,154	Result was "IS" or "NR"	1,008	Result was "IS" or "NR"	966	Result was "NR"
ADJ_CHECK_023	2,786	Subject citizenship is U.S.	1,328	Result was "US Not by Birth"	737	Result was "US by Birth Outside US"	721	Result was "Alien"
ADJ_CHECK_104	2,712	Subject place of birth is U.S.	116	Place of birth was Philippines	115	Place of birth was Germany	100	Place of birth was Mexico
ADJ_CHECK_083	1,858	Subject should have no late payments or charge offs (SF-86 response should be "No")	1,858	Response was "Yes"	--	--	--	--
ADJ_CHECK_405	1,818	FBIF Result Check	1,803	Result was "CR"	15	Miscellaneous other responses	--	--
ADJ_CHECK_441	1,807	FBIF - FBFN Cross-validation	1,802	Result was "CR"	5	Miscellaneous other responses	--	--
ADJ_CHECK_037	1,418	Subject should report no foreign national contacts (response on SF-86 should be "No")	1,418	Response was "Yes"	--	--	--	--
ADJ_CHECK_447	1,322	DCIF Result Check	586	Result was "IS"	412	Result was "NZ"	96	2 Results were "IS"
ADJ_CHECK_025	1,125	Subject should not have a foreign passport (response on SF-86 should be "No")	1,125	Response was "Yes"	--	--	--	--

eAdjudication Rule Code	Frequency	Rule Description	Reason 1		Reason 2		Reason 3	
			N	Description	N	Description	N	Description
ADJ_CHECK_062	953	Subject should have no police record ever (response on SF-86 should be "No")	953	Response was "Yes"	--	--	--	--
ADJ_CHECK_103	932	Foreign countries visited should not be on state advisory list	194	Travel to Haiti	183	Travel to Philippines	120	Travel to Israel
ADJ_CHECK_457	512	SIIC Result Check	339	Result was "IS"	173	Could not find SIIC check		

TIER 3 RULE MODIFICATION TESTING

As mentioned, for efficiency (as the business rule software takes significant time to process cases), business rule testing was initially completed on a subset of the sample ($n = 11,495$). Prior to beginning the rule changes, analysts first applied the baseline rules to the subset in order to understand the initial passing and failure rates. Table 3 shows case level results for this subset. Because the primary use for this sample was rule testing, researchers deliberately included a larger-than-normal number of unfavorable human adjudication cases (i.e., included all seven cases that were not favorably adjudicated). As a result, the sample included a larger percentage of correct rejections than might typically be found. Results shown in Table 4 otherwise mirror results for the overall sample, and provide the basis by which the additional rule tests can be compared. Each test presented uses prior results as a comparison; for ease of reference. Table 17 shows a summary table for all rule tests.

Table 4
T3: Baseline Subset Results ($n = 11,495$)

Human Adjudication		
eAdjudication	Favorable (Pass)	Unfavorable (Fail)
Favorable	Hits: 2,810 (24.4%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 8,678 (75.5%)	Correct Rejections: 7 (0.06%)

Test ID 01: SF-86 Selective Service Check Correction

The first test of a potential rule change involved the rule for the SF-86 question about Selective Service registration (eAdjudication rule code ADJ_CHECK_014). The baseline rule requires a “Yes” response, indicating that the applicant registered for the Selective Service, or requires one of five exceptions to be true: 1) a permissible result from the Selective Service (SESE) record check (a check of the actual records of Selective Service registration), 2) Active Duty military personnel, 3) all females, 4) males who were born before January 1, 1960, or 5) males under the age of 18.

However, the latest version of the business rules (in which they created the exception for the SESE check) introduced an error whereby the exception for males under 18 was not functioning correctly. That is, all males under the age of 18 failed due to ADJ_CHECK_014. Thus, the first test modified the business rules to allow an exception of anyone under the age of 18 (while maintaining all other exceptions). Table 5 shows the case level results for this test. Results showed that correcting this exception reduced false alarms by 5.9%, and did not result in any potential misses. If the exception remains in the rule, the rules should be updated to include this modification.

Table 5
T3 Baseline Subset: SF-86 Selective Service Rule Correction (n = 11,495)

Human Adjudication		
eAdjudication	Favorable (Pass)	Unfavorable (Fail)
Favorable	Hits: 3,483 (30.3%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 8,005 (69.6%)	Correct Rejections: 7 (0.06%)

Test ID 02: Allow All Case Seriousness Codes

The second potential rule modification test allowed for *all* case seriousness codes. That is, for the purposes of this test, the rule selecting only G cases (ADJ_CHECK_400) was deactivated. Because eAdjudication checks the results of all other investigative outcomes (that is, the rules still check all results to ensure that the case is clean), this should allow additional cases to pass without increasing potential misses. Table 6 shows the case level results for this test.

Table 6
T3 Baseline Subset: Allow All Case Seriousness Codes (n = 11,495)

Human Adjudication		
eAdjudication	Favorable (Pass)	Unfavorable (Fail)
Favorable	Hits: 3,030 (26.4%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 8,458 (73.6%)	Correct Rejections: 7 (0.06%)

Results showed that, as compared to baseline, this rule reduced false alarms by 2% and did not introduce any potential misses.

Test ID 03 & 04: All Case Seriousness Codes and Deactivate SF-86 Selective Service Rule

In the next test, just as in the previous one, the rule for case seriousness codes (ADJ_CHECK_400) was deactivated, allowing all case seriousness codes to pass through eAdjudication. In addition, the rule that checks the response to the question on the SF-86 about Selective Service registration (ADJ_CHECK_014) was also deactivated (i.e., any responses were allowed). As mentioned, ordinarily, this rule requires that eligible males respond “Yes” to the question about Selective Service registration on the SF-86. Because there is an additional investigative item for Selective Service registration (i.e., the SESE check), this seems unnecessary from a risk perspective, and often results in false alarms due to individuals providing an incorrect answer. Table 7 shows the results for this rule modification.

Table 7
T3 Baseline Subset: Allow All Case Seriousness Codes and Deactivate SF-86 Selective Service Rule (n = 11,495)

Human Adjudication		
eAdjudication	Favorable	Unfavorable
Favorable	Hits: 3,885 (33.8%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 7,603 (66.1%)	Correct Rejections: 7 (0.06%)

As compared to the baseline rules, these rule changes result in a 9.4% decrease in false alarms, suggesting that they have a reasonably large impact without any increase in potential risk. As an alternative to allowing all case seriousness codes, the next test presents the same deactivation of ADJ_CHECK_014 with a modification of ADJ_CHECK_400, a slightly more conservative test. Rather than deactivating it entirely, permissible values were added to allow both R and A case seriousness codes to pass through eAdjudication. Table 8 shows the results of this test on the subset.

Table 8
T3 Baseline Subset: Allow G, R, A Cases and Deactivate SF-86 Selective Service Rule (n = 11,495)

Human Adjudication		
eAdjudication	Favorable	Unfavorable
Favorable	Hits: 3,770 (32.8%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 7,718 (67.1%)	Correct Rejections: 7 (0.06%)

Again, results of this test show no increase in potential misses. In addition, here, 67.1% of cases were classified as false alarms, an 8.4% reduction from the baseline. This suggests that this particular combination of rules changes (deactivating ADJ_CHECK_014 and modifying ADJ_CHECK_400 to allow R and A cases) could substantially increase the number of hits (and, correspondingly, decrease the number of false alarms).

Because of the large beneficial impact these changes have on the results, the rest of the tests presented all include rule changes for ADJ_CHECK_400 (either deactivation, or allowing R and A cases) and deactivation of ADJ_CHECK_014. Subsequent tests are therefore compared against the results of Test ID 03 or Test ID 04 (Tables 6 and 7, respectively), as applicable, to determine whether the additional rule modifications have any impact on false alarm rates.

Test ID 05 & 06: Eliminate Failure for Supplemental Investigative Items

Starting with Tests 05 and 06 (shown in Tables 9 and 10), and continuing for the remainder of the tests (Tests 07 – 12), the case seriousness code rule (ADJ_CHECK_400) was modified (either deactivated or with permissible values for R and A added) and the Selective Service check on the SF-86 (ADJ_CHECK_014) was deactivated. In addition, for Test 5, researchers deactivated the rule disallowing supplemental investigative items (ADJ_CHECK_440). This rule modification allowed cases with supplemental investigative

items (e.g., GENL, OUTS) to run through the eAdjudication business rules. Table 8 displays the results of this test.

