Prof Christopher D. Carroll
Wyman Park Building 590
Johns Hopkins University
Baltimore, MD 21211

James Savage
Schmidt Futures
155 W 23rd St
New York, NY 10011

January 24, 2024

James:

When we last spoke in 2017, the newly founded Econ-ARK project had recently received a generous grant from the Alfred P. Sloan Foundation to develop the HARK toolkit, a software package for solving, simulating, and estimating heterogeneous agents models in economics (either heterogeneous agent macro or structural micro). With NumFocus as our fiscal sponsor, we have since received additional funding from other sources (including the Think Forward Initiative and T. Rowe Price as a "no strings attached" corporate sponsor) to continue the work and expand the range of models offered in the HARK package, allowing us to largely achieve our original set of goals. With this experience underneath our belt, we now see that our next steps involve developing a *language* for expressing dynamic structural models that can specify computational methods, describe simulation procedures, and generate model output. I am writing to you to ask whether Schmidt Futures might be interested in funding this endeavor.

To fix ideas, a structural model would be formalized as a model file: a set of statements characterizing its components, like how a a budget constraint might be captured with a simple equation saying that assets are whatever is left of the consumer's money after consumption: `a=m-c`.

The Dynare package provides a prototype example of the *kind* of thing we have in mind – but it cannot be used or extended for the kinds of models that are now *de rigeur* in both micro and macro modeling due to limitations in its syntax and specification. When discussing or presenting our work on the HARK package, other economists often interpret it through the lens of Dynare, with the hope that we have already built "Dynare for heterogeneous agents." This has left us no doubt that there is a large demand for exactly this sort of tool. With our prior experience implementing `HARK`, and given recent advances in other software tools, we are now prepared to design and create it.

Prior to beginning work on the new platform, we conducted a thorough search of *other* academic fields, investigating whether a general dynamic modeling schema has already been developed. Having explored all the nooks and crannies of the internet, we are confident that there is no comparable or related project that could be adapted or expanded for our purposes. We found that the universe of modeling- and optimization-adjacent software is both diverse and diffuse: We found many of the building blocks necessary to accomplish our goal, but no schemes for putting the building blocks together into anything like what we need. The lack of a common platform for representing dynamic models is akin to the lack of cohesion among the various artificial intelligence (AI) and deep learning toolkits that have recently been developed. Translated into that context, the AI equivalent would be a language that described the AI problem to be solved in a platform-independent way, allowing a user then to solve exactly the same model with each of the competing AI tools. (The problem is even more ambitious in that context than in ours, but what we accomplish might be a good stepping stone toward a platform-independent AI tool.)

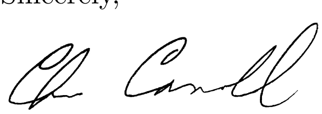
In addition to the technical value of this work, it will also significantly improve the transparency and replicability of structural economics research. Behind closed doors, everyone who works on these kinds of models admits (and laments) what they know to be true: Everyone's results depend on a host of ancillary assumptions – how many gridpoints to use, how many agents to simulate. While it is now expected that researchers will publicly archive their code, for many projects the code might as well be written in Klingon (so far as accessibility and transparency and replicability are concerned).

Moreover, even if an economist were so inclined, there is no standard for how the computational instantiation of the model should be described. Even worse, there is no direct relationship between the model as expressed *on paper* and the problem as solved *in code*– the academic refereeing system focuses deeply on the economics of the abstract math, and relies on trust with respect to the numerics. Indeed, there are famous examples of papers that have been published based on their strong economic content, but whose quantitative (and sometimes qualitative) results were later discovered to be based on errant code.

Our proposed modeling language aims to rectify these systemic issues with the workflow of economic research that uses dynamic structural models. If a model specification file is used to generate a numeric solution and model output, a reader or evaluator can be confident that the model presented on paper matches its execution in code. Furthermore, our language will include a format for specifying the methods used to solve the model numerically, transparently conveying this information alongside the "pure" mathematical content of the model. The software platform can thus act as a vehicle for evaluating the performance of a numeric solution to a theoretical model.

Our proposed platform will accelerate the development of models on the frontier of economic research, allow for the verifiability of numeric output from such models, and improve communication and collaboration among researchers. In addition to academic work, the platform would be of significant use both to governments (including central banks and financial regulators) in conducting prospective analyses of potential policy actions, and to private financial institutions who wish to make decisions or provide advice that is informed by a structural model (e.g. a model of optimal retirement savings). In developing the language and the software platform, we will seek out input from a variety stakeholders to ensure that their modeling needs are met.

Sincerely,



Christopher D. Carroll,
Professor of Economics