EXIM
EXPORT-IMPORT BANK
OF THE UNITED STATES

Office of Inspector General
Export-Import Bank
of the United States

Evaluation of EXIM's Credit Loss Factor Model and Loss Reserve Process

June 19, 2019
OIG-EV-19-03

The Export-Import Bank of the United States (EXIM or the Bank) is the official export credit agency of the United States. EXIM is an independent, self-sustaining executive agency and a wholly-owned U.S. government corporation. The Bank's mission is to support jobs in the United States by facilitating the export of U.S. goods and services. EXIM provides competitive export financing and ensures a level playing field for U.S. exports in the global marketplace.

The Office of Inspector General, an independent office within EXIM, was statutorily created in 2002 and organized in 2007. The mission of the EXIM Office of Inspector General is to conduct and supervise audits, investigations, inspections, and evaluations related to agency programs and operations; provide leadership and coordination as well as recommend policies that will promote economy, efficiency, and effectiveness in such programs and operations; and prevent and detect fraud, waste, abuse, and mismanagement.

This evaluation was conducted in accordance with the 2012 Quality Standards for Inspection and Evaluation as defined by the Council of Inspectors General on Integrity and Efficiency. This report does not constitute a government audit and therefore, it was not conducted following the Generally Accepted Government Auditing Standards (GAGAS).

EXIM
EXPORT-IMPORT BANK OF THE UNITED STATES

Office of Inspector General

To: Inci Tonguch-Murray, Acting Senior Vice President and Chief Financial Officer

From: Jennifer Fain, Assistant Inspector General for Audits and Evaluations

Subject: Evaluation of EXIM's Credit Loss Factor Model and Loss Reserve Process

Date: June 19, 2019

This report presents the results of the independent evaluation of EXIM's Credit Loss Factor model and loss reserve process. The objective was to complete an independent evaluation of the Bank's FY 2019 CLF model and to assess the reasonableness of the Bank's overall loss reserve process; specifically, to (1) determine the reasonableness of the model, focusing on changes since 2015, and (2) assess the model risk management policies surrounding the production of the CLF model outputs. Under a contract monitored by this office, we engaged the independent consulting firm of Summit Consulting, LLC to perform the evaluation.

The report contains seven recommendations for corrective action. In response to our report, management concurred with all seven recommendations. Management's comments are included as appendix A in this report. We consider management's proposed actions to be responsive. The recommendations will be closed upon completion and verification of the proposed actions.

This evaluation was conducted in accordance with the 2012 *Quality Standards for Inspection and Evaluation* as defined by the Council of Inspectors General on Integrity and Efficiency. Those standards require that we plan and perform the evaluation to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our evaluation objective. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions.

We appreciate the cooperation and courtesies provided to Summit Consulting, LLC and this office during the evaluation. If you have questions, please contact me at (202) 565-3439 or jennifer.fain@exim.gov or Courtney Potter at (202) 565-3976 or courtney.potter@exim.gov. You can obtain additional information about the EXIM Office of Inspector General and the Inspector General Act of 1978 at www.exim.gov/about/oig.

Attachment: Evaluation Report on EXIM's CLF Model and Loss Reserve Process, OIG-EV-19-03, June 2019

EXECUTIVE SUMMARY

Evaluation of CLF Model and Loss Reserve Process
OIG-EV-19-03, June 2019

Why We Did This Audit

We completed an evaluation of the Export-Import Bank of the United States' (EXIM or the Bank) Credit Loss Factor (CLF) model and loss reserve process. The primary objective of this evaluation was to complete an independent evaluation of the Bank's fiscal year (FY) 2019 CLF model and to assess the reasonableness of the Bank's overall loss reserve process. Specifically, our testing focused on changes to EXIM's CLF model since 2015. We also evaluated the model risk management policies and procedures surrounding the production of the CLF model outputs.

What We Recommend

We made seven recommendations to improve model governance and risk management, documentation, and the methodologic approach and execution of the Process: (1) create a single consolidated technical note, or add a justifications section to existing documentation, that thoroughly describes modeling choices (including the selection criteria for the statistical calculations used); (2) add in a comprehensive change log to existing documentation that is updated whenever the model or process is changed that includes how assumption changes are executed; (3) add or append current documentation with a comprehensive policies and procedures guide that outlines requirements to deem a run successfully executed; (4) update the FY 2019 Standard Operating Procedures (SOP) and ensure that each calculation step is accurately reflected in the User Guide for the CLF model; (5) automate the calculations and data transformation steps, especially across files and applications; (6) build out the error checking and reporting functions for the model; and (7) expand the current model program into a formal model risk management framework, particularly with an expansion to include better risk mitigation surrounding error checking, statistical reporting, execution of model changes, and role definition. One of these roles should include documentation updates (i.e., a checklist item) to ensure that the SOP matches the current process to reduce errors.

What We Found

We conducted an independent evaluation of the EXIM's FY 2019 CLF model and loss reserve process for first quarter. The evaluation was conducted by Summit Consulting, LLC (Summit), an independent firm with expertise in federal credit models. EXIM's CLF model and loss reserve process (collectively, the Process) produces an estimate of the expected cost of the Bank's lending and guarantee portfolio on an annual basis. Therefore, the CLF model and loss reserve process represent a significant risk based on the materiality of the Process' data integrity, documentation, management processes, and the controls.

To evaluate EXIM's FY 2019 CLF model and assess the reasonableness of the Bank's loss reserve process, we conducted three separate activities to determine whether the Process was (1) replicable, (2) reasonable, and (3) well managed. To do so, we replicated the most recent completed estimate of the loss reserve for FY 2018 and also the most recent version currently in production using FY 2019 first quarter estimates, while also assessing the quality and reasonability of the Process' documentation. This assessment included analyzing the written policies and procedures for management of the Process.

We determined that EXIM's FY 2019 CLF model and loss reserve process can create reasonable estimates of the credit subsidy and loss reserve estimates. Furthermore, the Bank's documentation, methodological approach and execution of the Process were found to be reasonable pending changes and enhancements to existing documentation. However, we found that the Process requires several manual steps and the model risk management policies are insufficiently documented regarding the execution of roles. Whereas manual steps introduce the risk of calculation error to the model, insufficient documentation introduces key person risk. We conclude that the Process should be more rigorous with robust safeguards, better diagnostics, and easier replicability.

For additional information, contact the Office of Inspector General at (202) 565-3908 or visit www.exim.gov/about/oig

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ABBREVIATIONS AND GLOSSARY

Term	Description
Bank or EXIM	Export-Import Bank of the United States
BCL	Budget Cost Level
CLF	Credit Loss Factor
CSC	Credit Subsidy Calculator
CSR	Credit Subsidy Rate
ELC	Exporter Letter of Credit
EOL	EXIM Online
ERS	EXIM Bank Reporting System
FCRA	Federal Credit Reform Act
FY	Fiscal Year
GCF	Guarantee Credit Facility
LT	Long-term
MT	Medium-term
MB	MultiBuyer
NPV	Net Present Value
OCFO	Office of the Chief Financial Officer
OIG	Office of Inspector General, EXIM
OMB	Office of Management and Budget
PD	Probability of Default
Process	Collectively, the CLF model and loss reserve process.
SOP	Standard Operating Procedure
Summit	Summit Consulting, LLC

INTRODUCTION

This report presents the results of the independent evaluation of the Export-Import Bank of the United States' (EXIM or the Bank) fiscal year (FY) 2019 Credit Loss Factor (CLF) model and loss reserve process, conducted by Summit Consulting, LLC (Summit). The objective was to complete an independent evaluation of EXIM's FY 2019 CLF model and to assess the reasonableness of the Bank's overall loss reserve process. Specifically, we focused our testing on changes to EXIM's CLF model since 2015. We also evaluated the model risk management policies and procedures surrounding the production of the CLF model outputs.

The evaluation was initiated in part to address the statutory requirement in the *Export-Import Bank Reform and Reauthorization Act of 2015* (the 2015 Reauthorization Act) for the EXIM Office of Inspector General (OIG) to review the portfolio risk management procedures of the Bank.[1] The CLF model and loss reserve process (collectively, the Process) produces an estimate of the expected cost of EXIM's lending and guarantee portfolio on an annual basis. Therefore, the CLF model and loss reserve process represent a significant risk based on the materiality of the Process' data integrity, documentation, management processes, and the controls. Accordingly, the evaluation was initiated as part of the OIG's annual work plan.