Table 9
T3 Baseline Subset: Allow All Additional Investigative Checks, Allow All Case Seriousness Codes, and Deactivate SF-86 Selective Service Rule (n = 11,495)

Human Adjudication		
eAdjudication	Favorable	Unfavorable
Favorable	Hits: 3,885 (33.8%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 7,603 (66.1%)	Correct Rejections: 7 (0.06%)

Results suggest that, as compared to Test ID 03, deactivating ADJ_CHECK_440 does not have an appreciable impact on the number of false alarms. Again, as a comparison, analysts ran the same test with the modification allowing for R and A cases (rather than deactivating the rule entirely). Table 9 shows the results of the test on the subset.

Table 10
T3 Baseline Subset: Allow All Additional Investigative Checks, Allow G, R, A Cases, and Deactivate SF-86 Selective Service Rule (n = 11,495)

Human Adjudication		
eAdjudication	Favorable	Unfavorable
Favorable	Hits: 3,770 (32.8%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 7,718 (67.1%)	Correct Rejections: 7 (0.06%)

Again, the results for Test ID 06 and Test ID 04 are identical, suggesting that deactivating ADJ_CHECK_440 does not change the frequency of hits, misses, or false alarms above and beyond the changes to ADJ_CHECK_014 and ADJ_CHECK_400. Note that, in this test, a very similar rule that allows for only specified investigative items (ADJ_CHECK_429) remained active and appears to have caused all cases that would have failed due to ADJ_CHECK_440 to fail instead due to ADJ_CHECK_429. Thus, this test appears to have no impact on the case-level results. Comparing the results of Test 05 and Test ID 06, it appears that allowing all case seriousness codes decreases false alarms by 1% (115 cases), but has no impact on potential misses. Again, for the remainder of the tests, we present comparisons between all case seriousness codes and all R and A cases allowed.

Test ID 07 & 08: Deactivate Rule Regarding Credit Counseling

In this next test, in addition to the deactivation of the case seriousness code and Selective Service checks, the rule regarding reported credit counseling (ADJ_CHECK_081) was deactivated. Table 11 shows the results of this test.

Table 11
T3 Baseline Subset: Allow ‘Yes’ to SF-86 Credit Counseling, Allow All Case Seriousness Codes, and Deactivate SF-86 Selective Service Rule (n = 11,495)

Human Adjudication		
eAdjudication	Favorable	Unfavorable
Favorable	Hits: 3,885 (33.8%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 7,603 (66.1%)	Correct Rejections: 7 (0.06%)

As compared to Test ID 03, this rule modification shows no impact on false alarms, hits, or potential misses. This suggests that deactivating the rule regarding credit counseling does not increase the pass rate for eAdjudication. Again, for comparison, analysts made the same rule modifications, but rather than deactivating the case seriousness code rule, the test allowed R and A cases to pass in addition to G cases. Table 12 displays the results of this test.

Table 12
T3 Baseline Subset: Allow ‘Yes’ to SF-86 Credit Counseling, Allow G, R, A Cases, and Deactivate SF-86 Selective Service Rule (n = 11,495)

Human Adjudication		
eAdjudication	Favorable	Unfavorable
Favorable	Hits: 3,770 (32.8%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 7,718 (67.1%)	Correct Rejections: 7 (0.06%)

Again, there are no differences here when compared to Test ID 04, suggesting that the rule change has no additional impact above and beyond the modifications to ADJ_CHECK_014 and ADJ_CHECK_400, and thus, is not a good candidate for rule modification.

Test ID 09 & 10: Deactivate Education Checks

In this test, both case seriousness code and Selective Service checks were deactivated and the rules checking the result of the education (EDUC) inquiries (ADJ_CHECK_423 and ADJ_CHECK_491) were also deactivated. Table 13 shows the results of the test on the subset.

Table 13
T3 Baseline Subset: Allow All Values for Education Check Results, Allow All Case Seriousness Codes, and Deactivate SF-86 Selective Service Rule (n = 11,495)

Human Adjudication		
eAdjudication	Favorable	Unfavorable
Favorable	Hits: 4,337 (37.7%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 7,151 (62.2%)	Correct Rejections: 7 (0.06%)

Here, as compared to Test ID 03, the results show a decrease in false alarms (3.9%). For comparison, we ran the same test allowing for R and A cases. Table 14 shows the results.

Table 14
T3 Baseline Subset: Allow All Values for Education Check Results, Allow G, R, A Cases, and Deactivate SF-86 Selective Service Rule (n = 11,495)

Human Adjudication		
eAdjudication	Favorable	Unfavorable
Favorable	Hits: 4,133 (36.0%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 7,355 (64.0%)	Correct Rejections: 7 (0.06%)

Again, when compared to Test ID 04, Table 14 suggests that the deactivation of the EDUC rules results in a 3.1% decrease in false alarms without increasing any potential misses. This suggests that deactivating this rule does allow for more cases to pass through eAdjudication without increasing potential risk; however, the impact is not as great as the effects of modifying or deactivating ADJ_CHECK_400 and ADJ_CHECK_014.

Test ID 11 & 12: Deactivate Employment Checks

In this test, the rule for case seriousness code and Selective Service responses remained deactivated. In addition, in this test, the rule checking the result of the employment (EMPL) checks (ADJ_CHECK_422, ADJ_CHECK_445, ADJ_CHECK_462, and ADJ_CHECK_490) were deactivated. Table 15 shows the results of the test on the subset.

Table 15
T3 Baseline Subset: Allow All Values for Employment Check Results, Allow All Case Seriousness Codes, and Deactivate SF-86 Selective Service Rule (n = 11,495)

Human Adjudication		
eAdjudication	Favorable	Unfavorable
Favorable	Hits: 4,268 (37.1%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 7,220 (62.8%)	Correct Rejections: 7 (0.06%)

When compared to the results of Test ID 03 (deactivating ADJ_CHECK_014 and ADJ_CHECK_400 only), deactivating these rules results in an additional 3.3% decrease in false alarms. Researchers ran the same test again, allowing R and A cases (rather than deactivating ADJ_CHECK_400). Table 16 displays the results.

Table 16
T3 Baseline Subset: Allow All Values for Employment Check Results, Allow G, R, A Cases, and Deactivate SF-86 Selective Service Rule (n = 11,495)

Human Adjudication		
eAdjudication	Favorable	Unfavorable
Favorable	Hits: 4,086 (35.6%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 7,402 (64.4%)	Correct Rejections: 7 (0.06%)

Results here suggest that, when compared to Test ID 04, deactivating the employment checks allows for an additional 2.7% increase in correct favorable determinations and no

increase in potential misses. However, again, this small increase suggests that deactivating a number of rules does not largely affect the false alarm rate.

Test of Recommended Modification with All Cases

By far, the most impactful rule changes were altering the rules for checking the result of the Selective Service registration, and the rule for checking the case seriousness code. In addition, results were presented for both deactivating the case seriousness code rule and for allowing R and A cases in addition to G cases. Allowing all case seriousness codes reduced false alarms by 1% more than simply applying R and A cases. However, when determining which rules to run against the full sample, we selected the more conservative test.

Thus, Table 17 presents the results on the entire sample of 52,186 for a modified version of the business rules which allowed R and A cases in addition to G cases, and deactivated the rule checking the response to the question on the SF-86 about Selective Service registration (ADJ_CHECK_014).

Table 17
All Cases: Allow G, R, A Cases and Deactivate SF-86 Selective Service

Human Adjudication		
eAdjudication	Favorable	Unfavorable
Favorable	Hits: 19,609 (37.6%)	Potential Misses: 0 (0.0%)
Unfavorable	False Alarms: 32,570 (62.4%)	Correct Rejections: 7 (0.01%)

Results suggest that these two modifications reduced false alarms by 8.4% (4,383) without causing any increase in potential misses. By deactivating two business rules, eAdjudication could favorably screen substantially more cases with seemingly no increase in security risk. However, the results here also suggest that further modification seems to result in diminishing returns.

