

The Asymmetry Engine, Appendix A: Notation and equations

Martin Roark

Appendix A of *The Asymmetry Engine: How AI Closes the Gaps, and What Stays Scarce*, October 2026. The online edition, with the interactive figures and the links between chapters, is at <https://future-seems-so-good.com/blog/the-asymmetry-engine#notation>. License: [CC BY 4.0](#).

A:1 Each symbol has one meaning, the same in every chapter. A symbol needed only inside one definition, proposition, proof or derivation is local: it is declared where it is used, appears nowhere else, and is not listed here.

A.1 Symbols

A:2 The tables give Greek letters, then Latin letters, then relations and upright word-symbols. Related symbols share a row, and their meanings follow in the same order, separated by semicolons. The last column links to the object that defines each symbol, where its conditions and units are stated.

A.1.1 *Greek letters*

A:3

Symbol	Meaning	Defined in
α	verification asymmetry, $c_{\text{sol}}/c_{\text{ver}}$	Definition 2.1
β	ideas-get-harder exponent of the research law	Proposition 11.1
γ_n, γ	contraction modulus of a self-modification round (pulls when < 1)	Definition 13.1
γ_E	Euler's constant, ≈ 0.5772	Proposition 4.1
δ_n, δ	drift a round adds that no verifier caught	Definition 13.1
ε	price elasticity of demand	(3.3)
ε_j	short-run supply elasticity of layer j	Definition 16.1
ε_s	elasticity of substitution in a CES aggregate (complements when < 1)	(11.2)
ϵ_+, ϵ_-	false-accept and false-reject mass of a verifier	(1.2)
ϵ_k	drift tolerated in domain k	Definition 13.2
ϵ_0	a twin's disagreement rate inside its envelope	Definition 14.2
$\epsilon(t)$	deviation that a delayed brake corrects	(4.3)
ζ	Pareto tail index of latent task values	Proposition 3.2
η	intelligence supply gained per unit of research gap closed	(0.2)
$\eta_{\text{bw}}, \eta_f, \eta_{\text{srv}}$	achieved fraction of peak bandwidth, of peak FLOPs; serving utilization	(10.1)
θ	stepping-on-toes (parallelization) exponent of research input	Proposition 11.1

Symbol	Meaning	Defined in
ϑ, ϑ^*	a value profile (an agent's values); the intended fixed point	Definition 13.1
ι	transfer exponent from root capability to a branch	Proposition 12.1
κ_k	conductance $s_k v_k a_k / \varphi_k$, so $\lambda_k = \kappa_k I$	(0.3)
$\lambda_k, \lambda_{\text{res}}$	closing rate of gap k ; of the research gap	(0.2)
$\Lambda_{\text{sup}}, \Lambda_{\text{RL}}$	leverage of backward construction; of a reward	(2.1)
μ	pairwise coordination cost in a swarm	(9.1)
ν, ν_{max}	per-stream decode speed (tokens per second); its ceiling $1/t_0$	Definition 5.2
ν_c	candidate changes per agent-hour	(9.2)
ν_{brk}	strength of a delayed brake	(4.3)
$\nu_b, \nu_d, \nu_p, \nu_f$	birth rate of latent vulnerabilities; per-hole discovery and patch hazards; rate at which holes are found	Definition 12.3; (12.1)
$\nu_{\text{cog}}, \nu_{\text{phys}}$	supply rates of cognitive and physical work to a gap	Proposition 15.1
$\nu_{\text{inv},j}$	investment response of layer j 's capacity to its markup	Proposition 16.2
ξ	launch speed: research speed-up at full automation	(11.2)
π	the constant 3.14159... only	—
Π_t	surplus of task t before fixed costs	(3.1)
ρ	latent error correlation among agents (shared misconceptions)	Definition 7.1
ρ_v	correlation between two agents' binary votes	Proposition 7.3
ρ_1, ρ_m	error correlation under one copied seed; under many seeds	Proposition 13.5
$\sigma_k, \bar{\sigma}$	regeneration: new gap per unit of value realized; its mean	(0.2)
τ, τ^*	decentralization (topology), 0 top-down to 1 bottom-up; its optimum	Definition 7.1
φ_k	inertia of gap k (divides its closing rate)	(0.2)
φ_0	inertia of purely digital work (local to the binding-link proposition)	Proposition 15.1
Φ	standard normal distribution function	Proposition 7.3
χ	variety excess: share of local variety one apex cannot absorb	Definition 7.1
ψ, ψ_m	cohesion: mean pairwise cosine of unit efforts; of a plurality of seeds	(7.2)
ω_k, ω_j	weights summing to one: regeneration weights; influence weights; rent shares; distribution weights ω_K, ω_L	(0.3)
Γ	total open gap $\sum_k G_k$	Proposition 0.1
Δ, Δ_j	lag of a delayed brake; build time of layer j	(4.3)
Δ_τ	dividend of decentralization	Proposition 7.1
Θ	intelligence-time $\int_0^t I dt'$	(0.3)