SCOPE AND METHODOLOGY

To evaluate EXIM's FY 2019 CLF model and assess the reasonableness of the Bank's loss reserve process, we conducted three separate activities to determine whether the process was (1) replicable, (2) reasonable, and (3) well managed. To do so, we replicated the most recent completed estimate of the loss reserve for FY 2018 and also the most recent version currently in production using FY 2019 first quarter estimates, while also assessing the quality and reasonability of the process' documentation. This assessment included analyzing the written policies on management of the process. See appendix B for more details on the scope and methodology.

We conducted this evaluation from March 2019 to May 2019 in accordance with the 2012 *Quality Standards for Inspection and Evaluation* issued by the Council of Inspectors General on Integrity and Efficiency (CIGIE).[2] We believe that the evidence obtained provides a reasonable basis for our findings and conclusions.

[1] *See* the *Export-Import Bank Reform and Reauthorization Act of 2015*, included in "Division E—Export-Import Bank of the United States" of the "FAST Act," which became public law on December 4, 2015 (Pub. L. No. 114-94) at https://www.congress.gov/114/bills/hr22/BILLS-114hr22enr.pdf.

[2] *See* https://www.ignet.gov/sites/default/files/files/committees/inspect-eval/iestds12r.pdf.

BACKGROUND

Established in 1934 through Executive Order, and subsequently made an independent agency of the United States (U.S.) through congressional charter in 1945, EXIM is a wholly-owned government corporation whose mission is to aid in financing and to facilitate the export of U.S. goods and services, and to contribute to the employment of U.S. workers. EXIM's charter, through its enabling legislation, establishes the Bank's operations and programs. With the passage of the 2015 Reauthorization Act, the authorization of the Bank's charter was extended to September 30, 2019.[3]

The Bank's core financing programs include direct loans and guarantees to foreign buyers, export credit insurance for exporters and foreign buyers, and working capital finance to small business exporters. The charter requires "reasonable assurance of repayment" for all Bank transactions, which are backed by the full faith and credit of the U.S. Government.[4]

The Credit Loss Factor Model and the Loss Reserve Program

The CLF model and the subsequent loss reserve process jointly produce an estimate of the expected cost of the Bank's lending and guarantee activities. Each outstanding loan owned by the Bank is evaluated for the likelihood of default, expected recoveries after any default, and any interest, reclamation costs, and depreciation of asset quality associated with such recoveries. The net cost (or surplus) of the entire loan portfolio is then calculated. These valuation estimates follow the same requirements associated with other Federal Credit programs as outlined in the Federal Credit Reform Act of 1990 (FCRA),[5] and they require a set of assumptions on how to discount and weight the cash flows associated with each loan, guarantee, or insurance product.

Prior Reviews of EXIM's CLF Model

There have been several reviews of the overall loss reserve process, including reviews focusing on the CLF model inputs, other on the CLF model itself, and reviews of the loss reserve calculations made with CLF outputs. This evaluation will focus on the CLF model and the post-CLF loss reserve calculations. To facilitate the review, OIG engaged the services of Summit. Prior to this evaluation, Summit conducted a review of EXIM's CLF model in 2015 (though not the loss reserve process) under a contract with the Bank. The 2015 evaluation of the CLF model was focused heavily on the model methodology and the vetting of data inputs, and the evaluation produced several recommendations on how to improve the model and its performance.

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[3] *Supra* note 1.

[4] *See The Charter of the Export-Import Bank of the United States* at http://www.exim.gov/sites/default/files/2015_Charter_-_Final_As_Codified_-_02-29-2016.pdf.

[5] *See* Title V, *The Federal Credit Reform Act of 1990*, included in the "Omnibus Budget Reconciliation Act of 1990," which became public law on November 5, 1990 (Pub. L. No.101-508) at https://www.fiscal.treasury.gov/files/ussgl/fcra.pdf.

RESULTS IN BRIEF

We determined that EXIM's FY 2019 CLF model and loss reserves process (collectively, the Process) can create reasonable estimates of the credit subsidy and loss reserve estimates. For example, we were able to reproduce the overall upward reestimate of approximately $146 million for FY 2018. Furthermore, the Bank's documentation, methodological approach and execution of the Process were found to be reasonable pending changes and enhancements to existing documentation. However, we found that the Process requires several manual steps and the model risk management policies are insufficiently documented regarding execution of roles; manual steps introduce the risk of calculation error, while insufficient documentation introduces key person risk. We conclude that the Process should be more rigorous with robust safeguards, better diagnostics, and easier replicability. We made seven recommendations to improve model risk management, process documentation, methodology, and execution of the Process.

Finding 1: The current process produced reasonable estimates for FY 2018 and FY 2019 first quarter.

Based on review of EXIM's documentation,[6] model structure, calculation steps, intermediate calculation values, and final calculation outputs, we find that the estimates produced in FY 2018 and FY 2019 quarter one are reasonable and that the model runs were executed in accordance with the Bank's internal policies.

RECOMMENDATIONS

We make no recommendations for this finding.

Finding 2: The process documentation can be improved to be more accurate and reduce key person risk.

Maintaining up-to-date and accurate model documentation is an essential part of reducing key-person dependency and increasing transparency with regards to the models used in the reserving process. This is particularly critical when a model uses as many manual copy-and-paste steps as EXIM's currently does. This is especially critical for this process in particular, as the institutional knowledge is concentrated in just a few staff which can create key person dependency risk. Proper documentation alleviates some of the key person dependency risk and is especially critical in smaller agencies. We found that EXIM

[6] EXIM's CLF model governance, policies, and controls for the FY 2018 and FY 2019 models are comprised of the following documents: (1) *Reestimate Background and Process*, (2) *Credit Loss Factors*, (3) *FY 2018 Cash Flow Methodology*, (4) *FY 2018 Reestimate Process Outlined*, (5) *FY 2018 Reestimate – Standard Operating Procedures*, (6) *FY 2020 Loss Factor SOP*, (7) *FY 2020 Loss Rate Report, (8) Cash Flow Model Change Log 10-1-18, (9) Loss Factor Model Update 9-19-18, (10) Re-estimate Management Review-Approval 10-4-18, and (11) Reestimate Retrospective FY 2017 Financial Audit Cash Flow Model Recommendations & FY 2018 Cash Flow Model 10-15-18*. *See* Appendix C: Summary of the Existing Process of this report for documentation obtained and reviewed as part of the evaluation.

can improve model documentation to align with industry best practices. The following observations were made in reviewing the Bank's documentation:

- **Systems Documentation/Technical Note:** The documentation lacks an adequate explanatory section justifying the modeling decisions made by the model builders. Such a section ideally will include justifications of estimators (e.g., why a Probit model was selected over Logit, including the testing that supports the decision), citations of relevant literature used when designing the model, testing procedures used to specify functional forms, and/or discussion of alternative specifications considered and rejected. Though the current documentation provides some of this information, it does so inconsistently and for a limited number of steps.
- **CLF Model Standard Operating Procedures (SOP):** The current documentation lacks a formalized guide tracking all annual changes made to the CLF model, and the existing logs (held outside the documentation) should be incorporated into the SOP as a formal appendix. Model change logs provide critical information on how the reestimate process has evolved, summarizes critical changes made to the model, explains why a change was required, and justifies the approach taken to implement the change, and explains what impacts the change had on the Process and estimates. This information is scattered across several documents and is not standardized across years.
- **Loss Reserve Process Policies and Procedures Guide:** The documentation lacks a description of the oversight and verification roles for vetting that the Process is executed accurately, and what error thresholds or types of model fit reviewers are to use when deeming a model run accurate. In particular, due to the risk of human error being introduced to the numerous manual calculations, a robust verification and/or audit framework should be laid out and followed as part of due course for modeling efforts.[7] The documentation does mention that the model should be produced twice independently as a check on accuracy, but there are formalized (and more dependable) ways to ensure the process is accurately run that is more transparent and efficient, including error checks and numerical test outputs that safeguard against mistakes.
- **FY 2019 CLF Model and FY 2018 Reestimate – Standard Operating Procedures:** The SOP documentation for the preparation of the CLF model inputs, which is meant to provide step-by-step instructions for replicating the Process, contains a few errors. Thus, the documentation is partially inconsistent and incomplete. We identified the following errors within the SOP documentation:
    - Attempts to reproduce the "Steps to Model" workbooks by following the exact steps listed in the SOP led to results that differed from the workbooks. We noted that certain filtering steps were not included or explicitly stated in the instructions. This issue could be resolved by providing more

[7] Note that this is in reference to the model execution and intermediate values, rather than the Process results. The SOP outlines how the Process results are reviewed.

comprehensive instructions with screenshots or monitored captures for every filtering step.