Summary of Rule Tests

The rule tests presented above examined the impact of modifying the rules that result in the most flags (and therefore, the most cases that fail eAdjudication). After testing these potential rule changes, very few modifications resulted in a substantial reduction of false alarms. Table 18 summarizes these results. The “Reference” column displays the basis for comparison for each test; every test after the rows shown in gray, compares the results to the results of those tests (the rows shown in gray). The final test results appear in bold at the end of the table.

Table 18
Hits and False Alarms for All Rule Tests

Test	Hits		False Alarms		Reference	Percent Increase in Pass Rate (Compared to Reference)
	N	%	N	%		
Baseline (<i>n</i> = 52,186)	15,226	29	36,953	71	--	
Baseline Subset (<i>n</i> = 11,495)	2,810	24	8,678	76	--	
SF-86 Selective Service Correction	3,483	30	8,005	70	Baseline Subset	5.9
All Case Seriousness Codes	3,030	26	8,458	74	Baseline Subset	1.9
Allow All Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	3,885	34	7,603	66	Baseline Subset	9.4
Allow G, R, and A Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	3,770	33	7,718	67	Baseline Subset	8.4
Deactivate Supplement Investigative Item Rule AND Allow All Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	3,885	34	7,603	66	Allow All Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	0
Deactivate Supplement Investigative Item Rule AND Allow G, R, and A Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	3,770	33	7,718	67	Allow G, R, and A Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	0
Deactivate Credit Counseling Rule AND Allow All Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	3,885	34	7,603	66	Allow All Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	0
Deactivate Credit Counseling Rule AND Allow G, R, and A Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	3,770	33	7,718	67	Allow G, R, and A Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	0

Test	Hits		False Alarms		Reference	Percent Increase in Pass Rate (Compared to Reference)
	N	%	N	%		
Deactive Education Check Rule AND Allow All Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	4,337	38	7,151	62	Allow All Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	3.9
Deactive Education Check Rule AND Allow G, R, and A Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	4,133	36	7,355	64	Allow G, R, and A Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	3.1
Deactive Employment Check Rule AND Allow All Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	4,268	37	7,220	63	Allow All Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	3.3
Deactive Employment Check Rule AND Allow G, R, and A Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	4,086	36	7,402	64	Allow G, R, and A Case Seriousness Codes and Deactivate SF-86 Selective Service Rule	2.7
Allow G, R, and A Case Seriousness Codes and Deactivate SF-86 Selective Service Rule (n = 52,186)	19,609	38	32,570	62	Baseline	8.4

DISCUSSION

This report presents the results of tests of potential modifications to the eAdjudication business rules for Tier 3 investigations, and suggests rule changes to increase the number of correct favorable determinations. These changes would reduce the number of false alarms and further reduce the human adjudication workload. Additional project work examined possibilities for integrating NLP into the eAdjudication process. These findings are discussed in more detail below.

BUSINESS RULE MODIFICATIONS

Overall, 12 tests of business rule changes were conducted. The rule changes covered five of the top ten eAdjudication flags and one additional change (for a total of six). Four of the six changes were tested twice, once on all cases regardless of case seriousness code and once on G, R, and A cases only. The initial tests of rule changes were performed on a subset of the available cases. The most promising modifications were applied to the entire sample of 52,186 Tier 3 investigations.

Recommended Modifications

The most promising modifications (i.e., the ones with the greatest increase in pass rates) were (a) changing the allowed case seriousness codes to include R and A (i.e., a change to ADJ_CHECK_400) and (b) deactivating the rule that screens responses to the SF-86 question about Selective Service registration (i.e., ADJ_CHECK_014). These changes resulted in an increase in the pass rate of 8.4% and did not result in any misses.

Additionally, the content of these rules makes them fairly low-risk rule modifications. That is, the case seriousness rule change (adding R and A cases) adds only cases with no actionable or minimal derogatory information, and the remaining intact business rules serve to screen any potentially derogatory information that might be present. Any risk associated with deactivating the SF-86 Selective Service rule is offset by the selective service record check that is conducted for individuals required to register. Individuals are historically bad at answering the SF-86 Selective Service question, and the record check has always been regarded as the authoritative source for this information. While the recommended rule changes have a noticeable effect on pass rates, they are also very conservative changes that could be implemented with minimal additional risk while still increasing the cost avoidance provided by eAdjudication.

Other Tested Modifications

Two of the rule changes tested had little to no effect on pass rate, regardless of the case seriousness code values. These changes were: (a) allowing all “extra” investigative items (i.e., items that were triggered by some other investigative check such as foreign birth) and (b) allowing a “Yes” response to the SF-86 question about whether subject had undergone credit counseling. The implication of the lack of effect on pass rate is that cases that had supplemental investigative items or credit counseling failed some other business rule as well.

The remaining two rule changes tested had minimal effect on pass rate, regardless of case seriousness code. These changes were: (a) allowing all values for Education check results and (b) allowing all values for Employment check results. Both changes increased the hit rate approximately 3%. Discussions with the working group revealed that working group members were concerned about the risks associated with both of these changes. However, it might be worthwhile to evaluate further during future work. For example, an examination of the reasons that a discrepant value is assigned to a G, R, or A case for education or employment could better inform assessments of risk.

FUTURE WORK

The results of the business rule testing here highlighted the need for increased complexity in the business rule engine to substantially reduce the number of false alarms. That is, simply deactivating rules that frequently resulted in failures did not substantially reduce false alarm rates. This suggests that more complex rule changes might be required in order to reduce the rate of false alarms.

Another potentially fruitful line of research relies on advances in NLP. In particular, because the ROI contains large amounts of unstructured text, the rules as they are currently operationalized are unable to process that text for adjudicatively relevant derogatory information. The consequence of this is that cases containing even extremely minor derogatory information cannot be automatically adjudicated. This is an area where the application of NLP and machine learning might be especially useful. As a portion of this effort, some initial tests of NLP for eAdjudication were performed and are shown in Appendix C. These results were quite promising, and suggest that future efforts should continue to explore the use of NLP to address the need to expand the capability of eAdjudication. Note as well, however, that changes in the structure of the ROI might also provide further opportunities for business rule modifications. In particular, reducing the amount of unstructured text in the ROI might allow for greater business rule complexity and help reduce the rate of false alarms.

LIMITATIONS

The testing here is an imperfect procedure, as it relies on a random sample of investigations and involves examining classification based on an extremely rare event (i.e., the denial of a clearance). No testing can completely guarantee that there is no risk; nonetheless, the extremely conservative rule modifications suggested here allow for significant reduction in false alarm rates (and therefore, greater cost avoidance). Additionally, after the testing was completed, it was discovered that the percentage of G cases in our sample was much larger than is currently observed. While this does not affect the validity of the testing, it does indicate that our overall pass rates are larger than would be observed with a smaller percentage of G cases.

In addition, the baseline rules here do not perfectly reflect the operational version due to lack of the updated Java environment for implementing those rules. As a result, the exact rates of hits, false alarms, correct rejections, and potential misses will likely vary in an

operational context. Nonetheless, the change in rates is likely to be similar in the broader population using the updated version of the rules.

RECOMMENDATIONS

PERSEREC recommends implementing the following changes to the eAdjudication business process.

1. Stakeholders should modify the eAdjudication business rules to deactivate the rule associated with the Selective Service question on the SF-86, and to allow case seriousness codes of R or A as permissible results.
2. The Government should continue to explore NLP capabilities to increase flexibility in the eAdjudication business rule engine. Results here indicate that few additional modifications to the existing Tier 3 eAdjudication business rules will substantially decrease the false alarm rate, and greater rule complexity will increase the cost savings associated with eAdjudication. The promising results presented in Appendix A suggest that NLP is a good avenue for such increased complexity.
3. Future efforts should explore the possibility of expanding the eAdjudication business rules to include additional case types (e.g., Tier 5 cases). This might include applications of some of the NLP capabilities developed here.
4. Testing should always begin with the production version of the business rules and the code for the most current Java environment.

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APPENDIX A: NATURAL LANGUAGE PROCESSING

As currently implemented, the electronic adjudication (eAdjudication) process ingests only structured text (i.e., text that is Extensible Markup Language-tagged) from the Standard Form 86 (SF-86) and the Case Closing Transmittal (CCT) portion of the Report of Investigation (ROI). It then compares selected fields against a set of pre-determined permissible values. Although this process functions well, it is also necessarily rigid; it does not ingest or analyze any free text (e.g., unstructured, free-response fields on the SF-86, investigator notes) contained in the SF-86 or the ROI, which in some cases can constitute a very large portion (e.g., 75%) of the ROI. As a result, eAdjudication currently cannot adjudicate any case types that have large amounts of unstructured text from interviews or reference checks, such as Tier 5 investigations (the investigation used for eligibility to access Top Secret information).