A.1.2 Latin letters

A:4 Script, bold and plain forms of one letter are distinct symbols: $\mathcal{D}$ is a task distribution and D a disturbance, $\mathbf{b}$ a benefit vector and b the bytes per parameter.

A:5

Symbol	Meaning	Defined in
a_k	alignment of the closers of gap k , measured as certified drift (trust)	(0.2); Definition 13.2
$a, a_j, \bar{a}$	alignment of a component with the goal (the share of its push along the goal, a cosine in the vector law); a member's alignment with a shared direction; progress per head	Definition 7.1
$\bar{a}_\omega$	influence-weighted mean alignment	Proposition 13.4
A_k	asymmetry c_k^+ / c_k^- of family k	Definition 0.1
$A_c, A_\ell, A_{\text{sec}}$	compute, latency and offense–defense asymmetries	(3.1); Definition 5.1; Definition 12.4
b, b_{kv}	bytes per parameter; cache bytes per context token	Definition 5.2
$\mathbf{b}$	benefit vector: how the organization values effort	Definition 8.1
B	compute budget per task	Definition 1.1
$\mathcal{B}_k$	verification budget per unit time of a research program	Proposition 14.1
c_k^+, c_k^-	cost of the expensive and of the cheap route	Definition 0.1
$c_{\text{ver}}, c_{\text{con}}, c_{\text{sol}}$	cost to check, to construct a solved pair, to find a solution	Definition 1.3
$c_{\text{ver},k}$	cost of one check in field k	Definition 14.1
c_{KL}	price of divergence from the base policy	Proposition 2.3
$c_{\text{fail},t}$	cost of a failed call on task t	(3.2)
c_{int}	fixed cost of integrating a workflow (the hands)	Proposition 3.1
c_{bit}	utility cost of one bit of deliberation	Definition 6.1
$c_{\text{opp}}, c_{\text{meet}}$	cost of opposed efforts; of meetings per unit τ	(7.1)
$c_{\text{atk}}, c_{\text{def}}$	cost of a breach to the attacker; of assurance to the defender	Definition 12.4
$c_{\text{close},k}, c_j$	a closer's cost per unit of effort; unit cost of layer j	Proposition 16.3; Definition 16.1
$C(f), C, C_0, C_i$	compute a policy spends per task; experiment compute; its start; compute per unit of task i	Definition 1.1; (11.2); Proposition 16.3
$d(\cdot, \cdot), d_n$	distance between value profiles; drift after n rounds	Definition 13.1; (13.1)
d_{TV}	total variation distance	(2.2)
d_S	decay rate of capability not reinvested	Proposition 11.3
$\mathcal{D}, \mathcal{D}_{\text{con}}$	task distribution; constructed distribution	Definition 1.1; (2.2)
D	disturbance faced by a regulator	Definition 4.1
$\mathbf{e}$	effort vector over tasks	Definition 8.1
E	research input in the research law	Proposition 11.1

