Suggested Variable Naming Conventions in the Econ-ARK Toolkit

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Abstract

Sharing code is easier when different contributors use similar names for similar objects. While we will not enforce the recommendations below, contributors can make their code more attractive to others by using names consistent with our guidelines. Þ_{ϕ}

Keywords ARK, Variable, Function, Object, Operator, Naming, Guidelines, Conventions

JEL codes None

html version at https://econ-ark.github.io/HARK/Documentation/NARK

1 Principles

Our aim has been to balance:

- Brevity
- Mnemonic quality
- Uniqueness (enabling global search-and-replace)
- Ubiquity (definitions useful for many projects)
- Combinatoriality (which encourages mashups)

2 Variables

2.1 Single-Letter

We strongly discourage the use of single-letter variable names. Reasons are presented *ad nauseum* in introductory CS texts (which, we know, few economists consult); here we will note only that the extent to which your code will be influential depends upon the extent to which someone else can easily read it, which is harder if you have used variable names which could mean almost anything. (We have made careful choices for the 'default' meanings of each Roman letter (see below); hence, in the context of the toolkit, use of a single-letter name for any meaning other than the designated one will be doubly confusing).

It is only slightly less objectionable to name a variable after a familiar letter in another commonly used alphabet (say, `delta`). Your future self (and other users) will not know which of the many possible meanings of δ you had in mind.

But, because brevity is a virtue, a single letter *in combination with a modifier or two* ('`hMin`' as the value of minimum human wealth, say) is fine – so long as the reader has some reason to expect that the lower-case letter `h` signifies human wealth (as they will, if they consult Table 1).

That is the spirit in which we offer preferred interpretations for the Roman letters below. The upper case version is an aggregated version of the variable (at the level of the whole economy, say, or of the whole market being studied), while the lower case indicates the level of an idiosyncratic consumer or firm or other subaggregate entity.

A few exceptions to these rules are explicitly noted below the table.

When an alternative is needed with a meaning similar to, but distinct from, the definitions below, please use a multi-letter name to represent it. For example, please do not use W for wealth (if some measure of wealth that differs from A, B, H, or N is needed); instead use, say, `Wlth` or `Wealth`. (Some examples follow in a subsequent section).

Finally, a few of the definitions below are actually prohibitions; these are based on many years of experience which have shown that use of the prohibited variable name generates more confusion than clarity.

2.2 Exceptions to the Rules

The letter T is an exception to the rule that lower- and upper-case versions of variables are idiosyncratic and aggregate quantities. We reserve the capital letter to designate the end of the horizon (death, or the end of the economy, occurs at the end of period T). The lower case version t is so ubiquitiously used as the current time period that we follow that convention here.

Finally, the following are exempted from the prohibition on single-letter variable names because they are used so frequently that the prohibition would be more trouble than it is worth: a, b, c, k, m, v.

Letter	Meaning
A	*A*ssets *A*fter *A*ll *A*ctions *A*re *A*ccomplished (end of period)
B	*B*eginning *B*ank *B*alances *B*efore any *B*ehavior (*b*eginning-of-period)
C	*C*onsumption *C*hoice *C*onnects B_t to A_t (with possible contribution from Y_t)
D	*D*ebt
E	PROHIBITED: Too many possible meanings (expectations, effort, expenses)
F	Production *F*unction
G	*G*rowth
H	*H*uman wealth
I	*I*nvestment
J	Ad*J*ustment costs (e.g., in a Q model)
K	Capital or beginning of period nonhuman assets
L	PROHIBITED: Is it Labor or Leisure or Land or ...?
M	*M*arket resources (the sum of capital, capital income, and labor income)
N	*N*et wealth including human wealth ($= B + H$)
O	PROHIBITED: Too similar to the number 0; too many possible meanings
P	PROHIBITED: Is it prices, permanent income, present value, profits, ...?
Q	Hayashi/Abel Q (or similar asset price)
R	*R*eturn (see the variants articulated below)
S	PROHIBITED: "saving" (flow)? "savings" (stock)? or the "saving rate" (ratio)?
T	This is a tough one. See the discussion below.
U	*U*tility
V	*V*alue
W	*W*age
X	e*X*penditures (as distinct from consumption; e.g., for durables)
Y	Noncapital income (usually, the sum of transfer and labor income)
Z	Lei*Z*ure in consumption/leisure tradeoff

Table 1 Preferred Usages of Roman Letters

2.3 Standard Variable Names

There are more objects that are likely to be used extensively in ARK projects than there are Roman letters. We present preferred usages for some of those commonly-needed variables here.