The eAdjudication tool is also limited in the kind of information it can extract from the investigation. As currently implemented, it processes the summary results of the investigation as recorded on the CCT, and so can identify only whether the investigative item resulted in (for example) “Issues” or “No Issues.” However, the tool cannot determine the severity of any derogatory information. For example, if a Office of Personnel Management Law Enforcement (LAW) check found that an individual had a minor traffic violation, the CCT would show a result of “IS” (i.e., issues) for the LAW check. The eAdjudication process would determine that this result does not match permissible values, and forward the case to human adjudication (and, in all likelihood, if this is the only piece of derogatory information, the case would receive a favorable determination). If, however, eAdjudication could apply NLP to the investigator’s free text summary of the LAW check, it might be able to identify that the information is minor and favorably adjudicate the case, or, alternatively, provide guidance to the adjudicator regarding the criminal information that might streamline the human adjudication process.

The supplemental exploration presented in this appendix focused on whether natural language processing (NLP) technologies could be implemented in the context of eAdjudication. Such a capability might improve the eAdjudication process by either allowing new case types to be automatically adjudicated, or by providing more detailed information to human adjudicators (e.g., providing information about the nature or seriousness of derogatory information), thus improving the efficiency of the human adjudication process.

The approach described below was an attempt at using NLP to leverage information contained in unstructured text to improve the ability of eAdjudication to avoid false positives. Ideally, such a capability would identify the severity or nature of derogatory information contained in an investigative file to either favorably adjudicate cases with only minor concerns, or to better guide the human adjudicator during the adjudication process.

METHOD

The sample for NLP processing was the same one used for testing modification of the business rules. As a first step to examine the possibility of using NLP, researchers employed supervised machine learning models or algorithms to data produced by NLP processing. Developing NLP models requires a large set of data with a known correct outcome. In this context, that means that NLP requires a large body of text with known, associated security concerns. In order to develop initial NLP models, therefore, researchers relied on the results of the eAdjudication business rules and attempted to reproduce selected eAdjudication business rule flags. This represents an initial step in the NLP approach: efforts began to develop a model that could reproduce the known outcomes successfully.

Analysts created two dichotomous variables that identified cases that failed eAdjudication because of financial checks or criminal records checks. If a case had an eAdjudication flag (i.e., the case contained derogatory information) related to law enforcement checks (both inquiry and record check types), the Financial Crimes Enforcement Network, or police record checks, the case was assigned a value of “1” for the variable *failed criminal*; otherwise, the case was assigned a value of “0”. Similarly, cases that failed eAdjudication and had a flag associated with either financial records or the credit report were examined. Cases that met those criteria were assigned a value of “1” for *failed financial*; otherwise, the case was assigned a value of “0.” Models were constructed to classify cases into each of these groups separately. For NLP analyses, the sample was divided into training ($n = 22,353$), testing ($n = 16,764$), and validation ($n = 16,761$) samples of 40%, 30%, and 30%, respectively.

Each word in the criminal history section of the ROI for a given case was counted. When the word counts were completed for each case, the counts were organized into a data matrix where columns represented words and rows represented individuals. The process was repeated for pairs of adjacent words and then for triplets of adjacent words. Note that NLP jargon refers to words, adjacent word pairs, and adjacent word triplets as n-grams.

Next, the process was repeated to create data matrices for nouns, for verbs, for either nouns or verb, and for adjectives or adverbs. The NLP jargon for this approach is parts of speech tagging. A total of 7 matrices of frequency counts were produced up to this point. Another 7 matrices were created by normalizing the raw frequency matrices using an approach known as Term Frequency-Inverse Document Frequency scaling. Thus, there were 14 NLP data matrices for the criminal history section of the ROIs. The entire process was then repeated for the financial section of the ROIs, resulting in another 14 NLP data matrices.

Each of the NLP data matrices produced from the criminal history section of the ROIs was merged with the *failed criminal* variable. This process resulted in 14 analytic data sets with *failed criminal* as the dependent variables and the NLP frequencies and scaled values as independent variables or predictors. Likewise, each of data matrices produced from the financial section of the ROIs was merged with the *failed financial* variable to create another 14 analytic data sets.

Because of the large number of potential predictors, analysts used random forest classifiers⁵ to select the most useful analytic data set. Selecting the most useful data set was equivalent to selecting the most useful NLP approach (unigram count, unigram scaled, bigram count, etc.) to use in later predictive models. The random forest models were created using the training set, and then results were assessed on the testing set.

Using the NLP approach selected by the random forest classifiers, *document polarity analysis* (DPA) was then performed. For DPA, analysts took the terms that resulted from the NLP approach (e.g., the resulting set of n-grams) and created positive and negative lexicons. To do so, point bi-serial correlations⁶ were calculated between each term and the outcome. The sign of the coefficient was used to place that term in either a positive or a negative lexicon, up to a total of 1,000 terms. Positive and negative composite scores were then calculated for each individual ROI by using the coefficients as weights. Data transformations were conducted to ensure the scores remained within bounds (i.e., did not approach infinity).

Finally, analysts created four potential logistic regression models using variations on these lexicons as predictors. The best-performing model was applied to the validation sample, and the performance of the final model was assessed.

RESULTS

As described above, NLP testing began with document parsing and preparation for analysis, followed by creation of random forest classifiers to determine the most promising NLP approach. Finally, researchers conducted DPA to assess how well the NLP approach selected could predict *failed criminal* or *failed financial* cases.

Random Forest Classifier Results

Researchers first built random forest classifiers to classify cases into either *failed criminal* (i.e., indicate that the case had a criminal-related eAdjudication flag) or *failed financial* (i.e., indicate that the case had a financial-related eAdjudication flag) using variations on document term matrices. These random forest classifiers helped to select the NLP approach to use when building later logistic regression models in the DPA. This is useful because it helps to avoid overwhelming the logistic regression models with a large number of predictor variables.

Table 17 shows the results of the initial set of analyses using random forest classifiers to predict *failed criminal*. Specifically, the table presents: (1) the no information rate, which is the actual proportion of cases that failed due to *failed criminal*; (2) the balanced accuracy, which is the proportion of cases that the model correctly identified as failed due to *failed criminal*; (3) kappa, which is a measure of accuracy with respect to random classification.

⁵ Random forest classifiers create a set of decision trees from a randomly selected subset of the training data and aggregate the information from the decision trees.

⁶ Measure of the strength of association between a continuous-level variable (ratio or interval data) and a binary variable

In a model that performs well, the classification accuracy exceeds the no information rate—implying the model performed better at classifying results than the raw proportions. Although there is no single standard for interpreting kappa, previous guidelines have suggested that a kappa value of .41 - .60 would be considered moderately good performance, and .61 - .81 very good performance (Landis & Koch, 1977).

The no information rate was 0.93, indicating that only 7% of the individuals failed due to the criminal checks. Given that the data were so unbalanced—that is, the actual proportions were not evenly distributed across the pass/fail groups—classification accuracy showed only a slight improvement over the no information rate. However, eight of the models had kappa values above 0.50 and balanced accuracy approaching 0.73, suggesting good model performance. With little difference in performance among the top eight models, we arbitrarily selected unigram counts as the basis for developing the dictionaries of positive and negative words for criminal history.

