Fallacy of composition

The fallacy of composition occurs when it is automatically presumed that what is true at an inferior or small scale (for individuals or parts of an economy) is true at a superior or larger scale (for groups of individuals or the entire economy).

• **Example 1.** A seller who reduces prices may sell more products. But if all sellers reduce their prices, it is not likely that all of them would sell more products.

• **Example 2.** If just one driver leaves home earlier to avoid a traffic jam, he will avoid it. If everybody leaves home earlier, then the jam is no avoided but merely brought forward.

Fallacy of division

The fallacy of division occurs when it is automatically presumed that what is true at at superior or aggregate scale (a large group of people, the economy) is true at some inferior or smaller scale (individuals, parts of the economy).

• **Example 1.** A cell is a living entity, but the cells that make up the cell are not living entities.

• **Example 2.** Conscience emerges from the brain's activity, despite the fact that the neurons that constitute the brain are not conscious entities.

Emergent property

A property or phenomenon is emergent if it arises out of lower level constituents but cannot be reduced, explained, or predicted from them.

• **Example 1.** Life and consciousness both appear to be emergent properties.

• **Remark.** The existence of emergent properties explains the fallacies of composition and division: when going from one scale to another, the property emerges or vanishes. The fallacy is created by applying the same reasoning when the property is present and when it is absent.

• **Example 2.** If one firm suffers losses, then the firm has a problem. If all the firms of an economy incur losses, then it is the economy that has a problem.

• **Example 3.** If one macroeconomics student fails, then the student has a problem. If all the students fail, then the teacher has the problem.

An example on how different realities can be manifactured out of the same data

The second row of the table below show the values of a certain variable (like production or employment) quarter by quarter. The annual value V of the variable is the sum of the values in four consecutive quarters. The government decides to make public V every two quarters: at the beginning of quarter t, $t + 2$, $t + 4$… the government announces the sum of the values in the previous four quarters $t - 1$, $t - 2$, $t - 3$, and $t - 4$.

quarter	1	2	3	4	5	6	7	8	9	10	11	12	13
value	10	10	10	10	9	12	7	14	4	18	3	19	…
V	–	–	–	–	40	39	41	38	42	37	43	36	44

Though V oscillates, the government may induce people to believe that V grows by choosing to report V in an odd quarter. The value anounced are then 40, 41, 42, 43, 44… The opposition may reply that the government is lying by reporting V in an even quarter: 39, 38, 37, 36…

Simpson's paradox

Simpson's paradox occurs when something true for different groups is false for the combined group.

• **Example.** The table below shows the taxes paid by three groups in two periods, their income, and the corresponding tax rate (taxes in relation to income). The tax rate of each group diminishes from $t = 1$ to $t = 2$. Surprisingly, for the aggregate group, the tax rate increases from $t = 1$ to $t = 2$.

	period $t = 1$			period $t = 2$		
	taxes	income	tax rate	taxes	income	tax rate
group 1	5	100	**5%**	2	50	4%
group 2	150	1,000	**15%**	63	450	14%
group 3	40	200	**20%**	255	1,500	17%
all groups	195	1,300	15%	320	2,000	**16%**

***Cum hoc ergo propter hoc* fallacy**

The *cum hoc ergo propter hoc* ('with this, therefore because of this') fallacy consists in inferring causality from the proximity of events. One commits this fallacy when the presence of a statistical association between two variables is considered enough to declare a causal connection between them. Statitiscal correlation does not imply (nor proves) causality.

• **Example 1.** Students attending the classes typically pass the course. This, however, does not imply that coming to class guarantees that the course will be passed.

• **Example 2.** James Flynn (*Keys to unlock the modern world*, 2012) reports that there is a general correlation between IQ and the length of a woman's legs (hip to knee). But it would be fallacious to conclude that long legs cause higher intelligence. One explanation of the statistical correlation is:

(i) that men prefer women with such long legs;

(ii) that in the 'marriage market' in which men look for women, men with higher status (who also tend to have higher IQ) tend to get those women; and

(iii) that their daughters are more prone to have both long legs and above average IQ.