Symbol	Meaning	Defined in
f, f_0, f_B^*	a policy (the map from tasks to solutions); the base policy; the best within budget B	Definition 1.1
$F(i, \tau)$	effectiveness of an organization	(7.1)
$\mathcal{F}_{\text{acc}}, \mathcal{F}_{\text{attn}}$	FLOP rate of an accelerator; attention FLOPs per token	(10.1)
g	growth rate of a deviation under a delayed brake	(4.3)
g^*	dominant growth rate of the open gap in intelligence-time	Proposition 0.1
g_0, g_C, g_J	base pace of software progress ($\ln 3/\text{yr}$); growth of experiment compute; scale of idea production	(11.2); Proposition 11.1
g_j, g_Y	capacity growth of layer j ; growth of final output	Definition 16.1
g_g, g_s	productivity growth of automatable goods; of human-intensive services	Proposition 15.3
g_{root}	growth rate of root capability per unit of effort	Proposition 12.1
$\mathbf{g}$	gauge: the measure pay rewards	Definition 8.1
$G_k, G_{\text{res}}, G_k^*$	gap of family k ; the research gap; residual gap under free entry	Definition 0.1; (0.2); Proposition 16.3
G_ℓ	latency gap summed over calls	Definition 5.1
G_j^{att}	expected gain of the best option over the default	Definition 6.1
h, h_j	focused hours of an agent; labor-hours bought of skill j	Definition 8.1; Definition 12.2
h_k	family k 's share of the open gap	Proposition 18.1
$H(\cdot), H_D(R)$	entropy in bits; entropy of the response given the disturbance	(4.1)
H_j, H_{att}	bits to resolve decision j ; attention budget in bits	Definition 6.1
$H_{n,z}$	generalized harmonic number $\sum_{j \leq n} j^{-z}$	(4.2)
H_{hbm}	HBM capacity of an accelerator	Definition 10.1
$i, \hat{i}$	mean competence of components; competence of the apex	Definition 7.1
$I, I_k, \bar{I}$	intelligence supply; aimed at gap k ; the constant of the one-gap blow-up	(0.2); (0.4)
$I(D; R)$	mutual information (always two arguments and a semicolon)	(4.1)
$\mathcal{I}(B)$	the intelligence curve	(1.1)
$\mathbf{J}$	matrix of the gap dynamics in intelligence-time	(0.3)
j	index of a request type, a layer, a skill, a member, a decision	—
k	index of an asymmetry family or field	Definition 0.1
k_{cog}	factor by which cognitive work speeds up	(15.1)
K_V, K_M, K_j	verifier capacity and merge capacity per hour; nameplate capacity of layer j	(9.2); Definition 16.1
K_{fix}	defenders' repair capacity: found holes they can fix per unit time	(12.1)
$\mathcal{K}(P)$	Kardashev–Sagan index of a power	Definition 18.1
ℓ, ℓ_k	wall-clock latency; latency of one check in field k	Definition 5.1; Definition 14.1
L	automated research labor ($L = S$ under full automation)	(11.2)