Table 19
Accuracy of Models Predicting Which Cases Fail the Criminal Check

NLP Approach	No Information Rate	Accuracy with Testing Sample		
		Classification Accuracy	Kappa	Balanced Accuracy
Unigram - Count	0.93	0.95	0.54	0.73
Unigram - Scaled	0.93	0.95	0.54	0.73
Bigram - Count	0.93	0.95	0.56	0.74
Bigram - Scaled	0.93	0.95	0.54	0.74
Trigram - Count	0.93	0.94	0.49	0.71
Trigram - Scaled	0.93	0.94	0.49	0.71
Nouns only - Count	0.93	0.95	0.56	0.75
Nouns only - Scaled	0.93	0.95	0.54	0.74
Verbs only - Count	0.93	0.94	0.38	0.64
Verbs only - Scaled	0.93	0.94	0.38	0.65
Nouns and Verbs - Count	0.93	0.95	0.56	0.74
Nouns and Verbs - Scaled	0.93	0.95	0.55	0.74
Adjectives and Adverbs - Count	0.93	0.93	0.34	0.63
Adjectives and Adverbs - Scaled	0.93	0.93	0.35	0.63

Table 18 shows the results of random forest classifiers to predict *failed financial*. Given a no information rate of 0.98, it is not surprising that none of the models performed well. The evidence here suggests that using the text from the Investigative Results Report (IRR)/ROI does not generate a model that can predict (at above chance levels) the likelihood that a particular case will pass or fail financial business rules for eAdjudication. Because Table 18 demonstrates that the *failed financial* models do not perform well, DPA was performed only for the *failed criminal* outcome.

Table 20
Accuracy of Models Predicting Which Cases Fail the Financial Check

NLP Approach	No Information Rate	Accuracy with Testing Sample		
		Classification Accuracy	Kappa	Balanced Accuracy
Unigram - Count	0.98	0.98	<0.01	0.50
Unigram - Scaled	0.98	0.98	<0.01	0.50
Bigram - Count	0.98	0.98	<0.01	0.50
Bigram - Scaled	0.98	0.98	<0.01	0.50
Trigram - Count	0.98	0.98	0.02	0.50
Trigram - Scaled	0.98	0.98	<0.01	0.50
Nouns only - Count	0.98	0.98	0.01	0.50
Nouns only - Scaled	0.98	0.98	0.01	0.50
Verbs only - Count	0.98	0.98	0.00	0.50
Verbs only - Scaled	0.98	0.98	0.00	0.50
Nouns and Verbs - Count	0.98	0.98	<0.01	0.50
Nouns and Verbs - Scaled	0.98	0.98	0.00	0.50
Adjectives and Adverbs - Count	0.98	0.98	0.01	0.50
Adjectives and Adverbs - Scaled	0.98	0.98	0.00	0.50

Document Polarity Analysis

Based upon the promising results from the random forest classifier for the *failed criminal* outcome, for that outcome only, analysts proceeded to calculate the models for DPA. DPA results allow analysts to determine how well the selected NLP approach is able to predict the *failed criminal* outcome. In other words, results of DPA show whether the selected NLP approach is able to use the text from the IRR/ROI to reproduce the criminal eAdjudication flags.

Table 19 compares four logistic regression models produced for DPA, each using different variations on the selected NLP approach to predict individual’s criminal history (as operationalized by the *failed criminal* outcome variable). The table presents kappa, balanced accuracy, and pseudo R². Pseudo R² for logistic regression is analogous to R² for linear regression—it is the proportion of variability in *failed criminal* that is explained by the regression model—and can be interpreted in the same manner.

Table 21
Logistic Regression Models for DPA Predicting Criminal History

Predictors	Pseudo R²	Kappa	Balanced Accuracy
Positive Composite Score, Negative Composite Score	0.18	0.24	0.58
Ln(Positive Composite Score ÷ Negative Composite Score)	0.15	0.10	0.53
Ln(Positive Composite Score), ln(Negative Composite Score)	0.25	0.29	0.61
Ln(ln(Positive Composite Score) ÷ ln(Negative Composite Score))	0.04	0.04	0.51

The results of the models suggest that the model using the natural log of the positive composite score and the natural log of the negative composite score performed best on the training sample, with a pseudo R² of 0.25. When the model was applied to the testing sample, the value of kappa was 0.29 and balanced accuracy was 0.61. These measures indicate that the model fit the data and it was more accurate than a random model or a 50/50 model. Table 20 shows the regression weights for this model.

Table 22
Selected Regression Model for DPA

Predictor	Regression			Odds Ratio
	Weight	Error	P	
Ln(Positive Composite Score)	1.01	0.02	<.01	2.73
Ln(Negative Composite Score)	-0.09	0.01	<.01	[1.10]*

*Inverted odds ratio

Table 20 shows that both predictors were significant, but that the effect size of the positive composite score was much larger than the effect size for the negative composite score. The odds ratio of 2.73 for the positive composite score indicates that a one standard deviation increase in the natural log of the positive composite score makes it 273% more likely that the individual would fail the eAdjudication criminal checks. In contrast, the inverted odds ratio of 1.10 for the natural log of the negative composite indicates that a decrease of one standard deviation in that score is associated with a 110% increased likelihood that the individual would fail the eAdjudication criminal checks.

INTEGRATION OF NLP

This appendix presents results of some preliminary NLP testing to determine whether the eAdjudication business rule flags might be expanded to incorporate the processing of unstructured text. In the results presented here, analysts extracted text from the criminal and financial history sections of the IRR/ROI, and used variables built from this unstructured text to classify individuals as having either criminal or financial issues, according to the eAdjudication business rule flags. Results showed that models predicting eAdjudication criminal flags performed well. Specifically, they showed a balanced accuracy of .61, and effect sizes suggested that the positive and negative composite scores constructed here were substantially related to the likelihood of a criminal flag. This

suggests that the text from the ROI's criminal history section can be used to determine an individual's criminal history in an automated fashion, without using hard-coded rules.

In contrast, models predicting eAdjudication financial flags did not show better than chance performance. This could be due to the high no information rate—that is, 98% of individuals did not have a financial flag. It could also be that, in order to better predict an individual's financial history, other information, such as the information from the credit report, would need to be processed. Future efforts might explore the possibility of applying NLP or other techniques to extract information from the credit report in order to predict the likelihood of financial concerns.

Although this is a preliminary step to building in unstructured text processing, it is quite promising. In particular, using no manual effort, models here were able to accurately classify approximately 98% of the cases as either having or not having a criminal flag, and a kappa value of .29 suggests that the model does perform better than chance. By processing this text, with an adequate training sample, models were generally able to recreate the outcome of the eAdjudication business rule flags without any hard-coded rules. That is, the models did not require specification of what constituted an "issue," unlike the existing eAdjudication business rule engine, which requires that permissible and impermissible results be entered manually into the code. By discovering these rules using a set of known information, a NLP approach introduces substantial flexibility into the eAdjudication business process. Avoiding hard-coded rules, and instead building models using unstructured text, allows for processing of more nuanced or detailed investigative information. With further research, the NLP approach might also allow for processing of additional investigative types.

APPENDIX B: EADJUDICATION FLAGS

Table 23
eAdjudication Flags with Rule Description

eAdjudication Rule Code	Description	Frequency
ADJ_CHECK_400	The CCT reflects an Office of Personnel Management Case Seriousness Code of G. If the case Seriousness Code is anything other than G, the case is not eligible for eAdjudication	28,777
ADJ_CHECK_440	Any items other than the following will cause the case to fail: CRED, SII, DCII, FBIF, FBIN, SESE, LAWE, MILR, SISC, SSN, TECS, MILD, LAWE, SIIF, SIIC, FBFN, DCIF, INVA, CGIN, PUBR, BVS, SCHR, BAR, OPF, EMPL, EDUC.	18,145
ADJ_CHECK_429	Items OUTS, STPA, SIMM, IMM, EFI, LAWE PR, SSTP, GENL, SPIN, MEDI, PUBR, FNCN, FMSP, SECF, SUBC, FINL, TESI must not be present on the CCT.	18,144
ADJ_CHECK_411	Credit Report - A CRED item must be present and it must have a permissible result.	10,786
ADJ_CHECK_490	Employment - If EMPL inquiry is present, it must have a permissible result.	9,077
ADJ_CHECK_402	SIIF - If SII is present on the CCT, SIIF must have an acceptable response: AA, Acceptable Attached, RF, Referred, PF, or Previously Furnished.	7,614
ADJ_CHECK_491	Education - An EDUC item must present and it must have a permissible result.	6,857
ADJ_CHECK_014	Selective Service Record - The applicant must respond to the SF-86 Section #14 (Were you born a male after December 31, 1959?). The Response must be a Permissible Result or else the case fails eAdjudication.	6,677
ADJ_CHECK_036	Relatives - If the applicant responded to SF-86 Section #18, the applicant must respond to the SF-86 Section #18.3 (Provide your relative's country(ies) of Citizenship.). The Response must be a Permissible Result or else the case fails eAdjudication.	5,780
ADJ_CHECK_061	Police Record - The applicant must respond to the SF-86 Section #22 (Have any of the following happened?). The Response must be a Permissible Result or else the case fails eAdjudication.	4,234
ADJ_CHECK_064	Illegal Use of Drugs and Drug Activity - The applicant must respond to the SF-86 Section #23 (In the last seven (7) years, have you illegally used any drugs or controlled substances?). The Response must be a Permissible Result or else the case fails eAdjudication.	3,570
ADJ_CHECK_488	Law Enforcement - The LAWE check with an Inquiry completion method (I) must have one of the permissible results or the case fails eAdjudication.	3,346
ADJ_CHECK_414	MILR Military Personnel Records (G01): If the MILR check is present, it must have one of the permissible results or the case fails eAdjudication. If a subject answers "yes" to SF-86 Question 15, then this check becomes mandatory. Exception-if the military service occurred more than 15 years ago AND the subject selects the Honorable discharge option for Question 15, the MILR check is not conducted. In this case, the case will not fail eAdjudication if there is no MILR check. If there are more than two MILR results with a combination of NR and AC results, as long as one of the results is "AC" then the case will pass eAdjudication.	3,290