• **Example 3. Common factor.** Imagine that people suffering from anxiety tend to smoke more than the rest of people. Though it is tempting to conclude that anxiety causes smoking, it could be that some genetic factor predisposes a person to simultaneously smoke and suffer from anxiety.

• **Example 4. Reverse causality.** Imagine that event B is observed whenever event A occurs. The conclusion that A causes B is not guaranteed because it is B that could cause A. For instance, is a country poor because it has a large population or it has a large population because it is poor? Does the government budget deficit worsen because the economy stagnates or the economy stagnates because the deficit has increased?

***Post hoc ergo propter hoc* fallacy**

The *post hoc ergo propter hoc* ('after this, therefore because of this') fallacy consists in attributing causality to the order of events. This fallacy presumes that, if event *A* precedes event *B*, then *A* causes *B*. To sustain the causal claim, one must identify the connection (mechanism, process) leading from *A* to *B*.

• **Example 1.** A reduction in the unemployment rate following a change in the law regulating labour contracts does not endorse the conclusion that the legal reform lowered unemployment.

• **Example 2. Chicken-egg problems.** As, in a economy, most likely everything eventually affects everything, it is difficult to separate cause from effect. Are there more workers hired because firms sell more or firms sell more because more workers have been hired? Are prices going up because consumers spend more now or consumers spend more now because prices are going up (and they expect them to rise further in the future)?

• **Example 3. Superstitions.** Superstitious behaviour is an expression of the *post hoc* fallacy. Why Friday 13th is supposed to be an unlucky day? How keeping fingers crossed can make wishes come true? On which grounds is it unlucky to deny a pregnant woman her cravings? Why fear speak ill of the dead? Why new clothes are not to be worn to a funeral? Are you really protected from evil spirits by standing inside a circle? What makes breaking a mirror so unlucky? Or having horseshoes hanging above the doors of homes so protective? Is it lucky or unlucky to see a black cat? Why is it bad luck to walk under a ladder? (Superstitions taken from Chloe Roads, *A book of old-fashioned superstitions*, 2012).

***Petitio principii* fallacy**

The *petitio principii* ('begging the question' or 'assuming the initial point') fallacy is committed when a proposition that has to be proved is (implicitly or explicitly) assumed without proof. The fallacy is a form of circular reasoning.

• **Example.** In textbooks on the orthodox kind demand side policies turn out to be ineffective to increase GDP (economic activity) in the medium run. But this conclusion has actually been assumed because one of the premises of the model is that medium run GDP remains constant.

***El Farol* bar problem**

(Suggested by William Brian Arthur, 1994) 100 persons are independently planning whether to go to a bar. If more than 60 persons come, the experience is not fun; it is if at most 60 persons attend. Thus, everyone would like to stay away if the bar is overcrowed (with more than 60 persons) and would like to go to the bar otherwise.

• **Analysis.** The paradox is that if everyone chooses the same strategy, the strategy fails in the sense that everyone would prefer to have selected the other strategy. If all persons decide to go, the bar is overcrowded and, hence, they would have been preferable not to come. If all persons decide not to come, the bar is empty, for which reason each person would have liked to go. Consequently, if there is a 'natural' way of predicting what a person will do, the prediction will be self-defeating: if the prediction is that few will attend, then all will attend; if it is that all will attend, then no person will attend.

• **Remark.** El Farol bar problem illustrates the limitations of a common strategy in macroeconomic analysis: to study the behaviour of a whole collective (all consumers, all firms) by presuming that the collective can be replaced by a single agent that represents the collective (the representative consumer, the representative firm). In fact, in many economic activities participants actively seek to differentiate themselves from the others as a strategy to outperform competitors. For this reason it is inappropriate neglect the heterogeneity of economic agents: not everybody is content with behaving just like the rest and, in consequence, they will reject 'one size fits all' solutions.

Tinkerbell effect

The Tinkerbell effect (after the fairy from the Peter Pan stories) refers to phenomena that exist just because they are believed to exist (in the Peter Pan 1904 play, the death of Tinkerbell is prevented by the audience's belief that she shall not die).