- The worksheet names in the SOP are not always consistent with the ones observed in the completed "Steps to Model" workbooks, and the Excel formulas listed are incorrect (i.e., they contain incorrect worksheet and cell references).
- The documentation fails to explain an inconsistency in the *FY 2018- 1) Portfolio Download.xlsx* workbook's "1) PD August Closing" worksheet. The label for U.S. dollar transactions is a mix of blanks and "US Dollars." To avoid confusion, EXIM should either correct this inconsistency in the workbook or provide an explanation in the documentation.

Typically, a well-governed model's documentation includes the following sections:

- **Data Dictionary:** The data dictionary defines each variable appearing in the underlying data.
- **User Guide:** The user guide is a technical document that provides step-by-step instructions for operating the model and producing the expected outputs. This document should provide clear instructions for any audience, regardless of level of experience, and it must allow for a successful step-by-step replication of model results without outside assistance. Currently, the FY 2018 version of the User Guide had errors (see Finding 3 of this report) and thus prevented a successful run of the model. Replication of the model had to be carried out using intermediate files provided by Bank staff, which allowed for a backwards engineering of differences in the User Guide versus the actual model estimation.
- **Standard Operating Procedures:** The SOP is an all-encompassing document that serves as a framework for detailed organizational policy, including best practices. This is alternatively called a Model Owner's Handbook by some model risk management (MRM) frameworks. Presently, the CLF and loss reserve process SOP does not match these requirements.[8]
- **Systems Documentation:** The systems documentation is a comprehensive technical document which describes the model's purpose, update history, methodology, structure, and testing results. The sections on model methodology should include relevant literature, key assumptions and their justifications, model limitations, and data use and treatments detailing data transformations. This should include a Technical Note[9] or Developer's Guide on the theory behind the model, the

[8] The existing *Reestimate Background and Process* and the *Credit Loss Factors* documents have some elements of these and combining these into a single document and expanding the document to include the verification and validation procedures (rather than just saying such procedures exist without detailing them) would provide much more of the required information.

[9] Note that some potential elements of a technical note are listed in the document *FY 2020 Loss Rate Report Final.pdf*, though the justifications, alternatives analysis, and quantitative testing results are lacking. Similarly, there are several explanations of statistical tests that are slightly inaccurate, such as the explanation of the p-value in the *Model Evaluation* section.

diagnostics and error checking methodologies employed in the run, and other critical information required to understand the function of the model.

Not all of the above documents or sections are required or expected for each step of the reserving process, but each one should exist for EXIM's overall CLF model and loss reserve process. These documents reduce risk, including audit risk and key-person dependency risk. The reproducibility of federal credit models is dependent upon its documentation. The lack of adequate documentation could result in users being unable to reproduce model runs if key personnel leave EXIM.

RECOMMENDATIONS

We recommend EXIM's Office of the Chief Financial Officer update its documentation to align with the best practices of federal credit programs that follow MRM procedures by:

1. Creating a single consolidated technical note, or adding a justifications section to existing documentation, that thoroughly describes modeling choices (including the selection criteria for the statistical calculations used).
2. Adding a comprehensive change log to existing documentation that is updated whenever the model or process is changed that includes how assumption changes are executed.
3. Adding or appending current documentation with a comprehensive Policies and Procedures guide that outlines requirements to deem a run "successfully executed."

Finding 3: Improvements can be made to EXIM's methodologic approach and execution of the Process.

Although we were able to reproduce the entire Process in the replication almost exactly, EXIM can improve the methodological approach and execution of the Process. We attempted to independently reproduce results using documentation and data files provided by the Bank. We also reviewed documentation and individual calculations to assess the model's theoretical validity and the execution of that theory. We received copies of all intermediate files used in the FY 2018 model estimation, as well, to compare our replication with the historical runs.

Our evaluation and replication of the Process identified several issues. For example, the manual nature of the reserving process introduces risk of error. Similarly, we found that the Process does not produce sufficient error checking or diagnostic information to ensure that the Process is executed correctly.

Reserving Process is Reproducible, with Exceptions

For the Process, we attempted to replicate both the FY 2018 reestimate and the FY 2019 first quarter versions of the model. For the reestimate, we limited our attempt to reproducing the FY 2018 version of the reestimate Credit Subsidy Calculator (CSC) as it was the most current version available. The FY 2019 discount rates were not available to either EXIM or the reviewers when the first quarter reestimates were produced. Note that we did not request access to the EXIM Bank Reporting System (ERS), as direct access to the

data system and functionality of downloading data was outside the scope of our evaluation. Thus, we cannot comment on the reasonableness of the data extraction process in the model replication. Table 1 summarizes the results of Summit's attempts to reproduce the reserving process.

Table 1: Reserving Process Replication

Process	Reproduced
Data Download	Not Applicable
Data Cleaning	✓
Probability of Default Regressions	✓
Recovery Rates	✓
Qualitative Factors	✓
Probability of Default Curves	✓
CSC-Formatted Cash Flows	✓
Calculation of CSR and NPVs	✓

Key:	Fully Reproduced	Partially Reproduced	Not Applicable

Using the documentation alone, we were able to fully reproduce the *12-31-18 AuthPlusClaims Loans Steps to Model.xlsx* and the *12-31-18 AuthPlusClaims Insurance Steps to Model.xlsx* workbooks. However, we were only able to fully reproduce the *12-31-18 AuthPlusClaims Guarantees Steps to Model.xlsx* workbook after reverse-engineering the one prepared by EXIM staff. More specifically, the discrepancies resulted from ambiguous instructions for populating the "NoLTCGF<3Yr1stInstal-NoMajorFrd" worksheet.

Using the data contained in the *Quantitative Model* and *Qualitative Model* workbooks, we were able to fully reproduce the following:

- The Probability of Default (PD) regression coefficients,
- The mean and standard deviation of Recovery Rates for non-aircraft loan and guarantees, aircraft loans and guarantees, and insurance,
- The mean and standard deviation of age of default used to calculate transaction-specific PD curves, and
- The qualitative factors.

Reproducibility is tightly linked with documentation and, as previously noted, the documentation for the CLF model contains a few errors. However, the documentation is partially inconsistent and incomplete.

Using the data contained in the workbooks, we were able to reproduce the overall upward reestimate of approximately $146 million. However, using the process described in the SOP resulted in a slight discrepancy in the Medium-Term Guarantees FY 1992 cohort. The replication resulted in a total reestimate of $14,185 for the cohort, whereas, the Bank's cash flows produced a total reestimate of $14,143. This difference of approximately negative $42 on a single cohort-year was viewed as immaterial. However, this is noteworthy because an exact replication could not be achieved despite multiple attempts to correct the issue. Following the SOP and using the same input files should result in an exact replication of the Process, and this proved infeasible despite significant effort to track down this error.

Additionally, we were unable to verify the Probability of Default Estimation Guarantees and Insurance for budget cost level (BCL) 10 and 11 on the worksheet "ICRAS" within the workbook *FY 2018- 2) Portfolio Download – Undisbursed Disbursed.xlsm.* The *FY 2020 Quantitative Model.xlsx,* where this information is copied from, only contains estimates for BCL's 1-8 and BCL 9 is justified within the *FY 2018 Reestimate – Standard Operating Procedures.pdf.*

Overall, these discrepancies were small and could be from innocuous causes (such as rounding errors due to not having direct access to download data). The lack of exact reproducibility, however, is problematic from a model execution standpoint and better documentation and internal controls are necessary (see Finding 2).