Symbol	Meaning	Defined in
L_N	standard normal loss function	Proposition 18.3
m	index of a model tier	Definition 3.1
m_j	markup of layer j	Definition 16.1
$\mathcal{M}$	a round of self-modification, as a map on value profiles	Definition 13.1
n	streams served at once by one accelerator; a generic count	Definition 5.2
$n_k, n_t, \Delta n_k$	units demanded a year; calls of task t a year; latent demand	Definition 0.1; Definition 3.1
$n_{\text{acc}}, n_{\text{ctx}}, n_{\text{in}}, n_{\text{inst}}$	tokens accepted per step; context tokens; uncached input tokens per output token; accelerators per serving instance	Definition 5.2; Definition 10.1
n_{edit}	files one task edits	Proposition 9.1
n_{eff}	effective number: of independent votes, or of influential members	Proposition 7.3; Proposition 13.4
$n_k^{\text{ser}}, n_k^{\text{ser}, \min}, n_k^{\text{chk}}$	serial depth of a research program; its irreducible minimum; checks per unit time	Proposition 14.1; (14.1)
$n_{\text{yr}}, n_{\text{rd}}$	self-modification rounds a year; rounds counted by the drift bound	Proposition 13.2; (13.1)
n_j	units of layer j per unit of output	Definition 16.1
N, N^*	number of agents or components; the swarm size that peaks	Definition 7.1; (9.1)
$N_{\text{act}}, N_{\text{tot}}$	active and total parameters	Definition 5.2
$N_{\text{types}}, N_{\text{rules}}$	request types; hand-written rules	(4.2)
$N_{\text{files}}, N_{\text{part}}, N_{\text{span}}$	files in a codebase; independent partitions of a swarm's state; components an apex can tailor directives for	Proposition 9.1; (9.2); Definition 7.1
$N_{\text{open}}, N_{\text{vuln}}$	found-but-unfixed vulnerabilities; latent vulnerabilities	(12.1); Definition 12.3
$N_k^{\text{par}}, N_{\text{rec}}$	checks that can run at once in field k ; recipients of a dividend	Definition 14.1; (17.2)
$N(P)$	concurrent agents supported by power P	(10.1)
$\mathbf{o}, \mathbf{o}_j$	an agent's own agenda	Definition 8.1; Proposition 13.4
O, O^*, o_{def}	outcome; a chooser's best option; the default	Definition 4.1; Definition 6.2
p, p_0, p_k	a probability: single-agent accuracy; base pass rate; a program's hit rate	Proposition 7.3; Proposition 2.3; Proposition 14.1
$\Pr[j]$	frequency of request type j in a Zipf stream	(4.2)
$p_{\text{ok}}, p_{\text{conf}}, p_a, p_{\text{keep}}$	share of candidates correct; conflict probability; probability an adversary uses an open hole; probability a default is kept	(9.2); Proposition 9.1; (12.1); Definition 6.2
$p_{\text{base}}, p_{\text{sens}}, p_{\text{fp}}$	base rate of true successes; sensitivity and false-positive rate of a screen	Proposition 14.2
$p_m, p^*(q), p_{\text{front}}$	price per call of tier m ; cheapest sufficient price at quality q ; the frontier's	Definition 3.1
$p_{\text{in}}, p_{\text{out}}, p_{\text{tok}}$	price per input token, output token, token	(3.3)
p_C, p_K, p_Y, p_j, p_q	price of compute; rental price of capital; price of final output; price of layer j ; price of a unit of quality	Proposition 16.3; (17.1); (16.1); Definition 16.1; Definition 12.2

