Chapter 12 Exercise Hints and Solutions

Agent-based and Individual-Based Modeling: *A Practical Introduction, 2nd Edition*

The Excel workbook used to produce figures 12.4 and 12.5, and the contour plots, is provided with the instructor materials (`Ch12_Fig12.3-7_ExcelFile_2ndEd.xlsx`).

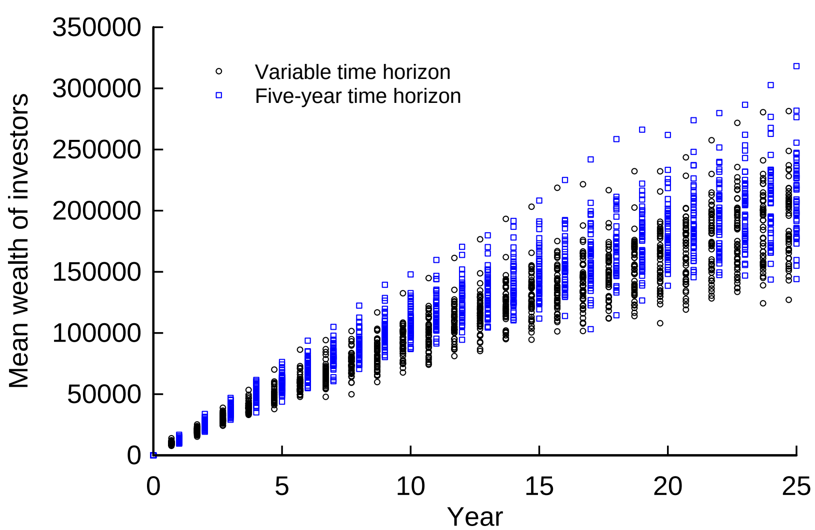
Exercise 1

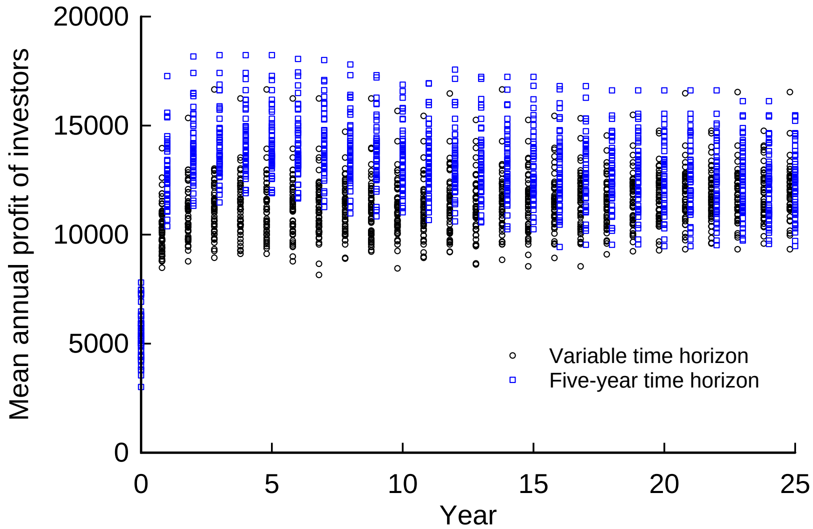
Students can develop a hypothesis of how investors will behave if their time horizon is the year after the simulation ends by using the contour plots of the existing utility function. They can compare how utility varies with risk and profit (a) at the start of a simulation when wealth is low and the time horizon is long (see Figure 12.7) and (b) near the end of 25 years when wealth should be high and the time horizon short (more like Figure 12.6).

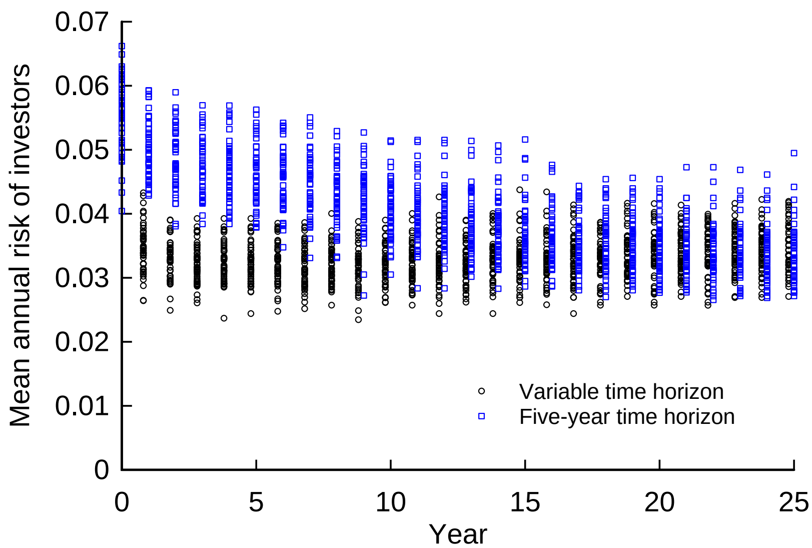
There are two competing processes as time goes by. Most investors get wealthier, which makes them more averse to risk (discussed in Section 12.4). But the shrinking time horizon makes investors less concerned about risk (compare figures 12.6 and 12.7, though it is best to examine the effect of time horizon when wealth is higher). And keep in mind that many investors fail and start over with low wealth at least once in the 25 years.

This utility function is implemented in `BusinessInvestors_Ch12-Ex1_2ndEd.nlogo`, provided with instructor materials. Implementing it requires changing the simulation time from 50 to 25 years, initialize the global variable for time horizon to 26, and adding a statement near the beginning of the go procedure to reduce the time horizon by one on each tick.