Reserving Process is a Manual Process

We observed that, with the exception of the creation of cash flows, the majority of steps involved in the reserving process are performed manually and involve repeatedly the copying and pasting of data.[10] While automating or coding the model is not a requirement for compliance, reducing the number of manual steps through coding could lower the risk of error. The number of manual copy-paste transactions across multiple sheets, files, and applications is unwieldy and invites risk. Further, such manual processes lose information on accuracy and replicability when cell equations or values are not preserved.[11] While robust internal controls can be a viable strategy for overseeing a manual process, the volume and frequency of manual steps in EXIM's CLF model introduces unnecessary risk, lengthens the time to execute a run, and limits the ability to check model accuracy and implement improvements to the Process. Additionally, in order to avoid key person risk, the manual process requires that the SOPs be updated and verified any time even a small change is made, whereas coding steps greatly reduces the need for such updates.

[10] Specifically, the CLF model requires the user to manually copy and paste data 40 times between five Excel files and two R files. Similarly, the loss reserve process requires the user to manually copy and paste data 27 times between five different Excel files. Each copy and paste step invites potential errors.

[11] Specifically, the diagnostics information from the Probit Model in R are not executed and thus are lost when the application is closed. Additionally, formula references across Excel spreadsheets are overwritten with numerical values. Both of these make calculations opaque and validation of the results difficult or impossible.

Federal credit programs following industry best practices have been automating their models to reduce level of effort, the risk of user error, and audit risk.[12] Further, automated models also benefit from being easier to run, allowing for more evaluation of the model, as well as facilitating wider sensitivity analyses. Automating models involves building the processes using programming languages such as VBA, R, Python, Stata, or SAS, which can readily reproduce previous outputs by selecting the same input files. These programming languages are also able to produce logs that record each step in the automated process and are useful for validating results and confirming successful runs.

Regarding the Process, EXIM should consider automating the following manual processes:

- **Modeling Expected Loss Rates:** This includes the creation of the *Steps to Model* workbooks, populating the *Quantitative Model*, and performing the PD regressions. The creation of the *Steps to Model* workbooks is an entirely manual process that lends itself to user error. Moreover, despite the data cleaning steps being split up into multiple worksheets, the entire process is not well documented and does not leave auditable results. This paired with inconsistent documentation, results in a process that is difficult to reproduce. Further, data from the *Steps to Model* workbooks is manually copied into the *Quantitative Model*, resulting in formatting inconsistencies (i.e., rounding to the nearest dollar). Similarly, the output of the PD regression, which results from a script written in R programming language, is manually copied into the *Quantitative Model*. Both processes can be automated to reduce level of effort, reduce the potential for user error, and increase reproducibility.
- **Reestimate:** While the reestimate process provides some automation in the VBA macros that copy and paste calculations from various tabs, it still requires a substantial amount of manual manipulation. It appears the Bank attempted to organize the data cleaning process by separating the process into five Excel workbooks each associated with a different type of information or portion of the process. However, by doing this it creates an inefficient process with data contained in several different locations. This requires multiple workbooks and tabs to be open at the same time and creates a high risk for user error.
- **Sensitivity Analysis and Stress Testing:** The amount of manual steps makes conducting any sensitivity or stress testing onerous and potentially error prone. Testing would be straight forward and could be conducted routinely if the process was converted to a statistical language (such as VBA or R). This could strengthen the Bank's understanding of portfolio risk as a whole, as well as facilitate model upgrades to specification.

[12] Some recent examples of FCRA-compliant programs increasing automation include the Veterans Affair's Loan Guarantee Service seeking sources to transition away from manual spreadsheets, and the Department of Education's Federal Student Aid program moving to a microsimulation model.

Legacy Code Risk

We understand from the User's Guide that the Bank uses an archived version of the CLF model spreadsheet as the first step in developing and conducting reestimates for current years. This can result in many adverse issues, including the user incorrectly updating or overlooking crucial updates to the model, as well as legacy functions, code, cell definitions, or formatting issues which may be transcribed forward. These problems manifest in the current model versions. For example, in the worksheet "Interest Rate" in the reestimate file *FY 2018- 1) Portfolio Download* column J contains a list of Deal Numbers and a justification for the inconsistent interest rates associated with them. However, deals 084728 and 087838 exist in the list, but not in the pivot table in columns A through C. The first deal number did not exist in the "1) PD August Closing" worksheet, whereas the second deal only had one associated transaction. Furthermore, we did not request access to the transaction documents which were referenced in this table because the information is obsolete. The appearance in the table was a result of using historical workbooks with legacy information. Although not the case, this legacy code gave the appearance of incomplete documentation. While this did not result in any errors, as the information is not directly pulled by the model when run, it is an example of legacy code risk present in the model.

Lack of Error and Residual Diagnostics Regime

One major element of a successful econometric model is that it be transparent, accurate, and stable. Currently, the model run in the R programming language does not save, store, or have a step to examine the regression's proscribed error, fit, or stability tests (i.e., thorough examination of the results and historical back-testing) included as part of its code. Without a routine testing regime, it is unclear whether the regression is accurate (e.g., if it has normally-distributed errors or a curve that fits the data accurately). A robust diagnostic regime should include error reports for all runs, as well as a technical discussion in the documentation on how the model developers assess and affirm the accuracy of the CLF model and Process during the annual revisions.[13]

RECOMMENDATIONS

To improve the execution and model design, we recommend that EXIM's Office of the Chief Financial Officer:

4. Update the FY 2019 SOP and ensure that each calculation step is accurately reflected in the CLF Model User Guide. This would include revising the SOPs to verify that results can be replicated with just the user guide and archived data files after model updates.
5. Automate calculations and data transformation steps, especially across files and applications.

[13] These might include programming in the R code a print command that summarizes the regression output, as well as other tests or checks that show commands are executed appropriately and that data are not duplicated or lost across calculations or filtering steps.

6. Build out the error checking and reporting functions for the model.

Finding 4: Current risk management procedures require additional focus on execution and reducing calculation risk.

EXIM's CLF model governance, policies, and controls (the documentation) were recently updated and are specific to the CLF model. The documentation calls for a year-to-year change analysis and mandates a review of the model by stakeholders outside the Office of the Chief Financial Officer (OCFO) as part of its oversight.[14] Currently, the process and procedures outlined in the documentation, and the manual steps required in the CLF model and the loss reserve process, fail to address risks in estimating the Bank's loss reserves process. Specifically, as noted in previous findings, current standards and estimation procedures introduce legacy code risk and manual error risk in calculation and versioning. Furthermore, the Process lacks reports on model performance and documentation on the process for the approval of changes is incomplete. These factors are critical elements of MRM and should be outlined explicitly in the documentation.

Improvements Needed to EXIM's Model Risk Management

Based on the documentation and current model procedures, we observed that there were gaps in the model controls. For example, the CLF model documentation does not outline requirements on how change impact analyses must be performed to identify proper model updates, and only states they be updated through a review of best practices. The definitions of these best practices are unclear, and there is no discussion of how recommendations are approved, executed, or verified within the OCFO. While a management plan is in place, we find that the descriptions lack sufficient detail on objective standards and execution of procedures, which further exacerbates existing key person dependency risk. Existing model change memos provide sufficient information. However, additional documentation detailing objective standards and execution of procedures would strengthen the current process.

Similarly, version control is not discussed or outlined. This is critical because the current first step in running the model requires opening a previous year's version. With such a step, the Process should have robust access controls that define where these official runs are stored, who has access to them, and a "pre-check" step that verifies such a version is accurate and up-to-date. Versioning, change authorization, change implementation, and change verification are critical elements of any MRM structure.

