Reproducibility Standards for Economics

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1 Project Overview

1.1 Project Summary

The Economics profession needs to catch up to other technical fields in software development, reproducibility practices, and "exchangeability" of results.

To that end, Econ-ARK has been working for several years on the REMARK project, a set of standards and tools for reproducibility for computational modeling in economics. REMARK are self-contained and complete projects whose contents should be executable by anyone on any modern computer (local or cloud), so long as the platform has the necessary hardware (generically described). A critical aspect of REMARK is the emphasis on clear documentation, testing procedures, and standardized metadata to ensure that research outputs are reproducible, easily understandable, and reusable.

The design specs of the REMARK standard have been crafted with the collaboration of the editor of a projected journal that would require all submissions to abide by the REMARK standard.

While we have solved most of the computational challenges (using the blossoming ecosystem of tools including Docker containers, version control, etc.), one piece of the infrastructure needed to complete the specification is still lacking: A robust, reproducible, and portable standard for the production of the text of the paper (or other research product) that can directly integrate reproducible content.

The project sponsored by FossProf allowed us to hire an open-source contractor, Curvenote, to fill in some crucial gaps required to translate the standard medium of technical writing, $\LaTeX$, to the new world of lightweight, reproducible content. The bulk of the other FossProf funding allowed some JHU PhD students to create new examples of REMARKs that use these tools.

1.1.1 A brief history of REMARK

The REMARK project started as a means to enhance the sharing and reproducibility of research that utilized the Econ-ARK's HARK toolkit. As the development of [HARK] was guided mainly by active research, it was essential to expand the codebase and integrate the code with the documentation and drafting of academic manuscripts. In economics, however, the standard practice is to treat the research manuscript and code as entirely separate entities, with the code being used as a tool to generate results that are posted in the manuscript but then relegated to a `.zip` file attached to the published paper. This practice is inconvenient

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for researchers and limits the ability to reproduce and build upon previous work, setting back the field of Economics.

Recognizing the need to integrate scientific software development with the publication of research, Econ-ARK began working on the REMARK standard to make the models and results from the toolkit easy to share. As the project grew, it became clear that REMARK could be helpful for the broader Economics community.

1.2 Target Audience

REMARKs origins are deeply rooted in the field of Economics, and it primarily targets students, researchers, and practitioners interested in reproducibility and open economic science. However, this project is not limited to the field of Economics and is intended to be a valuable resource for any field that uses scientific publishing technologies. As we have worked on the REMARK standard, we have recognized the broader need for reproducible research practices in Economics and the broader Computational Social Sciences, where practitioners are increasingly interested in catching up to the standards set by open source software in other fields.

1.3 Code Repository

This project is a collaboration between the Econ-ARK team and Curvenote. The REMARK standard can be found at the REMARK GitHub repository, but much of the code generated during this project has been integrated into the MyST project.

> **Tip**
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> - The R[eplications/eproductions] and Explorations Made using ARK project is publicly available on GitHub.
> - This project led to many contributions to the MyST project, which provides a collection of tools for working with MyST Markdown. MyST is part of Project Jupyter and is open source and publicly available on GitHub.

2 Project Activities and Progress

2.1 Work Completed

The primary goal of this project was to engage with and integrate the MyST Markdown tools into the REMARK project to expand the range of tools available for the standard. To do this, we identified three existing REMARKs that showcased current gaps in the open-source tooling for typesetting and integrating reproducible results directly into a REMARK. Through these examples, we prioritized our contractors, Curvenote (who are core MyST developers and members of the steering council), and identified efficient ways to integrate MyST into REMARK.

We also worked with some Johns Hopkins Economics PhD students to produce REMARKs of their projects, providing feedback on the REMARK standard and showing how REMARK can produce high-quality, reproducible research.

Lastly, we gave a presentation of the REMARK project at the 30th International Conference for Computing in Economics and Finance, where we engaged with many students and researchers interested in open source software for reproducible research and advocated for the adoption of REMARKs as a standard for reproducible research in Economics.

2.1.1 Collaboration with Myst/Curvenote

Throughout the project, we used the following issue to track our progress:

- REMARK #152: Improvements to MyST Markdown

This issue tracks the many contributions to the MyST project that were supported by this grant. A primary focus of this work was the extension of MyST markdown to support the translation of LaTeX syntax into MyST markdown.

