Memo on Econ-ARK's Plans for a Modeling Language — September 20, 2024

Overview: Econ-ARK is developing a *modeling language* for representing dynamic structural models. We are seeking funding from the Alfred P. Sloan Foundation to help support our work. This memo summarizes what we've done so far and what we're trying to do next.

What Econ-ARK Has Done: Our progress since founding in 2016 is summarized here. Our primary software output is HARK, a Python package for solving and simulating heterogeneous agents (HA) macroeconomic models.

- HARK is a framework for HA models that makes it easy to add or change *ex ante* heterogeneity among agents, in both infinite horizon and lifecycle frameworks.
- You can install it from the command line (`pip install econ-ark`) or see a gentle introduction here.
- Includes representations of variations on the canonical consumption-saving problem, including: shocks to marginal utility of consumption, a second consumption good with random marginal utility, aggregate productivity shocks, an exogenous discrete state, endogenous labor supply, portfolio allocation, non-normalizable income processes, etc.
- Also has a framework for representing (and solving for) equilibrium conditions in HA models, using a generalized Krusell-Smith-style algorithm.
- Can be used outside of typical HA macro, e.g. endogenous pricing of health insurance.
- Has tools for discrete-continuous choice models, with an example implementation.
- Recently begun integrating with the SSJ toolkit to enable analysis of (e.g.) HANK models in HARK.
- Models are *documented* to explain what they mean/do, but these equations (etc) are not *encoded* in HARK itself. That's what we're going to change with this grant.

Econ-ARK has also designed the REMARK structure for archiving research projects and reproductions of other papers that use HARK. This grant application is not about REMARKs. You might be interested in the reproductions of Jeppe Druedahl's guide to non-convex consumption-saving models, the deep learning method from Maliar, Maliar, & Winant (2018), and Alan Lujan's EGM^n method notebook.

What We're Trying to Address: In broad terms, our organizational focus is on reproducibility and robustness in economic research. We don't think there's a "replicability crisis" *per se*, but we want to address the following significant issues related to replicability:

- Exact model specifications, and especially computational and numeric details of the solution and/or estimation method, are not well communicated in published research.
- Potential dependency of economic conclusions on "hidden choices" is often obscure.
- Implementation details might be in online appendix, or only in the code itself.
- Impact of these details on conclusions is not really probed in the refereeing process.
- Reproducing or replicating someone else's project often "starts from zero".
- There is no easy way to directly compare two implementations of the same project or idea, and even verifying that two things are tackling "the same" problem is difficult.

What We're Going to Do: Econ-ARK's proposed solution is a new language for unambiguously specifying both the precise mathematical structure of a model *and* the methods and approximations used to numerically solve the model and generate output from it.

- A lot like DYNARE for a (much) wider class of models: feature set broad enough to be used for HA macro, dynamic structural microeconomics, industrial organization, etc.
- DYNARE model file contents are strictly informed by DYNARE software capabilities: can only specify model features that the package is capable of handling.
- New modeling language *not* tied to any particular software. Meant to be common/shared way to precisely represent models *across* solution methods or software packages.
- Large feature set informed by iterative feedback from working group of experts in the field. If language can't describe a feature they want, then it needs to expand.
- Will organize a workshop to present preliminary version of the language to a working group and solicit feedback. Funding for this event is requested in the grant.
- HARK doesn't formally represent models internally. Will develop model specification for HARK to inform language design. This will not restrict the modeling language.
- Language will have explicit separation of representation of the "pure mathematical" or "Platonic ideal" model vs computational implementation.
- This grant application is to make HARK "language compatible" as groundwork, establish working group, begin developing modeling language, and hold workshop.
- Completing development of the language exceeds scope of this grant. We have ambitious future plans for what can be done with the modeling language.

What We Want to Accomplish: There are several potential upsides that we hope to achieve with this project, some of which we have explicitly discussed with you. Your letter need not advocate for the proposal, but feel free to use any of these points if you want.

- Economics is not immune to "failure to replicate," and the reasons can be subtle. There are papers whose results were reversed by due to issues with numeric methods.
- Frontier models have features that make solution not "well behaved" (e.g. discrete-continuous choice). "Most interesting" papers might be most susceptible to hard-to-detect numeric complications.
- Even without any new software, a common format for representing choices about numeric integrals, discretized state spaces, etc is a big step in the right direction.
- Greatly reduces burden on reader / evaluator to understand what was *actually done*– the *first prerequisite* to independently reproducing the work.
- Some top journals use a "data editor" who tries to reproduce results in accepted papers, using the authors' own files. Reproduces paper results; does *not* address robustness.
- "Robustness checks" in refereeing focus on model specification, not numeric details.
- Systematic representation / documentation of computational methods (etc) could make it feasible to *actually* investigate whether and how "hidden choices" affect conclusions.
- There is no "standard software" in structural modeling, nor standard *anything*. Other than well known numeric packages (`numpy`, `lapack`), researchers hand code everything.
- Some economists publish toolkits for solving particular types of models or handling a specific method, but there's no commonality among them or way to link them.
- Some software tools are "inherited" from adviser or coauthors; need to be an "insider".
- Some overlap among toolkit capabilities. How does their output compare when given *exact same* problem? Currently no easy way to specify "exact same".
- Includes AI / deep learning platforms not specifically designed for economics.
- Common platform for interacting with multiple toolkits would accelerate research.
- Economists are independent and opinionated. The kinds of economists who will be invited to the workshop have strong opinions about the topic and want to be included.
- Dynamic models are diverse, many with some "unusual" feature. It would not be reasonable for a small team to "get everything" *without significant outside feedback*.