Adopting and adhering to a MRM plan or standard could greatly improve model governance and eliminate the introduction of risk into the Process. Due to the size of the EXIM's portfolio and the current state of the Process (including the number of manual steps required for estimation), the policies and procedures are insufficient to the Process' needs and we recommend a stronger MRM plan be developed. For example, in 2013, the Federal Housing Finance Agency (FHFA) published a set of guidelines for MRM and this document

[14] These stakeholders for reestimates include potential reviews by EXIM OIG, internal EXIM senior management, the Bank's Financial Statements Auditor, and OMB's Budget Review Division.

is a benchmark within the industry.[15] In addition, there are several other Federal MRM guidance documents available upon which EXIM could pattern their own framework.[16] Specifically, EXIM requires a document to addresses unauthorized model change risk by requiring stricter change control procedures, as well as formalized housing and archiving of "official" model runs. While references to such procedures exist in the documentation, execution steps for these control procedures should be laid out explicitly and include (1) the use of change control logs that document all model updates and processes to prevent accidental changes from human error, (2) the development of a permanent model ownership group which oversees all aspects of model monitoring and maintenance, and (3) the creation of a formal and explicit model review process that includes execution steps to help leadership maintain strong oversight of model development.

RECOMMENDATIONS

We recommend that EXIM's Office of the Chief Financial Officer strengthen the Process' governance by:

7. Expanding the current model program into a formal MRM framework, particularly with an expansion to include better risk mitigation surrounding error checking, statistical reporting, execution of model changes, and role definition. One of these roles should include documentation updates (i.e., a checklist item) to ensure that the SOP matches the current process to reduce errors.

[15] *See* FHFA's *Model Risk Management Guidance* (AB 2013-07), dated November 20, 2013 at https://www.fhfa.gov/SupervisionRegulation/AdvisoryBulletins/Pages/AB-2013-07-Model-Risk-Management-Guidance.aspx.

[16] The Board of the Governors of the Federal Reserve System (FRB) and the Office of the Comptroller of the Currency (OCC) *Supervisory Guidance on Model Risk Management* (FRB SR 11-7 or OCC 2011-12, dated April 4, 2011) is also an accepted standard for managing financial risk. *See* https://www.federalreserve.gov/supervisionreg/srletters/sr1107.htm and https://www.occ.gov/news-issuances/bulletins/2011/bulletin-2011-12.html.

CONCLUSION

EXIM's FY 2019 CLF model and loss reserves process can create reasonable estimates of the credit subsidy and loss reserve estimates. Furthermore, the Bank's methodological approach and execution of the Process were found to be reasonable pending changes, and most of the documentation is up to date. However, the Process is highly-manual (e.g., the majority of steps involved in the reserving process are performed manually) and the policies surrounding model management are insufficiently documented which introduces potential risk. Therefore, we made seven recommendations to improve model governance and risk management, documentation, and the methodologic approach and execution of the Process.

APPENDIXES

Appendix A: Management Response and OIG Evaluation

Reducing Risk. Unleashing Opportunity.

June 13, 2019

Parisa Salehi
Acting Inspector General
Office of the Inspector General
Export-Import Bank of the United States
811 Vermont Avenue, NW
Washington, DC 20571

Dear Ms. Salehi,

Thank you for providing the Export-Import Bank of the United States ("EXIM Bank" or "the Bank") management with the Office of the Inspector General's ("OIG") draft report, "Evaluation of EXIM's Credit Loss Factor Model and Loss Reserve Process, OIG-EV-19-03" dated June 6, 2019 (the "Report"). Management continues to support the OIG's work which complements the Bank's efforts to continually improve its processes. EXIM Bank is proud of the strong and cooperative relationship it has with the OIG.

The OIG contracted with Summit Consulting, LLC ("Summit") to conduct an evaluation of EXIM's FY 2019 Q1 Credit Loss Factor model and loss reserve process ("Process"). The Bank appreciates Summit acknowledging that "the estimates produced in FY 2018 and FY 2019 quarter one are reasonable and that the model runs were executed in accordance with EXIM's internal policies."

The OIG, through Summit, has made seven recommendations to EXIM's model risk management, process documentation, methodology, and execution of the Process. The Bank concurs with all seven recommendations and will move forward with implementing the recommendations.

Recommendation 1: Update its documentation to align with the best practices of federal credit programs that follow MRM procedures by creating a single consolidated technical note, or adding a justifications section to existing documentation, that thoroughly describes modeling choices (including the selection criteria for the statistical calculations used).

Management Response: The Bank concurs with this recommendation.

The Bank will update its documentation to align with the best practices of federal credit programs that follow MRM procedures by creating a single consolidated technical note, or adding a justifications section to existing documentation, that thoroughly describes modeling choices (including the selection criteria for the statistical calculations used).

Recommendation 2: Update its documentation to align with the best practices of federal credit programs that follow MRM procedures by adding a comprehensive change log to existing documentation that is updated whenever the model or process is changed that includes how assumption changes are executed.

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Reducing Risk. Unleashing Opportunity.

Management Response: The Bank concurs with this recommendation.

The Bank will update its documentation to align with the best practices of federal credit programs that follow MRM procedures by adding a comprehensive change log to existing documentation that is updated whenever the model or process is changed that includes how assumption changes are executed.

Recommendation 3: Update its documentation to align with the best practices of federal credit programs that follow MRM procedures by adding or appending current documentation with a comprehensive Policies and Procedures guide that outlines requirements to deem a run "successfully executed."

Management Response: The Bank concurs with this recommendation.

The Bank will update its documentation to align with the best practices of federal credit programs that follow MRM procedures by adding or appending current documentation with a comprehensive Policies and Procedures guide that outlines requirements to deem a run "successfully executed."

Recommendation 4: Update the FY 2019 SOP and ensure that each calculation step is accurately reflected in the CLF Model User Guide. This would include revising the SOPs to verify that results can be replicated with just the user guide and archived data files after model updates.

Management Response: The Bank concurs with this recommendation.

The Bank will update the FY 2019 SOP and ensure that each calculation step is accurately reflected in the CLF Model User Guide. This will include revising the SOPs to verify that results can be replicated with just the user guide and archived data files after model updates.

Recommendation 5: Automate calculations and data transformation steps, especially across files and applications.

Management Response: The Bank concurs with this recommendation.

The Bank will automate calculations and data transformation steps, especially across files and applications.

Recommendation 6: Build out the error checking and reporting functions for the model.

Management Response: The Bank concurs with this recommendation.

The Bank will build out the error checking and reporting functions for the model.

Recommendation 7: Strengthen the Process' governance by expanding the current model program into a formal MRM framework, particularly with an expansion to include better risk mitigation surrounding error checking, statistical reporting, execution of model changes, and role definition. One of these roles

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OF THE UNITED STATES

Reducing Risk. Unleashing Opportunity.

should include documentation updates (i.e. a checklist item) to ensure that the SOP matches the current process to reduce errors.

Management Response: The Bank concurs with this recommendation.

The Bank will strengthen the Process' governance by expanding the current model program into a formal MRM framework, particularly with an expansion to include better risk mitigation surrounding error checking, statistical reporting, execution of model changes, and role definition. These will include documentation updates (i.e. a checklist item) to ensure that the SOP matches the current process and contains to reduce errors.

We thank the OIG for your efforts to ensure the Bank's policies and procedures continue to improve, as well as the work you do with us to protect EXIM funds from fraud, waste, and abuse. We look forward to strengthening our working relationship and continuing to work closely with the Office of the Inspector General.

Sincerely,

Jeffrey Goettman
Executive Vice President and Chief Operating Officer
Export-Import Bank of the United States

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OIG Evaluation

On June 13, 2019, EXIM provided its management response to a draft of this report, concurring with all seven of the OIG's recommendations. The response identified the Bank's actions to address the recommendations. OIG considers EXIM's actions sufficient to resolve the reported recommendations. The recommendations will remain open until OIG determines that the agreed upon corrective actions are completed and responsive to the reported recommendations.

Appendix B: Scope and Methodology

EXIM's Office of Inspector General (OIG) contracted with Summit Consulting, LLC. (Summit) to conduct an independent evaluation of EXIM's FY 2019 Credit Loss Factor (CLF) model and to assess the reasonableness of the Bank's overall loss reserve process. Specifically, we focused our testing on changes to EXIM's CLF model since 2015. We also evaluated the model risk management policies and procedures surrounding the production of the CLF model outputs. This evaluation was performed from March 2019 through May 2019 at EXIM's headquarters in Washington, D.C., in accordance with the 2012 *Quality Standards for Inspection and Evaluation* as defined by the CIGIE.[17]

To answer the objective, the evaluation of the Process for calculating the loss reserve was broken into four tasks, as outlined below.