• **Example 1.** Money is what it is believed to be money: the euro is money in Spain, not in China.

• **Example 2.** If all believe a bank to be solvent, the bank is solvent. If all believe a bank to be insolvent, clients will withdraw their deposits, other banks will refuse to lend to the bank, and the bank will most likely turn insolvent.

• **Example 3. *Consensus gentium* fallacy.** This is the fallacy of postulating that something is true because everybody believes it is true. The scientific community seems to be a constant victim of the fallacy. Once scholars held that the Sun made orbits of the Earth. Copernicus' alternative view required generations to become accepted. The story repetead itself with Alfred Wegener's theory of continental drift, proposed in 1912 and accepted in the 1950s. If all mathematicians believe correct the proof of a theorem, then the proof and the theorem are both regarded as correct.

Reverse Tinkerbell effect

The reverse Tinkerbell effect (suggested by David Post, 2003) is the phenomenon of having the truthness of hypotheses or theories depend inversely on the number of people that believe them: the hypotheses or theories become more true as more people believe them to be false, and vice versa.

• **Remark.** The reverse Tinkerbell effect implies that:

(i) the fewer the people holding the hypotheses or theories, the more true they become (what people believe becomes more true as fewer people believe them to be true);

(ii) the more people accept them, the less true they become (what people believe becomes less true as more people believe them to be true);

(iii) with more people believing something to be false, the less false it becomes.

• **Example 1. Self-defeating prophecies.** The more people believe that some undesirable event (like the Y2K effect) is going to happen, the more they will try to prevent the outcome.

• **Example 2. Attractive destinations for tourists.** The more people believe that some place is a good destination to spend the holidays, the more likely the place will cease to be attractive.

• **Example 3. Charity.** The more people believe that some person or organization is in need to be funded, the less need of funds.

Benford's law

Benford's law is the observation/claim that the leading significant digit of many collections of numerical data capturing or measuring real-world phenomena does follow a logarithm distribution wih the relative frequencies indicated next.

first digit	1	2	3	4	5	6	7	8	9
frequency	0.30	0.17	0.12	0.09	0.07	0.06	0.05	0.05	0.04

• **Interpretation.** If Benford's law holds for a particular kind of data, the percentage of numbers starting with 1 is, following the table above, around 30%. In general, the smaller the number from 1 to 9, the larger the proportion of cases in which this number is the leading significant digit.

• **Remark 1.** Since many macroeconomic series seem to obey Benford's law, this law can be used to test whether the data have been manipulated.

• **Example.** In "Fact and fiction in EU-governmental economic data," *German Economic Review* 12(3), 2011, Bernhard Rauch and coauthors use Benford's law to test the data relevant to the deficit criteria reported by the eurozone countries. They find that, among them, the Greek data have the largest deviation from Benford's law.

• **Remark 2.** "For decades now, to begin with, the US government, like that of most other nations, has tinkered with economic figures to make unemployment look lower, inflation milder and the country more prosperous." J. M. Greer (2011): *The wealth of nature: economics as if survival mattered*.

McNamara (or quantitative) fallacy

The McNamara fallacy originates in the presumption that it is a good strategy to base decisions solely on feasible quantitative measures, disregarding factors that cannot be quantifiable, or cannot be quantifiable in an easy or obvious way, as irrelevant.

• **Remark.** The fallacy is named after Robert McNamara, US Secretary of Defense (1961-68) during the Vietnam War. For that conflict, success was defined in terms of counting enemy deaths, with victory ensured after exceeding some threshold of deaths (spoiler: the US did not win the war).

• **Example 1.** To measure the academic achievement of students just in terms of exam scores.

• **Example 2.** To use money as the sole indicator of well-being or happiness: the more money you possess, the happier you are.

Easterlin paradox

The Easterlin (or happiness-income) paradox is the suggestion, by Richard Easterlin in 1974, that, once a country has passed a certain income level (in terms of GDP per capita), additional income increases do not seem to make the population happier.

