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Danny Goroff
The Alfred P. Sloan Foundation

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Danny (and other interested parties):

When the Econ-ARK project's generous founding grant from Sloan to develop the HARK toolkit was nearing its end, your emphasis that Sloan's ambition was to fund the startup period of projects that would eventually be able to make their own way in the world was something we took seriously. So seriously, in fact, that we did not apply to Sloan for a renewal of the grant.

We have since received about \$750K in additional funding from other sources (including the Think Forward Initiative and T. Rowe Price as a "no strings attached" corporate sponsor through NumFocus) to continue that work and expand the range of tools and models offered in the HARK package. We have now largely achieved our original set of goals. But with this experience underneath our belt, we now see that the next steps involve developing a *language* for expressing dynamic structural models. Such a language would specify computational methods, describe simulation procedures, and generate model output. I am writing to you to ask whether Sloan 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 budget constraint might be captured with a simple equation saying that assets are whatever is left of the consumer's money after consumption: $a = m - c$ (of course much more sophisticated mathematical propositions would also be accommodated). The language (or perhaps a better term would be schema) will provide a common format for describing dynamic structural models and will convey model content in a human- and machine-readable way that is independent of the code to actually solve and implement the model. As we develop the schema, we would simultaneously build a software platform to parse the model file into the implied code (though nothing would prevent someone else from inventing a better software platform in the future).

The Dynare package provides a prototype example of the *kind* of thing we have in mind, but limitations in its syntax and specification mean that it cannot be used or extended for the kinds of models that are now *de rigueur* in both micro and macro modeling. When explaining our work on HARK, we have found that 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 such a 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 elsewhere. 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.

This work 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, etc. 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). 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 wrong as a result of coding errors.

Our proposed modeling language aims to rectify these systemic issues with the workflow of economic research. 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.

Our sense is that, among potential funders, Sloan would be the best fit.

Thanks for your time and consideration in this matter.

Sincerely,

A handwritten signature in black ink, appearing to read "Ch Carroll". The signature is fluid and cursive, with the first name "Ch" and last name "Carroll" clearly distinguishable.

Christopher D. Carroll, Professor of Economics, Johns Hopkins University