Name	-	Description
`CND`	-	Consumption of Nondurable Good
`CNS`	-	Consumption of Nondurables and Services
`Cst`	-	Cost of something
`Dgd`	-	Stock of durable good
`Dvd`	-	Dividends
`Hse`	-	Quantity of housing (*not* value, which is quantity × price)
`Inc`	-	Income
`Nlq`	-	Quantity that is **N**ot **liq**uid (e.g., `aNlq` is illiquid financial)
`Lbr`	-	Quantity of labor (hours)
`Sav`	-	Saving (=Income Minus Consumption)
`Tax`	-	Tax – should be modified by `Rte` or `Amt` articulated below
`Popn`	-	Size of population
`Perm`	-	Permanent (noncapital) income - aggregate
`prm`	-	permanent (noncapital) income - idiosyncratic component
`perm`	-	permanent (noncapital) income - combined aggregate and idiosyncratic
`Tran`	-	Transitory (noncapital) income - aggregate
`trn`	-	Transitory (noncapital) income - idiosyncratic
`tran`	-	Transitory (noncapital) income - combined aggregate and idiosyncratic

Table 2 String Variables

3 Factors and Rates

When measuring change over time, lower-case variables reflect rates while the corresponding upper-case variable connects adjacent discrete periods.[1,2] So, for example, if the time interval is a year and the annual interest rate is $\mathsf{r} = 0.03$ or three percent, then the annual interest factor is $\mathsf{R} = 1.03$.[3]

We depart from the upper-lower case scheme when the natural letter to use has an even more urgent use elsewhere in our scheme. A particularly common example occurs in the case of models like Blanchard (1985) in which idiosyncratic agents are subject to a Poisson/Bernoulli probability of death. Because death was common in the middle ages, we use the archaic Gothic font for the death rate; and the probability of survival is the cancellation of the probability of death:

[1]This convention rarely conflicts with the usage we endorse elsewhere of indicating idiosyncratic-level variables by the lower and aggregate variables by the upper case.

[2]If there is a need for the continuous-time representation, we endorse use of the discrete-time rate defined below. Any author who needs a continuous-time rate, a discrete-time rate, and a discrete-time factor is invited to invent their own notation.

[3]In the rare cases where it is necessary to distinguish between a continuous-time rate and a discrete-time rate – for example, when there is an analytical result available in continuous time – the variable in question can be modified by `Cnt` or `Dsc`.

Code	Output	Description
\Rfree	R	Riskfree interest factor
\rfree	r	Riskfree interest rate
\Risky	$\mathbf{R}$	The return factor on a risky asset
\risky	$\mathbf{r}$	The return rate on a risky asset
\Rport	$\mathbb{R}$	The return factor on the entire portfolio
\rport	$\mathbb{r}$	The return rate on the entire portfolio
\RSave	$\underline{\mathsf{R}}$	Return factor earned on positive end-of-period assets
\rsave	$\underline{\mathsf{r}}$	Return rate earned on positive end-of-period assets
\RBoro	$\bar{\mathsf{R}}$	Return factor paid on debts
\rboro	$\bar{\mathsf{r}}$	Return rate paid on debts

Table 3 Factors and Rates

Code	LaTeX	Description
\DiePrb	D	Probabilty of death
\LivPrb	$\not{\mathsf{D}}$	Probability to not die $= (1 - \mathsf{D})$

Table 4 Special Cases: Factors and Rates

4 Parameters

Some parameters are worth defining because they are likely to be used in a high proportion of models; others are subject to enough constraints when used (such as the need for similar-looking upper- and lower-case Greek representations), as to be worth standardizing.

Programmers should use the corresponding variable name without the backslash as the name of the corresponding object in their code. For example, the Coefficient of Relative Risk Aversion is `\CRRA` in a LaTeXdocument and `CRRA` in a software module.

Mnemonics:

- Hebrew `daleth` is the fourth letter of the Hebrew alphabet (as d and δ are of the Roman and Greek) and is an etymological and linguistic cousin of those letters
- ϑ is the lower case Greek letter `omega`, because people say "OMG, I've got to think about the future."
- You are invited to scrutinize Ξ yourself to imagine reasons it could represent something to do with population growth.
- The glorious letter **Þ** (pronounced 'thorn') enriched Old English, Gothic, and some other defunct alphabets; sadly, it remains in use today only in Iceland. It is useful because having to type the many symbols in the object $(\mathsf{R}\beta)^{1/\rho}$ over and over again is a *thorn* in the side of economists working with dynamic models! (It is the 'absolute patience factor' because if it is less than one the consumer wants to bring resources from the future to the present and is therefore absolutely impatient; for a fuller discussion of this terminology, see Carroll (2016).)