Symbol	Meaning	Defined in
$p_j^{\text{sh}}, p_{\text{att}}^{\text{sh}}$	shadow price of layer j ; of attention	(16.1); Proposition 6.1
$P, P_{\text{acc}}, P_0, P_c$	power of a fleet; all-in power per accelerator; a starting draw; a ceiling	(10.1); Proposition 18.2
P_{breach}	probability at least one open hole is used	(12.1)
$\mathcal{P}_j$	revealed-priority index of skill j	Definition 12.2
q_t^*	quality threshold of task t	Definition 3.1
$Q_m, Q_\rho(i)$	capability of tier m ; quality of the components' pooled reading	Definition 3.1; (7.1)
Q_{ans}	quality of an answer before its wait discounts it	Definition 5.1
r	returns to research, $\theta s_L / \beta$	Proposition 11.1
R, R_{act}	a regulator's response; an actuator set	Definition 4.1; Proposition 15.2
s_k	share of intelligence aimed at gap k	(0.3)
s_L	labor's share of research input	Proposition 11.1
$s_{\text{cap}}, s_{\text{lab}}$	capital's and labor's income shares	(17.1)
s_j	cost share of layer j	Definition 16.1
$s_{\text{ser}}, s_{\text{tok}}, s_{\text{blk}}, s_{\text{dec}}, s_W$	serial share of a task; token share of a workflow's cost; share of a wait spent blocked; decode share of a call; share of a step streaming weights	(9.1); (3.3); Definition 5.1; Proposition 5.3; Proposition 10.1
$s_{\text{phys}}, s_{\text{cog}}, s_{\text{pub}}, s_{\text{root}}$	physical share of a process; weight of cognition in a closing rate; public ownership share; effort share on the root	(15.1); Proposition 15.1; (17.2); Proposition 12.1
s_{ad}	adopted share of a technology	Definition 15.1
$\mathbf{s}$	the direction a collective's members share	Proposition 13.4
$S, S_0, S_{\text{max}}, S_{\text{ign}}$	software efficiency; its start, ceiling and ignition threshold	Proposition 11.1; (11.2); Proposition 11.3
$\mathcal{S}_j$	scarcity index of layer j	Definition 16.1
t, t^*	time; a blow-up time	(0.4)
$t_0, t_{\text{sync}}, t_{\text{kv}}, t_{\text{step}}$	per-step floor; synchronization cost; time per added stream; one decode step	Definition 5.2
$t_{1/2}$	wait that halves an answer's value	Definition 5.1
t_{left}, t_W	step time left after the floor; of it, time streaming weights	(10.1)
$T, T_2, T_k, T_{\text{br}}$	a horizon; a doubling time; time to a verified discovery; branch-first window	Proposition 12.1; Proposition 14.1
u_k, u_t	value of one unit of family k ; of one successful call of task t	Definition 0.1; Definition 3.1
$\mathbf{u}_c$	a collective's net direction	Proposition 13.4
$U(f), \hat{U}(f), U_{\text{unc}}$	true and verified success; uncovered mass of a rule pipeline	Definition 1.2; Proposition 4.1
v_k, v_j	verifiability of gap k , of skill j	(0.2); Definition 12.2
$\mathbf{v}_j, \bar{\mathbf{v}}$	unit effort vectors; their mean direction	(7.2)

Symbol	Meaning	Defined in
$V(x, y)$	verifier: 1 if it accepts y for x	Definition 1.1
w, w_i, w_j	wage, or value of a person's time; wage of task i , of skill j	Definition 5.1; Proposition 16.3; Definition 12.2
w_0, w_1	base pay; incentive intensity	Definition 8.1
W, W_{AI}	cumulative value realized by closing gaps; value of the AI capital stock	(0.2); (17.2)
$x, \mathcal{X}$	a task description; the set of them	Definition 1.1
$X(N), X_{acc}(\nu)$	accepted changes per hour of a swarm; tokens per second per accelerator at per-stream speed ν	(9.2); (5.1)
$y, \mathcal{Y}, \mathcal{Y}^*(x)$	a candidate solution; the set; the correct solutions of x	Definition 1.1
Y, Y^*	output of an agent's effort; output of a chain	Definition 8.1; (16.1)
z	Zipf exponent of request types	(4.2)
z_H	root of $z_H \cot z_H = g\Delta$ in the brake theorem	Proposition 4.3
Z_0, Z_j	shared and idiosyncratic standard-normal factors	Proposition 7.3

A.1.3 Relations and word-symbols

A:6

Symbol	Meaning	Defined in
$\succeq$	reachability preorder on skills	Definition 12.1
$\text{cov}, \text{compl}_k$	coverage of a rule pipeline; completeness of a field's verifier	(4.2); Definition 14.1
$\text{spend}, \text{speedup}, \text{premium}(\nu)$	total spend; speed-up; price of speed relative to the throughput optimum	(3.3); (9.1); Proposition 5.1
$\text{SNR}, \text{Var}(e)$	a collective's signal-to-noise ratio; variance of each member's error	(7.3)
BS	Brier score	Definition 18.2
div, yld	dividend per recipient; a fund's sustainable yield	(17.2)

A.2 Equations

A:7 Every numbered equation, in the order the chapters reach it. Each link opens the display at its home, where its symbols and conditions are stated.

A:8 In Part I. The gaps:

- (0.1) *The gap*. The asymmetry A_k is the cost of the expensive route over the cost of the cheap one, never below one; the gap G_k is the yearly value it locks up, the saving on units already demanded plus the value of the latent demand Δn_k the cheap route would serve.
- (0.2) *The master equation*. Value is realized at the sum over gaps of closing rate times gap; each closing rate is intelligence supply times verifiability times alignment, divided by inertia; closing a gap regenerates new gap; and closing the research gap adds to intelligence supply.