Task 1: Updates to the CLF Model

Documentation Review: We reviewed EXIM's documentation applicable to the design, maintenance, and operation of the EXIM reserving process from September 2011 to the first quarter of FY 2019. This included the previous CLF model analysis, any change memos, and user's guides.

Code Review: In addition to the review of documentation, we reviewed the step-by-step execution of the Process calculations. Specifically, this focused on tracking calculation steps through the model and remaining process, diagraming the executed model process flow, and comparing the steps actually executed against the descriptions of the process in the documentation.

Methodological Review: A review and evaluation of the methodological construction of EXIM's CLF model was conducted. We reviewed the CLF model design to determine whether the existing CLF model is adequately supported by published research and methodologies employed by other federal credit agencies. We also reviewed and assessed any judgment-based adjustments to components of the CLF model.

Task 2: Assessment on the Process

We provided a step-by-step assessment on the accuracy and efficacy of the post-CLF portion of the loss reserve estimation process. This included tracking CLF model outputs conversion to Federal Credit Reform Act (FCRA) compliant cash flows, evaluation of the Probability of Default and Recovery Rate estimates, and calculations of Credit Subsidy Rates (CSR) and Net Present Values (NPVs).

Document Review: We evaluated all EXIM's documentation applicable to the current version of the CLF model and loss reserve process in order to validate the comprehensiveness of the documentation.

Operational and Outputs Review – Replication: We executed an independent run of each step of the CLF model and loss reserve process in Excel and R, following instructions in formal documentation and also by reverse engineering some steps from intermediate

[17] *See* https://www.ignet.gov/sites/default/files/files/committees/inspect-eval/iestds12r.pdf.

output files provided by the Bank. This facilitated the replication of the FY 2018 full-year process and the FY 2019 first quarter CLF estimates. As a result, the level of reproducibility of the most recent specification of the Process was established. We conducted a comparative test with its redundant EXIM Process run outputs. Our outputs from data cleaning and the model specification were compared to the outputs supplied to Summit by EXIM.

Inputs Review: We validated that the CLF model uses "best available data" in terms of availability, reliability, and model performance. All relevant model inputs, including underlying historic data as well as quantitative and qualitative components was inspected and validated The CLF model source inputs were reconciled from Excel sheets.

Task 3: Overall Reasonableness of the Process – FY 2019 First Quarter

The purpose of Task three was to report the observations and recommendations for improving the Process and to opine on the reasonability of the current estimations using the Process. Based on the results from Tasks 1 and 2, we identified and recommended alternative specifications or approaches that could potentially offer improvements in predictive accuracy, cost, or speed of completion. These elements pertain to the model operation regarding the most current execution of the model for FY 2019.

Task 4: Policies and Procedures Surrounding the Process

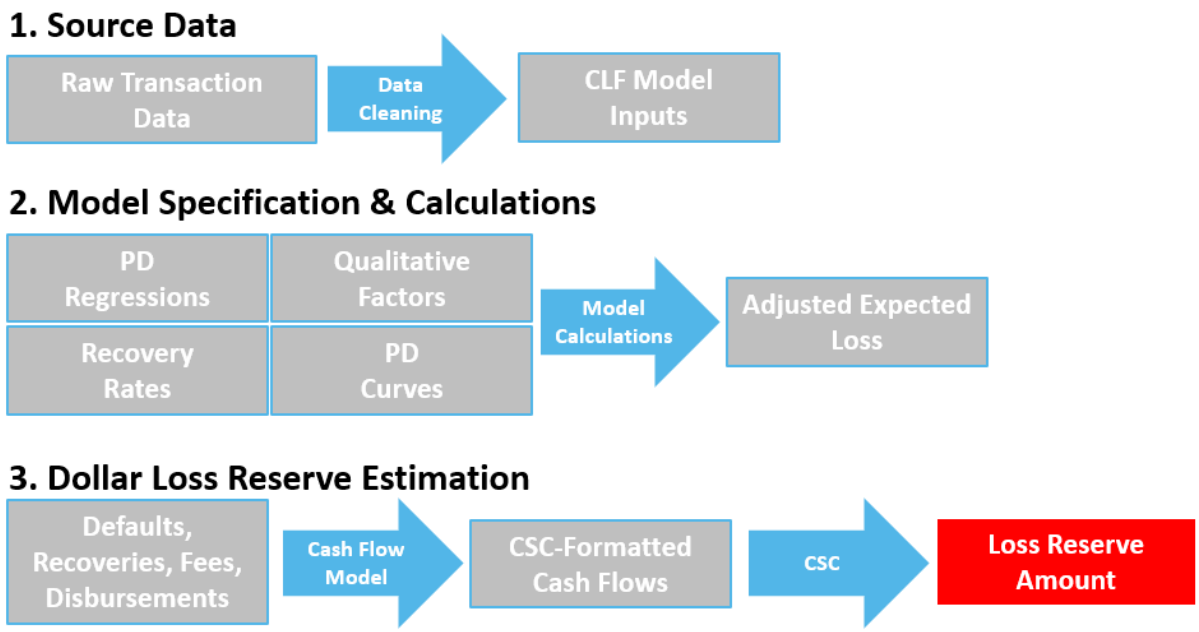
The purpose of Task four was to report the observations and recommendations for improving the Process' governance and risk management associated with the model's running and operation. Based on the documentation review, model replication, and policy and procedures documents, we identified various elements of the Process that could introduce risk to the accuracy and veracity of future runs of the model. These elements, which fall under the category of model risk management, pertain to the model operation as a going requirement. In addition to the recommendations based on the Process' accuracy and specifications, we also made recommendations in areas such as model documentation, model inputs, alternative methodologies, and prospective enhancements.

Appendix C: Summary of the Existing Process

Summary of the Existing Process

This section describes the current processes used to produce a loss reserve amount estimate. Figure 1 below provides a map of the current Process. First, source data is obtained from the accounting systems and from data providers and cleaned for accuracy. The model is then specified using this data. Using transaction specific inputs, the model is used to calculate a value for adjusted expected loss for each transaction. Finally, the adjusted expected loss is used to calculate an estimate of the dollar amount of the reserve for each transaction.

Figure 1: FY 2019 Model Overview



Documentation Provided

There are several sources of documentation that were used to define our understanding of the Process, as described in Table 2 below.

Table 2: Documentation Provided

File Name	Format
[PRM-BP.1] Reestimate Background and Process	PDF
[PRM-BP.2] Credit Loss Factors	PDF
EXIM-AnnualReport-2018	PDF
FY 2018 Cash Flow Model Methodology	PDF
FY 2018 Reestimate Process Outlined	PDF
FY 2018 Reestimate- Standard Operating Procedures	PDF
FY 2020 Loss Factor SOP FINAL	PDF
FY 2020 Loss Rate Report FINAL	PDF
Cash Flow Model Change Log 10-1-18	XLSX

File Name	Format
Loss Factor Model Update 9-19-18	PDF
Re-estimate Management Review-Approval 10-4-18	XLSX
Reestimate Retrospective FY 2017 Financial Audit Cash Flow Model Recommendations & FY 2018 Cash Flow Model 10-15-18	DOCX
Moody's Recovery Rate Recommendation Analysis	PDF

Source Data

There are several sources of data used to define the model, as described in Table 3.

Table 3: FY2019 Model Data Source

Data	Source
BCL Allocation Table	EXIM Connect
EIU Risk Tracker	ViewsWire
Moody's Annual Default Study: Corporate Default and Recovery Rates	EXIM Library
OMB Premia Rates	OCFO Treasurer
Moody's Sovereign Default and Recovery Rates	EXIM Library
Impaired and Major Delinquent Debt	OCFO
Major Fraud Cases	Prior Year's Folder
Economic Sector Listing	Prior Year's Folder
Authplusclaims Guarantees	ERS
Authplusclaims Insurance	ERS
Authplusclaims Loans	ERS

Note that we were never expected to get access to ERS, as direct system access and functionality of downloading data is outside the scope of our validation. Thus, we cannot comment on the reasonableness of the data extraction process.