5 Operators

A few operators are so universally used that it will be useful to define them.

6 Modifiers

There are a number of ways in which we need to refer to specific values of a variable like its min or max.

7 Stability Points

Shocks will generally be represented by finite vectors of outcomes and their probabilities. For example, permanent income is called `Perm` and shocks are designated `PermShkAgg`

Timing can be confusing because there can be multiple ordered steps within a 'period.' We will use `Prev`, `Curr`, `Next` to refer to steps relative to the local moment within a period, and t variables to refer to succeeding periods:

8 Model Imports

A convention in python is that when a tool is imported it is given a convenient short name, e.g. `import numpy as np`.

Here are the preferred shortnames for some of our models:

```
import ConsIndShockModel as cisMdl
```

Name	LaTeX	Description	Definition or Illustration
\CARA	α	Coefficient of Absolute Risk Aversion	$\mathrm{u}(\bullet) = -\alpha^{-1}e^{-\alpha\bullet}$
\CRRA	ρ	Coefficient of Relative Risk Aversion	$\mathrm{u}(\bullet) = (1-\rho)^{-1}\bullet^{1-\rho}$
\DiscFac	β	Time Discount Factor	$\mathrm{u}'(c_t) = \mathsf{R}\beta\mathrm{u}'(c_{t+1})$
\discRte	ϑ	Time Discount rate	$\vartheta = \beta^{-1} - 1$
\DeprFac	$\daleth$	Depreciation Factor (daleth)	$K_{t+1} = \daleth K_t + I_t$
\deprRte	δ	Depreciation Rate	$\delta = \daleth - 1 \approx \log \daleth$
\TranShkAgg	Θ	Transitory shock (aggregate)	$\mathbb{E}_t[\Theta_{t+n}] = 1$ if Θ iid
\tranShkInd	θ	transitory shock (idiosyncratic)	$\mathbb{E}_t[\theta_{t+n}] = 1$ if θ iid
\tranShk	$\boldsymbol{\theta}$	transitory shock (combo)	$\boldsymbol{\theta}_t = \Theta_t\theta_t$
\PermShkAgg	Ψ	Permanent shock (aggregate)	$\mathbb{E}_t[\Psi_{t+n}] = 1$ if Ψ iid
\permShkInd	ψ	permanent shock (idiosyncratic)	$\mathbb{E}_t[\psi_{t+n}] = 1$ if ψ iid
\permShk	$\boldsymbol{\psi}$	permanent shock (combo)	$\boldsymbol{\psi}_t = \Psi_t\psi_t$
\PermLvlAgg	P	Permanent Productivity (level)	$\mathrm{P}_{t+1} = \Phi_{t+1}\mathrm{P}_t$
\permLvlInd	p	permanent productivity (idiosyncratic)	$\mathrm{p}_{t+1} = \phi_{t+1}\mathrm{p}_t$
\permLvl	$\mathbf{p}$	permanent productivity (combo)	$\mathbf{p}_t = \mathrm{P}_t\mathrm{p}_t$
\PopnGroFac	Ξ	Population Growth (Aggregate)	$\mathbf{N}_{t+1} = \Xi\mathbf{N}_t$
\PopnGroRte	ξ	Population Growth rate	$\xi = \Xi - 1 \approx \log \Xi$
\PopnLvl	$\mathbf{N}$	Population Level	$\mathbf{N}_{t+1} = \Xi_{t+1}\mathbf{N}_t$
\PtyGroFacAgg	Φ	Productivity Growth (Aggregate)	$\mathrm{P}_{t+1} = \mathrm{P}_t\Phi$
\ptyGroFacInd	ϕ	productivity Growth (Idiosyncratic)	$p_{t+1} = \phi p_t$
\ptyGroFac	$\boldsymbol{\phi}$	productivity Growth (combo)	$\boldsymbol{\phi} = \phi\Phi$
\ptyGroRte	$\boldsymbol{\varphi}$	productivity growth rate (combo)	$\boldsymbol{\varphi} = \log \boldsymbol{\phi}$
\leiShare	ζ	Leisure share, Cobb-Douglas utility	$\mathrm{u}(c,z) = (1-\rho)^{-1}(c^{1-\zeta}z^{\zeta})^{1-\rho}$
\MPC	κ	Marginal Propensity to Consume	$\mathrm{c}'(m) = \partial c/\partial m$
\APF	$\mathbb{Þ}$	Absolute Patience Factor (Thorn)	$\mathbb{Þ} = (\mathsf{R}\beta)^{1/\rho}$
\GPF	$\mathbb{Þ}_{\boldsymbol{\phi}}$	Growth Patience Factor	$\mathbb{Þ}_{\boldsymbol{\phi}} = \mathbb{Þ}/\boldsymbol{\phi}$
\RPF	$\mathbb{Þ}_{\mathsf{R}}$	Return Patience Factor	$\mathbb{Þ} = \mathbb{Þ}/\mathsf{R}$
\APR	þ	Absolute Patience rate (thorn)	$þ = (\mathsf{R}\beta)^{1/\rho} - 1 \approx \rho^{-1}(\mathsf{r} - \vartheta)$
\GPR	$þ_{\boldsymbol{\varphi}}$	Growth Patience rate	$þ_{\gamma} = þ - \boldsymbol{\varphi}$
\RPR	$þ_{\mathsf{r}}$	Return Patience rate	$þ_{\mathsf{r}} = þ - \mathsf{r}$
\riskyshare	ς	Portfolio share in risky assets	$\mathbb{R}_{t+1} = (1-\varsigma)\mathsf{R} + \varsigma\mathbf{R}_{t+1}$