• **Remark.** More specifically, the paradox is that, though income differences between individuals tend to be positively correlated with happiness (subjective well-being), this correlation is lost when it is the economy's income that increases. All this suggests that economic growth does not necessarily lead to more happiness (interesting link: http://happyplanetindex.org/).

Zero-sum fallacy

The assumption that, in economic transactions, what is gained by someone must be lost by someone else (that every transaction involves exploitation).

• **Remark.** To the extent that transactions are voluntary, they will only be conducted if the transaction makes the two participants better off. More on this fallacy in *Economic facts and fallacies*, 2008, by Thomas Sowell, pp. 3-6.

Ponzi scheme

Named after Carlo (Charles) Ponzi, a Ponzi scheme has some fixed agent (an individual or an organization) receiving funds from investors by promising to pay a high return, which is actually paid by the funds provided by new future investors.

• **Remark 1.** A pyramid scheme differs from the Ponzi scheme in that investors participate in the scheme by recruiting new investors, with the return to old investors depending on how many new investors are recruited.

• **Example 1.** The unfunded, pay-as-you-go social security system pays pensions to current pensioners (the old investors of the system) with contributions by new investors (the people that are currently working). This structure looks like a pyramid scheme.

• **Remark 2.** Both schemes, Ponzi and pyramid, eventually collapse: since the participants do not conduct any activity generating income, it will be impossible to pay all the investors. This becomes evident when the flow of incoming investors is insufficient to match the payments due to exiting investors. It then appears that the two schemes are zero-sum economic transactions.

• **Example 2.** Though the above schemes are fraudulent, legal transactions that are purely financial are similar in spirit to the schemes. Actually, the purchase of many financial assets are just a way of implementing a bet: such assets are bought expecting an increase in their prices, so that a profit would be obtained by selling them later at the higher prices. This transaction obeys a zero-sum logic in which both parties cannot win and each bets that they other will be the losing party.

Regression to the mean

Regression to the mean is the phenomenon that, when measurements are affected by chance, if a first measurement of some trait results in an extreme value, then a subsequent measurement will tend to produce a less extreme value.

• **Example 1.** Skill and luck are important causal factors of exam scores. For a given exam, at least four groups could be defined. G1: skilled students with good luck. G2: unskilled students with good luck. G3: skilled students with bad luck. G4: unskilled students with bad luck. Members of G1 and some of G2 and G3 will be above average, whereas members of G4 and the rest of G2 and G3 will be below average. If the exam is repeated, it is not very likely that the members of G2 above average will repeat their luck; as a result, they will not perform as well as in the first exam. Similarly, it is to be expected that the members of G3 will improve their luck and, consequently, will do better in the second exam.

• **Example 2.** Let A be the boss of B. If, in the job, B makes a severe mistake, it is likely that A will scold B and requested from him a better performance next time. If, subsequently, B's performance is high above average, then A will be led to believe that his reprimand caused the improvement in performance. Regression to the mean is a better explanation: with or without A's rebuke, B's performance will be closer to average and thus an improvement with respect to the previous bad moment. Conversely, if B is praised for a job very well done, the return to average performance will be interpreted as a deterioration of performance due to the eulogium. In both cases, the effect of regression to mean is wrongly attributed to A's behaviour. In fact, A could infer that it is a bad policy to congratulate on good deeds and a good policy to strongly criticize the smallest mischief.

Confir-mation bias

Confirmation bias is the tendency to search, collect, process, or remember information to become compatible with existing beliefs or hypotheses and/or to make difficult their substitution or rejection. Specifically, prevalence is given to information confirming our views and information that contradicts our views is filtered out.

• **Remark.** Confirmation bias suggests that beliefs and preferences are not independent: people exhibit a tendency to prefer information confirming a preestablished position/opinion/view. People prefer to be right than to be wrong, so they look for evidence supporting beliefs and disregard or hide the evidence that questions them.

• **Example 1.** Policy-makers easily fall prey to confirmation bias: whatever good outcome an economy produces, they are quick and skilled at attributing the result to their (good) policies. In case of a bad outcome, they are also quick and skilled at blaming some factor not under their control.