Steps to Model Workbooks

12-31-2018 AuthPlusClaims Loans – Steps to Model

This workbook contains loan performance data for direct loans. This workbook is manually created by cleaning and filtering the raw Authplusclaims Loans data obtained from ERS according to the sequential steps listed below.

1. **AuthPlusClaims:** This worksheet contains the raw authplusclaims data for direct loans obtained from ERS.
2. **BCL 1-8NoUnkDeal#:** The raw data is filtered to exclude observations with an initial BCL not between 1 and 8 and is then sorted from oldest to newest by authorized date and first installment date.
3. **Major Delinquent:** This worksheet contains the list of transactions considered to be "impaired or major delinquent."
4. **Unique Deals (Advance Filter):** This worksheet is used to extract the unique deal numbers from the list of all deal numbers.

5. **Unique Deal Data – Filtered:** This worksheet contains data from the "BCL 1-8NoUnkDeal#" worksheet for all unique deals.
6. **No19-18 Delete0DisbNoLT<3YrInst:** Loans authorized in 2019 and 2018, and loans with no disbursements are dropped. Additionally, loans with no claims and less than 3 years from first installment are dropped.
7. **All LT-10Yr MT Model:** This worksheet contains the final data to be used in the CLF model. All medium-term (MT) loans authorized prior to 2008 are dropped.

12-31-2018 AuthPlusClaims Guarantees – Steps to Model

This workbook contains loan performance data for guaranteed loans. This workbook is manually created by cleaning and filtering the raw Authplusclaims Guarantees data obtained from ERS according to the sequential steps listed below.

1. **AuthPlusClaims:** This worksheet contains the raw authplusclaims data for guaranteed loans obtained from ERS.
2. **BCL 1-8 PolicyType<>WC:** The raw data is filtered to exclude observations with an initial BCL not between 1 and 8 as well as working capital policy types. The filtered data is then sorted from oldest to newest by authorized date and first installment date.
3. **Unique Deals (Advance Filter):** This worksheet is used to extract the unique deal numbers from the list of all deal numbers.
4. **Unique Deal Data – Filtered:** This worksheet contains data from the "BCL 1-8 PolicyType<>WC" worksheet for all unique deals.
5. **No19-18-PEFCO Delete0Disb:** Loans authorized in 2019 and 2018, PEFCO loans, and loans with no disbursements are dropped.
6. **Major Fraud**: This worksheet contains the list of transactions considered to be "major fraud."
7. **NoLTCGF<3Yr1stInstal-NoMajorFrd:** All long-term (LT) and MT credit guarantee facility (CGF) loans with no claims and less than 3 years from first installment, and deals listed in the "Major Fraud" worksheet are dropped.
8. **All LT-10Yr MT Model:** This worksheet contains the final data to be used in the CLF model. All MT deals authorized prior to 2008 are dropped.

12-31-2018 AuthPlusClaims Insurance – Steps to Model

This workbook contains loan performance data for insurance. This workbook is manually created by cleaning and filtering the raw Authplusclaims Insurance data obtained from ERS according to the sequential steps listed below.

1. **AuthPlusClaims:** This worksheet contains the raw authplusclaims data for insurance obtained from ERS.
2. **MT BCL 1-8 PolicyType<>MB-ELC:** The raw data is filtered to exclude observations with an initial BCL not between 1 and 8, non-MT deals, as well as multi-buyer, SB multi-buyer and ELC policy types. The data is then sorted from oldest to newest by authorized date and first installment date.
3. **Unique Deals (Advance Filter):** This worksheet is used to extract the unique deal numbers from the list of all deal numbers.

4. **Unique Deal Data – Filtered:** This worksheet contains data from the "MT BCL 1-8 PolicyType<>MB-ELC" worksheet for all unique deals.
5. **No19-18 No0Disb:** All deals authorized in 2019 and 2018 and deals with no disbursements are dropped.
6. **Major Fraud List:** This worksheet contains the list of transactions considered to be "major fraud".
7. **NoMajorFraud:** All deals listed on the "Major Fraud List" worksheet are dropped.
8. **10Yr MT Model:** This worksheet contains the final data to be used in the CLF model. All MT deals authorized prior to 2008 are dropped.

CLF Model Inputs

The "LTG-LTL-CGF PD Data" and "MT no CGF PD Data" worksheets of the *Quantitative Model* are used as the inputs for the R processes.

LTG-LTL-CGF PD Data

This data is assembled by copying LT guarantees, LT loans, and MT CGF loans and guarantees from the "All LT-10Yr MT Model" worksheets of the *12-31-2018 AuthPlusClaims Guarantees – Steps to Model* and *12-31-2018 AuthPlusClaims Loans – Steps to Model* workbooks.

MT no CGF PD Data

This data is assembled by copying medium-term insurance from the "10Yr MT Model" worksheet of the *12-31-2018 AuthPlusClaims Insurance – Steps to Model* workbook, and medium-term loans and medium-term guarantees from the "All LT-10Yr MT Model" worksheets of the *12-31-2018 AuthPlusClaims Guarantees – Steps to Model* and *12-31-2018 AuthPlusClaims Loans – Steps to Model* workbooks.

Model Specification and Calculations

All steps that produce a value for expected loss require specification. These steps can be broken down into four primary components: Probability of Default (PD) regressions, Recovery Rates, PD curves, and Qualitative Factors. The sections below describes how each component is specified.

Probability of Default Regressions

The FY 2019 CLF model uses two separate Probit regressions to forecast PD for long-term and medium-term deals. These sections describe the methodology for these regressions as well as their results. The regressions are performed using scripts written in R, an open-source statistical programming language.

Long-Term PD

The dependent variable, "Defaulted", is set to 1 for transactions that appear on the list of delinquent and impaired transactions, have a "Life to Date Write Off Amount" greater than 0, or a "Life to Date Claim Total Paid Amount" greater than 0. The first independent variable, "BCL", is set equal to the "Initial BCL" of that transaction. The second independent variable, "Aircraft Private", is a dummy variable that distinguishes between aircraft industry and non-aircraft industry transactions. The third independent variable, "Sovereign

BCL 1-7", is a dummy variable that distinguishes between transactions that have a sovereign risk classification and those that do not.

Using this data provided in the "LTG-LTL-CGF PD Data" worksheet of the *Quantitative Model*, the R script performs the regression described in Equation 1.

Equation 1: LT PD Regression

$$\mathbf{P(Defaulted)} = \boldsymbol{\Phi}(\boldsymbol{\beta}_1 + \boldsymbol{\beta}_2(\mathbf{BCL}) + \boldsymbol{\beta}_3(\mathbf{Aircraft\ Private}) + \boldsymbol{\beta}_4(\mathbf{Sovereign}))$$

$$\mathbf{where}\ \boldsymbol{\Phi}(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$$

Table 4 lists the results of the FY2019 CLF model run for calculating the long-term PD.

Table 4: FY2019 CLF Model Results – LT PD

Coefficient	Value
β_1	(b) (4)
β_2	(b) (4)
β_3	(b) (4)
β_4	(b) (4)

Medium-Term PD

The dependent variable, "Defaulted", is set to 1 for transactions that appear on the list of delinquent and impaired transactions, have a "Life to Date Write Off Amount" greater than 0, or a "Life to Date Claim Total Paid Amount" greater than 0. The independent variable, "BCL", is set equal to the "Initial BCL" of that transaction.

Using this data provided in the "MT no CGF PD Data" worksheet of the *Quantitative Model*, the R script performs the regression described in Equation 2.

Equation 2: MT PD Regression

$$\mathbf{P(Defaulted)} = \boldsymbol{\Phi}(\boldsymbol{\beta}_1 + \boldsymbol{\beta}_2(\mathbf{BCL}))$$

$$\mathbf{where}\ \boldsymbol{\Phi}(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$$

Table 5 lists the results of the FY2019 CLF model run for calculating the medium term PD.

Table 5: FY2019 CLF Model Results – MT PD

Coefficient	Value
β_1	(b) (4)
β_2	(b) (4)

Recovery Rates

Recovery rates are calculated separately for each of the following three distinct categories: (1) Long-Term Non-Aircraft, (2) Long-Term Aircraft, and (3) Medium-Term.