- (0.3) *Linear in intelligence-time*. With fixed shares of supply aimed at each gap and constant factors, the gaps evolve linearly in intelligence-time, through a matrix that closes each gap at its conductance and regenerates gaps in proportion to the value realized.
- (0.4) *One self-regenerating gap*. With a single gap that feeds the research loop, intelligence supply settles at a finite level when regeneration is below one, grows exponentially when it equals one, and diverges at a finite time when it exceeds one.
- (1.1) *The intelligence curve*. The best policy within a compute budget maximizes expected verified success over the task distribution, and the intelligence curve is that maximum as a function of the budget.
- (1.2) *Verified minus true success*. Measured success exceeds true success by the verifier's false-accept mass minus its false-reject mass, so a verifier that accepts wrong answers inflates every score it reports.
- (2.1) *Leverage of the data engine*. A supervised pair built backward returns the cost of solving over the cost of constructing plus checking; a reward returns the verification asymmetry itself, solving over checking.
- (2.2) *The distribution penalty*. For any loss in $[0, 1]$, a policy's accuracy on the world's distribution is at least its accuracy on the constructed distribution minus the total variation distance between the two.
- (2.3) *The review bound*. When generation is automated and human review is not, a task speeds up at most by the ratio of solving time to checking time, about 3.7 on GDPval tasks.
- (3.1) *Compute asymmetry and surplus*. A task's compute asymmetry is the frontier's price over the cheapest sufficient price, and its surplus is the value of a successful call minus that price, times the calls a year.
- (3.2) *Choosing with error costs*. When failed calls cost money, the best tier minimizes its price plus its failure probability times the cost of a failure, so cheap tiers win where failures are cheap.
- (3.3) *Jevons condition*. Under constant-elasticity demand, a price cut raises spend only if the elasticity exceeds one; when tokens are only a share of a workflow's cost, it must exceed the inverse of that share.
- (3.4) *The agent's markup*. The markup of the value an agent's work creates over its inference bill grows without limit as the token price falls; it is a markup on constant capital, not Marx's rate of surplus value.
- (4.1) *Requisite variety*. The entropy left in the outcome is at least the disturbance's entropy minus what the response carries about it, and so at least the disturbance's entropy minus the response's own variety.
- (4.2) *Coverage of the best rules*. Under Zipf traffic, perfect rules for the most frequent request types cover a share equal to a ratio of generalized harmonic numbers, which for $z = 1$ grows with the logarithm of the rule count.
- (4.3) *The delayed brake*. A loop amplifies a deviation at rate g while a brake of strength ν_{brk} pushes back on the deviation it observed a lag Δ earlier; Proposition 4.3 says when the brake holds.
- (5.1) *The two hyperbolas*. Across models, single-stream speed times active weight bytes is capped by effective bandwidth; on one chip, throughput per accelerator falls linearly to zero as per-stream speed approaches the ceiling set by the floor.

A:9 In Part II. Organization:

- (7.1) *The effectiveness surface*. Effectiveness blends the apex's competence, discounted by the variety it cannot absorb, with the components' aligned local and pooled readings, net of meeting costs and the cost of opposed efforts.
- (7.2) *The vector law*. The squared length of a sum of n unit efforts is $n + n(n - 1)\psi$, so a group's progress per head is bounded by the length of its mean direction, which tends to $\sqrt{\psi}$ as the group grows.
- (7.3) *Coherence duality*. A group's signal-to-noise ratio grows with its size only to the extent that its members agree on goals more than they agree on mistakes, and it tends to cohesion over error correlation.

- (8.1) *Hours times a cosine*. An agent spends its focused hours along the combined pull of pay and its own agenda, so output is hours times the length of the benefit vector times the cosine between benefit and that pull.
- (9.1) *The pairwise peak*. With a serial share and a cost for every pair of agents that must coordinate, a swarm's speed-up on one task peaks at a finite size N^* and falls beyond it.
- (9.2) *Swarm throughput*. A swarm's accepted changes per hour are the least of three capacities: the work its agents produce, the verifier's capacity and the merge capacity left after conflicts; only the first grows with the number of agents.