The following graphs show example results: they display separate points for each year of each of 50 replicates of two scenarios: a fixed 5-year time horizon and the variable horizon described in this exercise. The overall effect on wealth is small, while the variable time horizon makes investors use lower-risk, lower-profit patches early in the simulations.




20000
15000
10000
5000
0
Mean annual profit of investors
0
5
10
15
20
25
Year
Variable time horizon
Five-year time horizon


0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Mean annual risk of investors
0
5
10
15
20
25
Year
Variable time horizon
Five-year time horizon

Exercise 2

The Excel file `Ch12_BayesianUpdatingTrait_2ndEd.xlsx` provided with the instructor materials is equivalent to Figure 12.8. It should be clear from experimenting with it that estimated risks do not converge rapidly to accurate values, for risks both high and low compared to the mean. Instead, estimated risks stay close to their initial value, so investor decisions will be less sensitive to risk. The failure to converge on an accurate estimate of risk is because the risk values are all relatively low probabilities, so failure events are rare. Over 25 years, there are not enough failure events to making the Bayesian estimate converge on an accurate value. (Try the experiment again assuming risk is in the range of, for example, 50-80% per year, or using 100 years instead of 25.)

It appears that Bayesian updating is not well suited for estimating probabilities of rare events over short time periods. This is not because the method is flawed; there is just no way to estimate low probabilities accurately without many observations. But this conclusion does mean that we should be careful using this method in models, and not assume that it will rapidly converge on accurate estimates even if the initially assumed mean and variance are inaccurate.

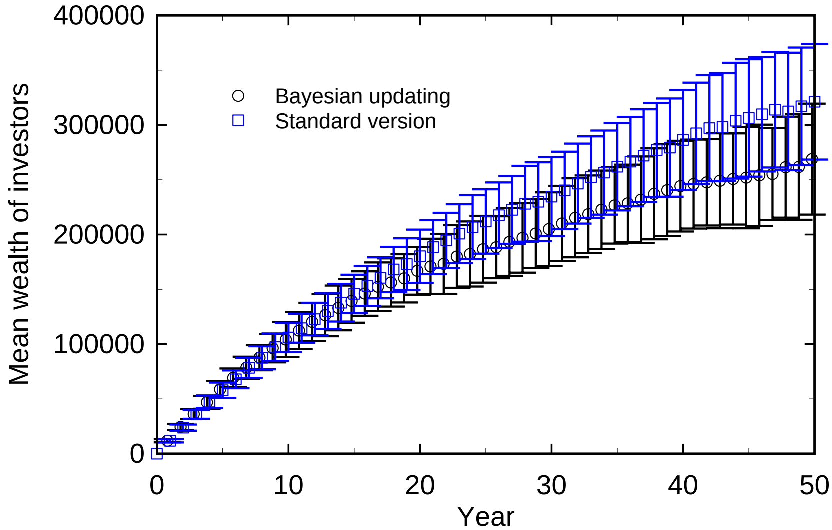
Exercise 3

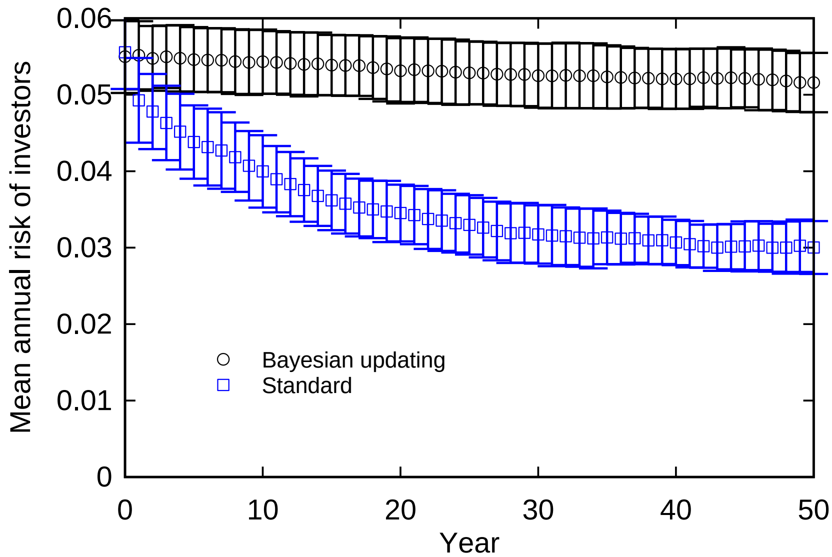
The Business Investor model with Bayesian updating trait for predicting risk at patches is provided as `BusinessInvestors_Ch12-Ex3_2ndEd.nlogo`.

Note that the updating is coded as part of the investors' utility calculation procedure. An investor estimates the current risk at a patch by adding the total number of failures in the patch so far to the initial estimate of α and adding the number of times the patch has been occupied *without* a failure to the initial β.

The NetLogo file includes test output that can be used to check whether the Bayesian updating trait was implemented correctly. This output produces a large file and executes slowly, so comment it out after testing the code.

The results look like the following graph; Bayesian updating to estimate risk produces mean wealth less than that from the standard version of the model that assumes investors know risk accurately. The reason for lower wealth appears to be use of patches with higher risk, presumably because the Bayesian updating approach produces inaccurate estimates of actual risk, especially at patches where risk is relatively low (which are the patches used by investors). Here the error bars represent the standard deviation in wealth over 50 replicate simulations.





Exercise 4

This rather open-ended exercise is intended mainly to help students think more deeply and completely about what the assumptions of models really mean and imply. Many, if not most, agent-based models include agent behaviors that presumably are included because they provide some future benefit to the agents, while a clear link between current behavior and future benefit is lacking. We hope that pointing out such implicit and unclear assumptions will encourage future modelers to think (and write, in ODD) more carefully about why they give their agent the behaviors that they do.