LT Non-Aircraft

LT recovery rates for non-aircraft export product type are calculated using historical direct and guaranteed loan recovery data, filtered to include only non-aircraft and long-term

deals. The recovery data is then split into two subsets based on the Life to Date Claim Total Paid Amount: (1) less than $10,000,000, and (2) greater than $10,000,000.

The net recovery and typical recovery rate are calculated as follows:

$$\textbf{Net Recovery} = \textbf{LTD Claim Recovery Amount} - \textbf{LTD Claim Expenses Paid Amount}$$

$$\textbf{Typical Recovery Rate} = \frac{\sum(\textbf{Net Recovery})}{\sum(\textbf{LTD Claim Total Paid Amount})}$$

LT Aircraft

LT recovery rates for the aircraft export product type are calculated using average corporate debt recovery rates from Moody's Annual Default Study – Corporate Default and Recovery Rates, published in February 2018, as opposed to historical data. This is because there is not enough data specific to aircraft export product types to model recovery rates.

More specifically, the 1st Lien Bank Loan and Sr. Unsecured Bank Loan average corporate debt recovery rates from the 1983-2018 period are used to for the typical recovery rate for secured and unsecured, respectively.

Medium-Term

MT recovery rates are calculated using historical direct and guaranteed loan recovery data, filtered to include only medium term deals.

The net recovery and typical recovery rate are calculated as follows:

$$\textbf{Net Recovery} = \textbf{LTD Claim Recovery Amount} - \textbf{LTD Claim Expenses Paid Amount}$$

$$\textbf{Typical Recovery Rate} = \frac{\sum(\textbf{Net Recovery})}{\sum(\textbf{LTD Claim Total Paid Amount})}$$

Qualitative Factors

Three qualitative factors are currently used in the reserving process: (1) Minimum Loss Rate, (2) Global Economic Growth, and (3) Recent Portfolio Growth.

The Minimum Loss Rate, which is equal to 0.40 percent in this version, is calculated as the average of the following three values:

1. Aaa-B Average Annual Credit Loss Rate, 1992-2018
2. Aaa, Aa, A, Baa Year 5 Average Cumulative Credit Loss Rate, 1983-2018
3. Loss Rate with 50 percent LGD

The Global Economic Growth, which is equal to 100 percent in this version, is set equal to 100 percent if the average EIU World Real GDP Percent Change for years 2019-2023 is greater than the average for years 1994-2018. If not, then this qualitative factor is calculated as follows:

$$\frac{\textbf{EIU World Real GDP \% Change } (1994-2018)}{\textbf{EIU World Real GDP \% Change } (2019-2023)}$$

The expected loss rates with qualitative factors are then adjusted for each BCL as the greater of the product of Expected Loss Rate and Global Economic Growth Percent Increase to Loss Rate or the Minimum Loss Rate.

Probability of Default Curves

PD curves are defined by the mean and standard deviation of the defaulted transactions' age at time of default. Separate curves are created for LT and MT transactions.

Dollar Loss Reserve Estimation

This section describes how the value for adjusted expected loss is used to calculate a dollar loss reserve amount. We were able to replicate the data input and cleaning process, where raw data was available, and reproduce the FY 2018 upward reestimate of approximately $146.3 million for the exposure of commitments between FY 1992 and FY 2018 with a non-material difference in the Medium-Term Guarantees FY 1992 cohort. This number is ultimately used to determine the dollar loss reserve appropriate for the Bank.

Loss Reserve Model Inputs

The table below lists the datasets used to produce the dollar loss reserve estimate and whether we were able to successfully replicate them. As the table shows, there were several worksheets that we could not replicate due to limited access to the raw data. However, of the sheets replicated, we were able to confirm the process is reasonable with few minor discrepancies described in Table 6, below.

Table 6: FY2018 Reestimate Model Inputs Replication

Workbook	Worksheet	Replicated?
FY 2018- 1) Portfolio Download	TB11	**Not replicated.** Out of scope[18]
	1) Portfolio August Closing	**Not replicated.** Out of scope
	High Risk	**Not replicated.** Out of scope
	Currencies	**Replicated.**
	Loan Rate	**Replicated.**
	Take-Out Options	**Not replicated.** Out of scope
	Interest Rate	**Replicated.**
	FMS Recon	**Not replicated.** Out of scope
FY 2018- 1.5) Portfolio Download - FC	FC	**Replicated.**
	Calculation – Garman Kohlhagen	**Reviewed.**
	Default Stream Adjustment – GK	**Replicated.**

[18] Note that the Team was not expected to validate the data extraction, transfer, or load processes, as it was deemed out of scope. Thus, the "Not replicated. Out of scope" designation does not imply a failure in the Process' replicability, but rather is noted when we were given archived versions of the file or data at the start of the replication.

Workbook	Worksheet	Replicated?
	Risk Free Rate Table	**Reviewed.**
	Exchange and Vol	**Replicated.**
	RFR	**Not replicated.** Out of scope
FY 2018- 2) Portfolio Download – Undisbursed Disbursed	Total	**Replicated.**
	Disbursed	**Replicated.**
	Undisbursed	**Replicated.**
	CF	**Replicated.**
	ICRAS	**Replicated** with a minor exception of the Probability of Default Estimation associated with BCL's 10 and 11.
	FC Rates	**Replicated.**
	Disb. Pattern	**Not replicated.** Unclear where data is derived from.
	EIU Country Ranking Data	**Not replicated.** Out of scope
	Int Rate and BCL	**Not replicated.** Out of scope
FY 2018- 3) FY Cohorts – Summary & CSC2 Input	LTL	**Replicated.**
	LTG	**Replicated.**
	MTL	**Replicated.**
	MTG	**Replicated** with minor exception of FY 1992 cohort.
	MTI	**Replicated.**
	STI	**Replicated.**
	Authorizations	**Not replicated.** Out of scope
	All Dis	**Not replicated.** Out of scope
	Cohort Summary	**Not replicated.** Out of scope
	Interest	**Not replicated.** Out of scope
	Inputs	**Not replicated.** Out of scope
	SEDR	**Not replicated.** Out of scope
	Historical	**Not replicated.** Out of scope
FY 2018- 4) Summary by Account	83X4161	**Replicated.**
	83X4162	**Replicated.**
	Calculation for JE	**Replicated.**

Marginal Defaults, Recoveries, Fees, and Disbursements

Marginal default and marginal recoveries are calculated for each FY in the life of the transaction. A disbursement amount and fee amount are also calculated for the transaction.

CSC-Formatted Cash Flows

Disbursements, fees, marginal default and marginal recoveries are formatted into a CSC compatible cash flow. The CSC discounts the cash flows produced in the previous step, and outputs CSRs broken down into financing, default, fee, and other subsidies. The CSC also produces NPVs for each of the subsidy components.

Loss Reserve Amount

The dollar loss reserve amount is equal to the NPV of the default subsidy component.

Appendix D: Distribution List

Kimberly Reed, President and Chairman
Jeffrey Goettman, Executive Vice President and Chief Operating Officer
David Slade, Senior Vice President and General Counsel
David Fogel, Senior Vice President and Chief of Staff
Lauren Fuller, Senior Advisor to the President and Chairman
David Sena, Senior Vice President of Board Authorized Finance
Kenneth Tinsley, Senior Vice President and Chief Risk Officer
Patricia Wolf, Controller, Vice President Controller
Cristopolis Dieguez, Director, Internal Controls and Compliance
Anthony Curcio, Principal, Summit Consulting LLC
Mark Hutson, Manager, Summit Consulting LLC
Tori Puryear, Consultant, Summit Consultant LLC
Julian Henry , Senior Analyst, Summit Consulting, LLC
Parisa Salehi, Acting Inspector General, OIG
Amanda Myers, Attorney-Advisor, OIG
Courtney Potter, Acting Deputy Assistant Inspector General for Audits and Evaluations and Manager, OIG
Lilith Sanchez, Senior Inspector, OIG

Office of Inspector General
Export-Import Bank *of the* United States
811 Vermont Avenue, NW
Washington, DC 20571
202-565-3908
www.exim.gov/about/oig