Among economists, the use of LaTeX is ubiquitous, and many researchers are deeply invested in the existing LaTeX environment. For this reason, we wanted to make the REMARK standard more flexible and accessible to adopt and provide easy entry points for integrating reproducible, interactive, and computational content.

2.1.2 Student generation of REMARKs

We used this grant to support the work of three Johns Hopkins University PhD students, [John Green], [Adam Edwards], and [Ashish Kumar], in the Department of Economics, for the development of REMARKs of their projects.

Engaging with students to produce REMARKs allowed us to gather feedback on the standard and to improve the documentation and tools available to researchers. Moreover, it will allow these students to produce high-quality, reproducible, and portable research that can be used as part of their job market and portfolio materials. We hope this will lead to more visibility and exposure for their research.

2.1.3 Presentation of REMARK project at CEF 2024

At the 30th International Conference for Computing in Economics and Finance, hosted by Nanyang Technological University in Singapore, we gave a presentation on the REMARK project and engaged with many students and researchers interested in open source software for reproducible research.

A Letter from President Lilia Maliar

This year, we introduced two new events: a lunch workshop by Christopher Carroll (Johns Hopkins University) and Alan Lujan, and a career workshop organized by Giulia Iori (Ca 'Foscari University of Venice). The lunch workshop, "A (Working) Platform for Reproducible Research", was well received with about 20 attendees. It discussed a platform developed by Christopher Carroll and co-authors to promote the reproducibility of research in economics. The career workshop, organized

Figure 1: *
An excerpt from A Letter from the Society for Computational Economics President Lilia Maliar describes the REMARK project presentation at the 30th International Conference for Computing in Economics and Finance. This screenshot was taken from the SCE website.

The presentation consisted of introducing the REMARK standard, showing off the capabilities of REMARKs through a demo, and discussing the benefits of reproducibility in the Economics community.

After the presentation, we received feedback from researchers who were very interested in the REMARK standard and were particularly eager to introduce their students to the newly developed tools. We would love to take this presentation and workshop on the road and introduce REMARKs to the next generation of economists.

Figure 2: *
A recap of our presentation at CEF 2024 and a discussion of REMARKs with the OpenSource.Science Economics interest group.

2.2 Technical Milestones

A significant milestone of this project was the expansion of MyST compatibility with the LaTeX syntax. Many existing REMARKs are written in LaTeX, and it is critical to ensure backward compatibility and

the ability to refresh existing REMARKs with new MyST capabilities, including rich cross-references, hover previews, and integrated computation. Although we have not yet reached the goal of complete backward compatibility, we have made significant progress in this area and have made it easier to transition to the new standard. This work will continue in the future, and we welcome contributions from the open source community to help us reach this goal.

Second, we started work on a `remark` command-line-interface tool that can be used to generate REMARK templates and check them against the REMARK standard. This tool also includes functionalities for building environments and running reproducibility scripts.

Third, we have continued to expand the catalog of existing REMARKs, including several new REMARKs of student projects and active research projects both within and outside Econ-ARK.

2.3 Challenges and Solutions

3 Outcomes and Impact

3.1 Project Impact

The overarching objective of REMARK is to improve the reliability and trustworthiness of scientific findings within fields heavily reliant on computational methods. By promoting the use of standardized tools and workflows, REMARK aims to make computational research in economics and social sciences more transparent and reproducible.

REMARK encourages the adoption of best practices in software development, documentation, and manuscript preparation within the economics community, which has traditionally lagged behind other computational fields. Our goal is to facilitate knowledge sharing and collaboration, reduce duplication efforts, and accelerate the dissemination of knowledge within the field.

3.2 Community Engagement

Our team primarily engaged with the main developers of the MyST project through consultants at Curvenote. We set up a weekly meeting where we discussed our needs for the REMARK project and suggestions for improving the MyST project itself. The team at MyST/Curvenote is incredibly experienced and connected with the open science and publishing communities, and we have learned a lot from them.

Additionally, we advocated for the use of reproducibility standards at the 30th International Conference for Computing in Economics and Finance and at the OpenSource.Science Economics interest group. We met with many students and researchers interested in open source software for reproducible research and advocated for the adoption of REMARKs as a standard for reproducible research in Economics.

3.3 Sustainability and Future Plans

3.3.1 Renaming the project

The need for REMARK arose from our desire to make our own research more reproducible and share our work with others. However, our engagement with the broader community has highlighted the need for reproducibility standards beyond our application and field. Currently, REMARK stands for "R[eplications]/[eproductions] and Explorations Made using ARK," clearly linking it to the Econ-ARK project. This close association can be perceived as a limitation, creating confusion and potentially hindering broader adoption.

