



# The ETACE Virtual Appliance: An Exploratory for the Eurace@Unibi model\*

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## Abstract

This paper presents the ETACE Virtual Appliance. The purpose of the software package is, among others, to provide researchers the possibility to explore the dynamics of the Eurace@Unibi agent-based macroeconomic model and to encourage the reproducibility and transparency of research. The package contains various components that allow the user to initialize, simulate and analyze the model. We also give a short overview of what can be done with the ETACE Virtual Appliance.

**Keywords:** Virtual Appliance, Eurace@Unibi Model, Agent-based Macroeconomics, Simulation Framework, Reproducibility, Open Science.

*"We work best when we work together."* – Neelie Kroes, 2013

## 1 Purpose

Recent developments in the area of agent-based economics have raised voices calling for the opportunity not only to provide the source code of agent-based models (ABMs) but also to provide a simple and user-friendly solution to experiment with these and analyze the results easily. In the light of its various dependencies, the Eurace@Unibi model, a model of the class of large-scale ABMs, has yet been far too complex to be portable. For this reason we created the **ETACE Virtual Appliance**. It enables the public as well as scientific collaborators to set up, run and visualize experiments in a straightforward fashion.

The Appliance is a stand-alone Linux-based simulation platform that provides a full suite of programmes for (large-scale) agent-based modeling and simulation. It is built around the core Flexible Large-scale Agent modeling Environment (FLAME), with additional programs such as graphical user interfaces including an editor for agent-based model design and an integrated solution for data visualization using R.

The intention behind the software package is to make every step related to the initialization, simulation and analysis of the model as simple as possible. A list of versions of the model that are included can be found in Section 2. It serves multiple purposes: (i) to ensure the reproducibility and transparency of results, (ii) to serve as a form of model documentation and model communication, and (iii) to increase the credibility of the model. These points will be discussed in more detail below.

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## How to get the package

Installation is easy and straightforward. We provide an **installation guide** that will lead the user through the necessary steps. The package can be **downloaded** from our servers. Finally, the appliance also includes a user guide, that can be downloaded from the website as well.

The Virtual Appliance is provided **as is**, without any warranty that it will work. We **do** however appreciate any remarks, comments, or suggestions for improvement and would appreciate any and all feedback on the following e-mail address: [etace@wiwi.uni-bielefeld.de](mailto:etace@wiwi.uni-bielefeld.de)

## 2 Why did we create it? The model communication problem and a tentative solution

A particular challenge for the research community of agent-based computational economics is to create computational models that satisfy the current best-practice in scientific computing. The problem is that the domain experts have been trained as economists, not as computer scientists. Hence, they often lack the basic computer engineering skills to develop professional-grade programs. Today's agent-based models are created either by single individuals, as is typically the case for small-scale PhD research projects, or by a group of people involved in a joined research project, as is typical for large EU-funded projects.<sup>1</sup>

The models that come out of such research projects are developed on various platforms (Mason, Netlogo, RePast, Flame, Matlab, Scala, LSD), and the source code is written in a host of different programming languages and paradigms (C, C++, Java, Haskell, Julia, Python). This means that the source code of one model cannot be easily compared to that of another. It is clear that with so many different languages and platforms it is hard for any single person, or even for a single research group, to be proficient in all of these languages.

This raises the issue of the communication problem. Not only do we want to communicate our research ideas and modeling concepts, we sometimes also would like to share our innovations in terms of the whole laboratory. Or, in other words, we would like to provide the possibility to run the model in order to study its behavior and the emergent phenomena. This is an integral point of our work, since one essential motivation behind agent-based modeling is that these phenomena do not result from the source code in an obvious fashion and as such are not trivial to see. To paraphrase the great Dr. Martin Luther King: A model should not be judged by the language it is written in, but by the content of its character.

We would like to emphasize that the release of the ETACE Virtual Appliance does not imply that we want to suggest the FLAME modeling framework as the only, best, or optimal solution for agent-based modeling. On the contrary, we would like there to be a wide variety of platforms to choose from. We do not advocate there to be a single, one-fits-all platform on which any and all ABMs should be able to run out-of-the-box. Different platforms serve different functions, and having a variety of tools is always better than having a single, large, clunky all-encompassing tool.

There seem to be indications that the functional programming paradigm (Python, Haskell, Julia, Scala) or object-based programming languages (C++, Java, ...) might suit the purpose of agent-based modelers better than imperative programming (such as C or R). However, also here one must be careful not to rush to conclusions. There are also cross-cutting combinations,

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<sup>1</sup> Some examples of large EU-funded projects that involved agent-based economic modeling since 2005 are: Complex Markets (2005-08), Eurace (2006-09), Finnov (2010-12), FOC-II (2009-13), Crisis (2012-15), and SimPol (2014-17).

for instance Scala is an object-functional programming language, and it is not so clear yet which of the two serves the needs of the agent-based modeling community best.

In our opinion the situation will already be much improved – and model comparisons will be helped tremendously – if, in addition to the source code, also the platform on which the model can be run out-of-the-box is made available to the research community. Also, independence of the operating system is desirable. However, for the purpose of reproducible research, the code and platform are not enough. Also the scripts that are required in order to transform the data that the model produces, are needed. While some of the modeling frameworks begin to enjoy a rather wide-spread use, there is almost no common ground on the processing of data, which is an integral part. Furthermore, the implementation of estimation or calibration procedures based on output data is puzzling and we would like to encourage dialog on these issues. We are convinced that this will strengthen the community.