eAdjudication Rule Code	Description	Frequency
ADJ_CHECK_023	Applicant Citizenship - The applicant must respond to the SF-86 Section #9 (Provide your current citizenship status.). The Response must be a Permissible Result or else the case fails eAdjudication.	2,786
ADJ_CHECK_104	Place of Birth - The applicant must respond to the SF-86 Section #3 (Provide your Place of birth.). The Response must be a Permissible Result or else the case fails eAdjudication.	2,712
ADJ_CHECK_083	Financial Record - The applicant must respond to the SF-86 Section #26 (Other than previously listed, have any of the following happened?). The Response must be a Permissible Result or else the case fails eAdjudication.	1,858
ADJ_CHECK_405	FBI fingerprint check (FBIF) - If Scope item code FBIF is missing, the case fails eAdjudication.	1,818
ADJ_CHECK_441	FBIF-FBI Identification Division, Fingerprint (B01) - The item must be complete and must be a Permissible Result, or else the case fails eAdjudication.	1,807
ADJ_CHECK_037	Foreign Contacts - The applicant must respond to the SF-86 Section #19 (Do you have, or have you had, close and/or continuing contact with a foreign national within the last seven (7) years with whom you, or your spouse, or cohabitant are bound by affection, influence, common interests, and/or obligation?). The Response must be a Permissible Result or else the case fails eAdjudication.	1,418
ADJ_CHECK_447	DCIF Defense Clearance Investigations File (DO_): If the DCIF check is present, it must have one of the permissible results or the case fails eAdjudication.	1,322
ADJ_CHECK_025	Dual/Multiple Citizenship & Foreign Passport Information - The applicant must respond to the SF-86 Section #10 (Have you EVER been issued a passport, or identity card for travel, by a country other than the U.S.?) The Response must be a Permissible Result or else the case fails eAdjudication.	1,125
ADJ_CHECK_062	Police Record - The applicant must respond to the SF-86 Section #22 (Other than those offenses already listed, have you EVER had the following happen to you?). The Response must be a Permissible Result or else the case fails eAdjudication.	953
ADJ_CHECK_103	Foreign Countries You have Visited - If the applicant responded to SF-86 Section #20c "Yes" to traveled outside the U.S. and "No" to solely for U.S. Government Business, the applicant must provide the Country visited. The Response must be a Permissible Result or else the case fails eAdjudication.	932
ADJ_CHECK_439	SESE Selective Service (F01): If the SESE check is present, it must have one of the permissible results or the case fails eAdjudication.	763
ADJ_CHECK_457	Security Suitability Investigations CVS (SIIC) - If Scope item code SIIC is missing for any case scheduled on or after 4/1/16, the case fails eAdjudication. For cases scheduled prior to 4/1/16, the SIIC will not appear in the event of a NR result; these cases will pass eAdjudication.	512
ADJ_CHECK_033	Marital Status - If the applicant responded "Married or Separated" to SF-86 Section 17, the applicant must respond to the SF-86 Section #17.1 (Provide your spouse's country(ies) of Citizenship). The Response must be a Permissible Result or else the case fails eAdjudication.	483
ADJ_CHECK_024	Dual/Multiple Citizenship & Foreign Passport Information - The applicant must respond to the SF-86 Section #10 (Do you now or have you EVER held dual/multiple citizenships?). The Response must be a Permissible Result or else the case fails eAdjudication.	425

eAdjudication Rule Code	Description	Frequency
ADJ_CHECK_026	Employment Activities: Employment & Unemployment Record - The applicant must respond to the SF-86 Section #13a (For this employment have any of the following happened to you in the last seven (7) years?). The Response must be a Permissible Result or else the case fails eAdjudication.	385
ADJ_CHECK_082	Foreign Countries You have Visited - The applicant must respond to the SF-86 Section #20c (Has your travel in the last seven (7) years been solely for U.S Government business?). The Response must be a Permissible Result or else the case fails eAdjudication.	373
ADJ_CHECK_422	Employment - If EMPL telephone check is present, it must have a permissible result.	363
ADJ_CHECK_087	Involvement in Non-Criminal Court Actions - The applicant must respond to the SF-86 Section #28 (In the last ten (10) years, have you been a party to any public record civil court action not listed elsewhere on this form?). The Response must be a Permissible Result or else the case fails eAdjudication.	361
ADJ_CHECK_481	Employment - If EMPL items are present, they must only be inquiries, telephone checks, or record checks (Method = I, T, or R).	320
ADJ_CHECK_077	Financial Record - The applicant must respond to the SF-86 Section #26 (In the last seven (7) years have you filed a petition under any chapter of the bankruptcy code?). The Response must be a Permissible Result or else the case fails eAdjudication.	298
ADJ_CHECK_462	Employment - If EMPL record check is present, the response must be a permissible result.	261
ADJ_CHECK_072	Use of Alcohol - The applicant must respond to the SF-86 Section #24 (Have you EVER been ordered, advised, or asked to seek counseling or treatment as a result of your use of alcohol?). The Response must be a Permissible Result or else the case fails eAdjudication.	249
ADJ_CHECK_038	Foreign Activities - The applicant must respond to the SF-86 Section #20a (Have you, your spouse, cohabitant, or dependent children EVER had any foreign financial interests in which you or have direct control or direct ownership?). The Response must be a Permissible Result or else the case fails eAdjudication.	243
ADJ_CHECK_047	Foreign Business, Professional Activities, and Foreign Government Contacts - The applicant must respond to the SF-86 Section #20b (Have you in the past seven (7) years attended or participated in any conferences, trade shows, seminars, or meetings outside the U.S.?). The Response must be a Permissible Result or else the case fails eAdjudication.	214
ADJ_CHECK_059	Psychological and Emotional Health - The applicant must respond to the SF-86 Section #21 (In the last seven (7) years, have you consulted with a health care professional regarding an emotional or mental health condition or were you hospitalized for such a condition?). The Response must be a Permissible Result or else the case fails eAdjudication.	213
ADJ_CHECK_017	If Subject answered yes to SF-86 Question 15, there must be a MILR check present (and it must have an acceptable response; shown in ADJ_CHECK_094). Exception-if the military service occurred more than 15 years ago AND the subject selects the Honorable discharge option for Question 15, the MILR check is not conducted. In this case, the case will not fail eAdjudication if there is no MILR check.	203