A:10 In Part III. The engine:

- (10.1) *Agents per gigawatt*. The concurrent agents a fleet sustains are its power times serving utilization over the power per accelerator, times the smallest of three per-accelerator limits: memory capacity, bandwidth and compute.
- (11.1) *Finite-time blow-up*. When software efficiency grows faster than in proportion to itself, it reaches infinity at a finite time set by its starting level, the scale of idea production and the excess of its exponent over one.
- (11.2) *The law of motion*. Software efficiency grows at the launch speed times the base pace of progress, times a CES blend of automated research labor and experiment compute, slowed as ideas get harder and as progress nears its ceiling.
- (12.1) *The backlog*. When vulnerabilities are found faster than they are fixed, the found-but-unfixed backlog grows linearly in time, and the probability that an adversary uses at least one open hole grows with it.
- (13.1) *The drift bound*. After n_{rd} rounds of self-modification, drift from the intended fixed point is at most the initial drift contracted by every round, plus the drift each round added, contracted by the rounds after it.

A:11 In Part IV. The world:

- (14.1) *Verifiability, operationally*. A field's verifiability is the completeness of its verifier, discounted by the minimum time to a verdict, its irreducible serial depth times the latency of one check, against a one-year normalizer.
- (15.1) *The physical share*. If cognition becomes k_{cog} times faster, a process speeds up by at most the inverse of its physical share, so a process that is half physical never runs more than twice as fast.
- (16.1) *Only the binding input earns rent*. In a chain of complementary inputs, an input has a positive shadow price only where it is the binding constraint, and the shadow prices of the binding inputs add up to the whole surplus.
- (17.1) *Factor shares under cheap capital*. Under a constant elasticity of substitution between capital and labor, capital's income share relative to labor's scales with the price of capital relative to the wage, raised to one minus the elasticity.
- (17.2) *Ownership dividend*. A public fund's dividend per recipient is its sustainable yield times its share of the AI capital stock, divided by the number of recipients.
- (18.1) *Pace and order*. A closing rate grows at the sum of the growth rates of its four factors, and the ratio of two closing rates does not depend on total intelligence supply, only on how it is shared and on the other factors.

A.3 Conventions

A:12 Four conventions keep the table small, and they bind every local symbol as well as the listed ones.

A:13 A c with a subscript is always a cost, as in c_{ver} , the cost to check. A p with a subscript or an argument is a price, as in p_{tok} or $p^*(q)$, except for the probabilities the table lists as such, $p_0, p_k, p_{\text{ok}}, p_{\text{conf}}, p_a, p_{\text{keep}}, p_{\text{base}}, p_{\text{sens}}$ and p_{fp} , and local probabilities declared as such where they are used. A bare p is a probability.

A:14 Other letters mark families. With a subscript, s is a share and lies in $[0, 1]$, g a growth rate, ν a rate of output per unit time, η an achieved fraction of a hardware peak, ω a set of weights that sum to one, N a count and K a capacity. The two epsilons differ: $\varepsilon_\bullet$ is an elasticity and $\epsilon_\bullet$ an error or a tolerance. Bold letters are vectors, and word-symbols such as **spend**, **cov** and **SNR** are set upright.

A:15 A bare Δ is the lag of a delayed brake, as in (4.3). Written before a symbol, Δ is a change in that symbol, as in the latent demand Δn_k of (0.1). The two subscripted forms are listed in the table: Δ_j , a layer's build time, and Δ_τ , the dividend of decentralization.

A:16 A symbol used inside only one object, proof, derivation or details block is local, and it is declared where it is used. Every Greek letter belongs to the table, so a local symbol is a Latin letter with a descriptive subscript, such as k_{br} or Q_∞ , or a standard normal Z , and it never coincides with a listed symbol. The experiments in Appendix B follow the same rule: each declares its own local symbols in its section.