This is precisely why we have released the ETACE Virtual Appliance. To provide all the code, data and tools necessary to reproduce the results. Another advantage of providing the model plus platform is that it prevents having to re-invent the wheel every time a new ABM is set up. For instance, for a new PhD project that builds on a pre-existing model, the availability of the model source code and platform would provide for a solid foundation for extensions, and further the agenda of Open Science.<sup>2</sup>

## 2.1 Open Science

Realizing that the competitive model of scientific collaboration has broken down, and the cooperative model should be given a try, many organisations support the Open Science initiatives that have sprung up over the last two years. One part of this is the Open Data movement, another part is Open Publications and Open Access, exemplified by the appearance of Open-Access e-Journals.<sup>3</sup>

Stodden (2010) summarizes a round-table discussion held in 2009 at the Yale Law School on the reproducibility of scientific results, especially with reference to scientific computing.<sup>4</sup> The reproducibility of research also appears to be the main purpose of the new data journal *Scientific Data*:

”Everyone wants better ways to make research data available and to give more credit to the researchers who create and share data. But for a data set to be widely reusable, scientists need to know how the data were produced and what quality-control experiments were performed. They need access to detailed descriptions of the data outputs, file formats, sample identifiers and replication structure. This is hard work that is often poorly rewarded. As a result, potentially valuable data sets go unpublished, or are not fully released to the public or not described in sufficient detail to permit reuse.” (Scientific Data Website, Accessed: 21.03.2014)

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<sup>2</sup> For more on the Open Science Agenda of the European Commission, see the speech by Kroes (2013)

<sup>3</sup> A search portal is <http://doaj.org/>. In economics, an Open-Access e-Journal is for example <http://www.economics-ejournal.org/>.

<sup>4</sup> See <http://www.stodden.net/RoundtableNov212009>

### 3 Content

The software package is based on the SliTaz distribution of free software, which includes the Linux kernel.<sup>5</sup> The core of the ETACE Virtual Appliance consists of the following programmes. To view the model and its agents, functions, messages, etc., use the **FLAME Editor**. This gives an overview on how the model mechanics work. It also provides a stategraph diagram that shows graphically how agents interact. Technically, it generates model.xml files, the XML description of the model. To generate initial data use the **Population GUI**. This can also be used to view or edit pre-existing population description files. The integral part for experiments is the **Simulation GUI**, it can be used to set up the simulation and specify which variables should be plotted, providing a range of different diagrams. Furthermore, the following programmes come pre-installed including their dependencies:

Xparser : Parser for Flame models.  
Libmboard : Message board library for Flame models.  
Xparser GUI : Wrapper GUI for Xparser to parse Flame models and compile using gcc.

Pre-compiled versions of the following models are currently included:

Dawid et al., 2011 : full source code of Eurace@Unibi v1.0  
Dawid and Gemkow, 2013 : main, model.xml, 0.pop and 0.xml for replication  
Dawid et al., 2013 : main, model.xml and 0.xml for replication  
Dawid et al., 2014 : main, model.xml and 0.xml for replication

The relevant documentation for all these programmes and a step-by-step user guide is included in the software distribution.

### 4 Conclusion

The ETACE Virtual Appliance is an "Exploratory" for the Eurace@Unibi model and its variants. The software package was developed not only such that the community can study the source code, but also to allow for experimentation with the model and to study its dynamics. The user can now critically assess the published features of the model, such as its stability or robustness with respect to parameter values. Hence the Virtual Appliance not only allows for the reproducibility of results, it additionally creates transparency and credibility. As such, it is a proof-of-concept for providing a unified solution to the model communication problem. It provides a versatile tool for academic use that could also be used for policy analysis and scenario testing. We would like to encourage the community of agent-based modellers to follow this example and provide tools that enable easy experimentation and replication of their results.

#### Links to Websites

1. ETACE Virtual Appliance Website (Accessed: 21.03.2014); ETACE Virtual Appliance Download (Accessed: 21.03.2014): [http://www.wiwi.uni-bielefeld.de/lehrbereiche/vwl/etace/Eurace\\_Unibi/Virtual\\_Appliance](http://www.wiwi.uni-bielefeld.de/lehrbereiche/vwl/etace/Eurace_Unibi/Virtual_Appliance)
2. Virtual Appliance, Wikipedia page (Accessed: 21.03.2014): [https://en.wikipedia.org/wiki/Virtual\\_appliance](https://en.wikipedia.org/wiki/Virtual_appliance)

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<sup>5</sup> The corresponding documentation of SliTaz is included in the ETACE Virtual Appliance or can be found at: <http://www.slitaz.org/en/>.

3. SliTaz Distribution Website (Accessed: 21.03.2014): <http://www.slitaz.org/en/>
4. Flame Framework Website (Accessed: 21.03.2014): <http://www.flame.ac.uk>
5. Oracle VM Virtual Box Website (Accessed: 21.03.2014): <https://www.virtualbox.org/>
6. Oracle VM Virtual Box, Wikipedia page (Accessed: 21.03.2014): <https://en.wikipedia.org/wiki/VirtualBox>

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