eAdjudication Rule Code	Description	Frequency
ADJ_CHECK_340	Marital Status - If the applicant responded “they are residing with a cohabitant” to SF-86 Section 17, the applicant must respond to the SF-86 Section #17.3 (Provide your cohabitant’s U.S. Social Security Number). The Response must be a Permissible Result or else the case fails eAdjudication.	187
ADJ_CHECK_337	Marital Status - If the applicant responded “Married or Separated” to SF-86 Section 17, the applicant must respond to the SF-86 Section #17.1 (Provide your spouse’s U.S. Social Security Number). The Response must be a Permissible Result or else the case fails eAdjudication.	179
ADJ_CHECK_048	Foreign Business, Professional Activities, and Foreign Government Contacts - The applicant must respond to the SF-86 Section #20b (Have you or any member of your immediate family in the past seven (7) years had any contact with a foreign government, its establishment or its representatives, whether inside or outside the U.S.?). The Response must be a Permissible Result or else the case fails eAdjudication.	173
ADJ_CHECK_079	Financial Record - The applicant must respond to the SF-86 Section #26 (In the past seven (7) years have you failed to file or pay Federal, state, or other taxes when required by law or ordinance?). The Response must be a Permissible Result or else the case fails eAdjudication.	160
ADJ_CHECK_034	Marital Status - If the applicant responded “Divorced, Annulled, or Widowed” to SF-86 Section 17. The applicant must respond to the SF-86 Section #17.2 (Provide the country(ies) of citizenship for your former spouse). The Response must be a Permissible Result or else the case fails eAdjudication.	159
ADJ_CHECK_071	Use of Alcohol - The applicant must respond to the SF-86 Section #24 (In the last seven (7) years has your use of alcohol had a negative impact on your work performance, your professional or personal relationships, your finances or resulted in intervention by law enforcement?). The Response must be a Permissible Result or else the case fails eAdjudication.	137
ADJ_CHECK_443	FBI Name Search, Records Management Division (FBIN) – If Scope item code FBIN is missing, the case fails eAdjudication.	135
ADJ_CHECK_042	Foreign Activities - The applicant must respond to the SF-86 Section #20a (Have you EVER provided financial support for any foreign national?). The Response must be a Permissible Result or else the case fails eAdjudication.	126
ADJ_CHECK_049	Foreign Business, Professional Activities, and Foreign Government Contacts - The applicant must respond to the SF-86 Section #20b (Have you in the past seven (7) years sponsored any foreign national to come to the U.S as a student, for work or for permanent residence). The Response must be a Permissible Result or else the case fails eAdjudication.	103
ADJ_CHECK_065	Illegal Use of Drugs and Drug Activity - The applicant must respond to the SF-86 Section #23 (In the last seven (7) years, have you been involved in the illegal purchase, manufacture, cultivation, trafficking, production, transfer, shipping , receiving, handling or sale of any drug or controlled substance?). The Response must be a Permissible Result or else the case fails eAdjudication.	103

eAdjudication Rule Code	Description	Frequency
ADJ_CHECK_094	Military History - If the applicant responded "Yes" to Section 15, the applicant must respond to the SF-86 Section #15.1 (Provide the type of discharge you received.). The Response must be a Permissible Result or else the case fails eAdjudication.	98
ADJ_CHECK_031	Military History - If the applicant responded "Yes" to Section 15, the applicant must respond to the SF-86 Section #15.2 (In the last 7 years, have you been subject to court martial or other disciplinary procedure under the Uniform Code of Military Justice (UCMJ), such as Article 15, Captain's mast, Article 135 Court of Inquiry, etc.?). The Response must be a Permissible Result or else the case fails eAdjudication.	84
ADJ_CHECK_081	Financial Record - The applicant must respond to the SF-86 Section #26 (Are you currently utilizing, or seeking assistance from, a credit counseling service or other similar resource to resolve your financial difficulties?). The Response must be a Permissible Result or else the case fails eAdjudication.	83
ADJ_CHECK_040	Foreign Activities - The applicant must respond to the SF-86 Section #20a (Have you, your spouse, cohabitant, or dependent children EVER owned, or do you anticipate owning, or plan to purchase real estate in a foreign counties?). The Response must be a Permissible Result or else the case fails eAdjudication.	75
ADJ_CHECK_051	Foreign Business, Professional Activities, and Foreign Government Contacts - The applicant must respond to the SF-86 Section #20b (Have you EVER voted in the election of a foreign country). The Response must be a Permissible Result or else the case fails eAdjudication.	74
ADJ_CHECK_035	Marital Status - If the applicant responded "they are residing with a cohabitant" to SF-86 Section 17, The applicant must respond to the SF-86 Section #17.3 (Provide your cohabitant's country(ies) of Citizenship). The Response must be a Permissible Result or else the case fails eAdjudication.	69
ADJ_CHECK_075	Investigations and Clearance Record - The applicant must respond to the SF-86 Section #25 (Have you EVER had a security clearance eligibility/access authorization denied, suspended, or revoked?). The Response must be a Permissible Result or else the case fails eAdjudication.	69
ADJ_CHECK_410	Social Security Administration (SSN) - If Scope item code SSN is missing, the case fails eAdjudication.	56
ADJ_CHECK_073	Use of Alcohol - The applicant must respond to the SF-86 Section #24 (Have you EVER voluntarily sought counseling or treatment as a result of your use of alcohol?). The Response must be a Permissible Result or else the case fails eAdjudication.	54
ADJ_CHECK_415	INVA Other Investigative Agencies, INV-79 (J01): If the INVA check is present, it must have one of the permissible results or the case fails eAdjudication.	51
ADJ_CHECK_069	Illegal Use of Drugs and Drug Activity - The applicant must respond to the SF-86 Section #23 (Have you EVER been ordered, advised or asked to seek counseling or treatment as a result of your illegal use of drugs or controlled substances?). The Response must be a Permissible Result or else the case fails eAdjudication.	44

eAdjudication Rule Code	Description	Frequency
ADJ_CHECK_041	Foreign Activities - The applicant must respond to the SF-86 Section #20a (As a U.S. citizen, have you, your spouse, cohabitant, or dependent children received in the past seven (7) years, or are eligible to receive in the future, any educational, medical, retirement, social welfare, or other such benefit from a foreign country?). The Response must be a Permissible Result or else the case fails eAdjudication.	41
ADJ_CHECK_045	Foreign Business, Professional Activities, and Foreign Government Contacts - The applicant must respond to the SF-86 Section #20b (Has any foreign national in the past seven (7) years offered you a job, asked you to work as a consultant, or consider employment with them?). The Response must be a Permissible Result or else the case fails eAdjudication.	40
ADJ_CHECK_053	Foreign Countries You have Visited - If the applicant responded to SF-86 Section #20c "Yes" to traveled outside the U.S. and "No" to solely for U.S. Government Business, the applicant must respond to the SF-86 Section #20c (While traveling to or in this country, were you involved in any encounter with the police?). The Response must be a Permissible Result or else the case fails eAdjudication.	40
ADJ_CHECK_052	Foreign Countries You have Visited - If the applicant responded to SF-86 Section #20c "Yes" to traveled outside the U.S. and "No" to solely for U.S. Government Business, the applicant must respond to the SF-86 Section #20c (While travelling to, or in this country, were you questioned, searched or otherwise detained by the local customs or security service officials when entering or leaving this country?). The Response must be a Permissible Result or else the case fails eAdjudication.	24
ADJ_CHECK_043	Foreign Business, Professional Activities, and Foreign Government Contacts - The applicant must respond to the SF-86 Section #20b (Have you in the past seven (7) years provided advice or support to any individual associated with a foreign business or other foreign organization that you have not previously listed as a former employer?). The Response must be a Permissible Result or else the case fails eAdjudication.	21
ADJ_CHECK_054	Foreign Countries You have Visited - If the applicant responded to SF-86 Section #20c "Yes" to traveled outside the U.S. and "No" to solely for U.S. Government Business, the applicant must respond to the SF-86 Section #20c (While traveling to on in this country, were you contacted by or in contract with any person known or suspected of being involved or associated with foreign intelligence, terrorist, security or military organizations?). The Response must be a Permissible Result or else the case fails eAdjudication.	20
ADJ_CHECK_080	Financial Record - The applicant must respond to the SF-86 Section #26 (In the past seven (7) years have you been counseled, warned, or disciplined for violating the terms of agreement for a travel or credit card provided by your employer?). The Response must be a Permissible Result or else the case fails eAdjudication.	20
ADJ_CHECK_070	Illegal Use of Drugs and Drug Activity - The applicant must respond to the SF-86 Section #23 (Have you EVER voluntarily sought counseling or treatment as a result of your use of a drug or controlled substance?). The Response must be a Permissible Result or else the case fails eAdjudication.	19
ADJ_CHECK_068	Illegal Use of Drugs and Drug Activity - The applicant must respond to the SF-86 Section #23 (In the last seven (7) years have you intentionally engaged in the misuse of prescription drugs?). The Response must be a Permissible Result or else the case fails eAdjudication.	18