Table 5 Parameters

Name	LaTeX	Code	Description	Illustration
\Ex	$\mathbb{E}$	Ex_	The expectation as of date t	$\mathbb{E}_t[\mathrm{u}'(c_{t+1})]$
\Mean	$\mathbb{M}$	Mean_	The population mean of a variable	$\mathbb{M}[\mathbf{p}] = 1$
\PDV	$\mathbb{P}$	PDV_	Present Discounted Value	$\mathbb{P}_t^T(y)$ is human wealth

Table 6 Operators

[object]`P`	-	"Prime" means derivative, e.g. `vPP` is the second derivative of value: v″
[object]`Agg`	-	Value of something at the aggregate level (as opposed to `Ind`)
[object]`Ind`	-	Value of something at the level of an idiosyncratic (as opposed to `Agg`)
[object]`Lvl`	-	Level
[object]`Rto`	-	Ratio
[object]`Bot`	-	Lower value in some range
[object]`Top`	-	Upper value in some range
[object]`Min`	-	Minimum possible value
[object]`Max`	-	Maximum possible value
[object]`Cnt`	-	Continuous-time value
[object]`Dsc`	-	Discrete-time value
[object]`Shk`	-	Shock
[object]`StE`	-	Steady-state Equilibrium value of a variable
[object]`Trg`	-	The 'target' value of a variable
[object]`Rte`	-	A 'rate' variable like the discount rate ϑ
[object]`Fac`	-	A factor variable like the discount factor β
[object]`Amt`	-	An amount, like `TaxAmt` which might be lump-sum
[object]`Nrm`	-	A normalized quantity; ex: `RNrm`=R/$\boldsymbol{\phi}$
[object]`Abve`	-	Range of points ABOvE some boundary
[object]`Belw`	-	Range of points BELoW some boundary
[object]`Grid`	-	Points to be used as a grid for interpolations
[object]`Xtra`	-	An "extra" set of points to be added to some existing set
[object]`P`	-	"Prime" means derivative, e.g. `vPP` is the second derivative of value: v″

Table 7 General Purpose Modifiers

[object]`BalGro`	-	Value of variable at a balanced growth point
[object]`Target`	-	The 'target' value of a variable

Table 8 Points of Stability

[object]`Dstn`	-	Representation of a probability distribution (includes both Prbs and Vals)
[object]`Prbs`	-	Probabilities of outcomes (e.g. `PermShkAggPrbs` for permanent shocks)
[object]`Vals`	-	Values (e.g., for mean one shock `PermShkAggVals` . `PermShkAggPrbs` = 1)

Table 9 Probabilities

[object]`tmn`	-	object in period t minus n
[object]`tm1`	-	object in period t minus 1
[object]`Now`	-	object in period t
[object]`t`	-	object in period t (alternative definition)
[object]`tp1`	-	object in t plus 1
[object]`tpn`	-	object in t plus n
[object]`Prev`	-	object in previous subperiod
[object]`Curr`	-	object in current subperiod
[object]`Next`	-	object in next subperiod

Table 10 Timing

References

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