To address this issue, we have discussed internally the need to rename the project into **"SCI-PASS"**, which stands for "Scholarly Communication Infrastructure for Publishing and Archiving Scientific Software." This name change signifies a strategic shift toward establishing a more universal and inclusive standard for reproducible scientific software. Moreover, it clearly communicates the project's purpose and intended scope, eliminating the misconception that it is solely tied to Econ-ARK or Python. This language-agnostic standard has the potential to attract a broader range of researchers and institutions, fostering greater collaboration and advancing the practice of reproducible research across disciplines.

It is important to note that renaming REMARK is not merely a cosmetic change but rather a crucial step toward building a robust and sustainable ecosystem for reproducible research. The evolution of the project

involves developing a comprehensive roadmap for implementation, which includes overcoming technical obstacles, establishing clear metadata guidelines, and creating user-friendly tools and resources to facilitate broad applicability and adoption. Additionally, we will continue actively engaging with the scientific community to promote the standard and foster collaboration, including establishing communication channels with journal editors, data editors, and researchers from diverse fields. In essence, "SCI-PASS" represents a pivotal step toward achieving the project's ambitious goals of promoting and standardizing reproducible research practices across the scientific community. As such, we also consider "SCI-PASS" to be short for "scientific passport," a term that encapsulates the idea of portability and exchangeability of research outputs.

> **Important**
> **SCI-PASS** stands for:
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> 1. *Scholarly Communication Infrastructure for Publishing and Archiving Scientific Software* - a new name for the REMARK project to better reflect its scope and potential for broader adoption.
> 2. *Scientific Passport* - enables scientific software to be portable across different environments.

3.3.2   Adapting to Evolving Research Practices

To succeed, the REMARK/SCI-PASS project must embrace modern publishing technologies. As we recognized the limitations of LaTeX, this grant helped us integrate modern scientific publishing tools like Jupyter Notebooks and MyST Markdown. This shift toward the Jupyter ecosystem is intended to enhance user-friendliness, interactivity, and accessibility for researchers. In the long-term, we aim to further integrate with open science infrastructure, such as established open science publishing platforms for peer-review and publishing like Open Journals and The Journal of Open Source Software.

While REMARK currently focuses on `python` software, we are committed to expanding language support to accommodate the diverse set of tools used in computational research. This expansion aims to broaden the project's reach and applicability across disciplines. Moreover, the project's long-term sustainability depends on active community engagement, which includes collaborating with journal and data editors, organizing workshops and tutorials, and establishing an independent board of advisors with expertise in computational science, library science, and relevant research domains. By embracing these adaptations, the REMARK/SCI-PASS project aims to evolve into a robust and sustainable standard for reproducible research, aligning with evolving practices and solidifying its place within the future of open science.

3.3.3   Taking REMARK/SCI-PASS on the road

This grant allowed us to host a workshop at the 30th International Conference for Computing in Economics and Finance in Singapore, where we discussed open science, reproducibility, and the REMARK standard. The experience and feedback we gathered were incredibly valuable, and we are eager to take the project on the road to more conferences and events. Below, we describe a few of the ways in which we plan to advocate for open science and reproducibility:

1. **Replication Competitions** - Competitions where researchers are challenged to replicate the results of notable papers, which will provide a practical demonstration of the REMARK standard and incentivize adoption.

2. **Tutorials and Workshops** - Target students and researchers to provide hands-on experience using our tools, demonstrating how to create reproducible research outputs and highlighting the advantages of open science.

3. **Talks** - Engage with journal editors and data editors to seek feedback and collaboration to understand better how our project can streamline the review process, ensure reproducibility, and enhance the credibility of published research.

The REMARK/SCI-PASS project can expand its reach and encourage wider adoption by combining these outreach efforts.

4   Financial Information

4.1   Grant Expenditures

> **Attention**
> Please see the attached Financial Report for a detailed breakdown of how the grant funds were used.

The majority of the funds were used to contract with Curvenote to integrate the MyST tools into the REMARK project. We also supported the work of three Johns Hopkins University PhD students over the summer of 2024 to produce REMARKs on their ongoing research projects. Finally, we hosted a workshop at the 30th International Conference for Computing in Economics and Finance in Singapore and used the remaining funds for travel and lodging.

Acknowledgments