eAdjudication Rule Code	Description	Frequency
ADJ_CHECK_044	Foreign Business, Professional Activities, and Foreign Government Contacts - The applicant must respond to the SF-86 Section #20b (Have you, your spouse, cohabitant, or any member of your immediate family in the past seven (7) years been asked to provide advice or serve as a consultant, even informally, by any foreign government official or agency?). The Response must be a Permissible Result or else the case fails eAdjudication.	17
ADJ_CHECK_066	Illegal Use of Drugs and Drug Activity - The applicant must respond to the SF-86 Section #23 (Have you EVER illegally used or otherwise been involved with a drug or controlled substance while possessing a security clearance other than previously listed?). The Response must be a Permissible Result or else the case fails eAdjudication.	16
ADJ_CHECK_039	Foreign Activities - The applicant must respond to the SF-86 Section #20a (Have you, your spouse, cohabitant, or dependent children EVER had any foreign financial interests that someone controlled on your behalf?). The Response must be a Permissible Result or else the case fails eAdjudication.	13
ADJ_CHECK_406	FBIF-FBI Identification Division, Fingerprint (BO1) - The item must be complete and must be a Permissible Result, or else the case fails eAdjudication.	12
ADJ_CHECK_067	Illegal Use of Drugs and Drug Activity - The applicant must respond to the SF-86 Section #23 (Have you EVER illegally used or otherwise been involved with a drug or controlled substance while employed as a law enforcement officer, prosecutor or courtroom official?). The Response must be a Permissible Result or else the case fails eAdjudication.	11
ADJ_CHECK_032	Military History - The applicant must respond to the SF-86 Section #15 (Have you EVER served, as a civilian or military member in a foreign country's military, intelligence, diplomatic, security forces, militia, other defense force, or government agency?). The Response must be a Permissible Result or else the case fails eAdjudication.	7
ADJ_CHECK_419	SCHR State Criminal History Repository (ZO_) (extra coverage code 8): If SCHR check(s) are present, it must have one of the permissible results or the case fails eAdjudication.	7
ADJ_CHECK_063	Police Record - The applicant must respond to the SF-86 Section #22 (Is there currently a domestic violence protective order or restraining order issued against you?). The Response must be a Permissible Result or else the case fails eAdjudication.	6
ADJ_CHECK_074	Use of Alcohol - The applicant must respond to the SF-86 Section #24 (Have you EVER received counseling or treatment as a result of your use of alcohol in addition to what you have already listed on this form?). The Response must be a Permissible Result or else the case fails eAdjudication.	6
ADJ_CHECK_086	Use of Information Technology Systems - The applicant must respond to the SF-86 Section #27 (In the last seven (7) years have you introduced, removed , or used hardware, software, or media in connection with any information technology system without authorization, when specifically prohibited by rules, procedures, guidelines, or regulations or attempted any of the above?). The Response must be a Permissible Result or else the case fails eAdjudication.	6

eAdjudication Rule Code	Description	Frequency
ADJ_CHECK_046	Foreign Business, Professional Activities, and Foreign Government Contacts - The applicant must respond to the SF-86 Section #20b (Have you in the past seven (7) years been involved in any other type of business venture with a foreign national not described above?). The Response must be a Permissible Result or else the case fails eAdjudication.	5
ADJ_CHECK_028	Employment Record - The applicant must respond to the SF-86 Section #13c (Have any of the following happened to you in the last seven (7) years at employment activities that you have not previously listed?). The Response must be a Permissible Result or else the case fails eAdjudication.	4
ADJ_CHECK_417	PUBH Public Health Service (R01): If the PUBH check is present, it must have one of the permissible results or the case fails eAdjudication.	4
ADJ_CHECK_002	Unknown Pre-Check	2
ADJ_CHECK_085	Use of Information Technology Systems - The applicant must respond to the SF-86 Section #27 (In the last seven (7) years have you illegally or without authorization, modified, destroyed, manipulated, or denied others access to information residing on an information technology system or attempted any of the above?). The Response must be a Permissible Result or else the case fails eAdjudication.	2
ADJ_CHECK_420	OPF Official Personnel Records (H0_): If the OPF check is present, it must have one of the permissible results or the case fails eAdjudication.	2
ADJ_CHECK_084	Use of Information Technology Systems - The applicant must respond to the SF-86 Section #27 (In the last seven (7) years have you illegally or without proper authorization accessed or attempted to access any information technology system?). The Response must be a Permissible Result or else the case fails eAdjudication.	2
ADJ_CHECK_076	Investigations and Clearance Record - The applicant must respond to the SF-86 Section #25 (Have you EVER been debarred from government employment?). The Response must be a Permissible Result or else the case fails eAdjudication.	2
ADJ_CHECK_056	Foreign Countries You have Visited - - If the applicant responded to SF-86 Section #20c "Yes" to traveled outside the U.S. and "No" to solely for U.S. Government Business, the applicant must respond to the SF-86 Section #20c (While traveling to or in this country, were you contacted by, or in contact with anyone exhibiting excessive knowledge of or undue interest in you or your job?). The Response must be a Permissible Result or else the case fails eAdjudication.	1
ADJ_CHECK_058	Foreign Countries You have Visited - - If the applicant responded to SF-86 Section #20c "Yes" to traveled outside the U.S. and "No" to solely for U.S. Government Business, the applicant must respond to the SF-86 Section #20c (While traveling to, or in this country, were you threatened, coerced, or pressured in any way to cooperate with a foreign government official or foreign intelligence or security service?). The Response must be a Permissible Result or else the case fails eAdjudication.	1
ADJ_CHECK_078	Financial Record - The applicant must respond to the SF-86 Section #26 (Have you EVER experienced financial problems due to gambling?). The Response must be a Permissible Result or else the case fails eAdjudication.	1

APPENDIX C: LIST OF BASELINE BUSINESS RULE MODIFICATIONS FOR TESTING

- ADJ_CHECK_428: MILD check. Our sample does not contain investigations with the MILD check, so this rule was deactivated for testing purposes.
- ADJ_CHECK_430: Cross-check between the Standard Form 86 (SF-86) reported education and CCT LAWE checks to ensure presence of associated LAWE check. This check was deactivated because our current version of the eAdjudication environment cannot accommodate this cross-validation.
- ADJ_CHECK_464: Cross-check between SF-86 identifying information and CCT LAWE checks to ensure presence of associated LAWE check. This check was deactivated because our current version of the eAdjudication environment cannot accommodate this cross-validation.
- ADJ_CHECK_431: Cross-check between SF-86 reported residences and CCT LAWE checks to ensure presence of associated LAWE check. This check was deactivated because our current version of the eAdjudication environment cannot accommodate this cross-validation.
- ADJ_CHECK_432: Cross-check between SF-86 reported civilian employment and CCT LAWE checks to ensure presence of associated LAWE check. This check was deactivated because our current version of the eAdjudication environment cannot accommodate this cross-validation.
- ADJ_CHECK_433: Cross-check between SF-86 reported self-employment and CCT LAWE checks to ensure presence of associated LAWE check. This check was deactivated because our current version of the eAdjudication environment cannot accommodate this cross-validation.
- ADJ_CHECK_434: Cross-check between SF-86 reported military employment and CCT LAWE checks to ensure presence of associated LAWE check. This check was deactivated because our current version of the eAdjudication environment cannot accommodate this cross-validation.
- ADJ_CHECK_435: Cross-check between SF-86 reported education and CCT EDUC checks to ensure presence of associated EDUC item. This check was deactivated because our current version of the eAdjudication environment cannot accommodate this cross-validation.
- ADJ_CHECK_436: Cross-check between SF-86 reported civilian employment and CCT EMPL checks to ensure presence of associated EMPL item. This check was deactivated because our current version of the eAdjudication environment cannot accommodate this cross-validation.
- ADJ_CHECK_437: Cross-check between SF-86 reported self-employment and CCT EMPL checks to ensure presence of associated EMPL item. This check was deactivated because our current version of the eAdjudication environment cannot accommodate this cross-validation.

- ADJ_CHECK_438: Cross-check between SF-86 reported military employment and CCT EMPL checks to ensure presence of associated EMPL item. This check was deactivated because our current version of the eAdjudication environment cannot accommodate this cross-validation.

The following line was deleted from the Baseline Extensible Markup Language file:

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<SF8X Name="SF86" Version="2017-07" />
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