• **Example 2.** When a severe crisis hits the economy, the same evidence (the crisis) is used by free-market believers to claim that the crisis was due to an excessive government intervention and by pro-government supporters to hold that the crisis was due to an insufficient intervention.

Self-serving bias

Self-serving bias is the tendency to attribute success to yourself and failure to others (external factors).

• **Example 1.** When you get a high mark in an exam, you probably think it was deserved, as you have spent a lot of time and effort to earn it. When the mark is low, you most likely do not blame yourself: the exam was unfair, or too difficult, or you had bad luck, or the teacher has it in for you.

• **Example 2.** A few days ago, the price of electricity in Spain reached maximum levels and the Spanish government blamed the weather. On the 26th of January, Primer Minister Rajoy declared that he trusted the rain to solve the problem ('No todo en esta vida depende del Gobierno').
http://www.publico.es/politica/rajoy-fia-precio-energia-lluvia.html

Dunning-Kruger effect

The Dunning-Kruger effect is the cognitive bias according to which people tend to believe that they are more competent than they actually are.

• **Remark 1.** The DK effect arises because ignorance prevails and is invisible. People are over-optimistic about their own capabilities: since they fail to acknowledge the gap between their actual performance and how they perceive their performance, people do not learn from their mistakes.

• **Remark 2.** "Never underestimate the difficulty of changing false beliefs by facts." Henry Rosovsky (1927) economic historian, quote in *Economic facts and fallacies*, Thomas Sowell, p. 1.

The Peter principle

"In a hierarchy every employee tends to rise to his level of incompetence" (Laurence J. Peters, *The Peter Principle*, p. 25)

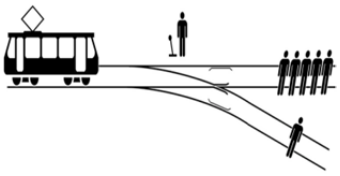
• **Remark 1. Peter's Corollary.** "In time, every post tends to be occupied by an employee who is incompetent to carry out its duties" (*The Peter Principle*, p. 27).

• **Remark 2.** "Work is accomplished by those employees who have not yet reached their level of incompetence" (*The Peter Principle*, p. 27).

https://en.wikipedia.org/wiki/Trolley_problem

The trolley problem

A runaway empty trolley is heading towards five persons. The only way of saving their lives is to pull a lever that will divert the trolley to another track, but at the cost of killing another person. Would you turn the trolley? Should it?



• **Solution 1: consequentialism.** Consequentialism is the ethical doctrine that judges (the morality of) actions by their consequences. The Spock character in the Star Trek franchise was consequentialist: "The needs of the many outweigh the needs of the few or the one," *Star Trek II: The Wrath of Khan* (1982). Since having five deaths seems a worse consequence than having only one, consequentialism recommends pulling the lever to divert the trolley.

• **Solution 2: deontological ethics (deontology).** Deontology is the ethical doctrine that judges actions by their by conformity with pre-established rules: moral actions should conform to duty. It is not only the consequences of actions that matter but also the principles that govern them. If people abide by the Decalogue, the commandment 'Thou shalt not kill' forbids pulling the lever.

• **Example 1. Alternative scenario of the trolley problem.** You are on footbridge with a fat man just above the track leading to the five persons. The only possibility of saving them is to derail the trolley by pushing the fat man and making him drop onto the track. Should the man be sacrificed?

• **Example 2.** The design of economic policies faces trolley problems. Alternative policy measures lead to different economic outcomes. In general, some outcomes are favourable to some people and, simultaneously, detrimental to other people. A high interest rate is more beneficial to lenders than a lower one, as they receive more for lending money. Yet, borrowers are worse off with a higher than with a lower interest rate, since they have to pay more for getting a loan of money.

The ultimatum game

Person 1 must propose Person 2 how to distribute x euros between them. If Person 2 rejects the offer, all the euros are lost. If he accepts it, the euros are allocated according to the proposal. You are Person 1. What is your proposal?

• **Remark.** The orthodox (game-theoretic) prediction on how to play this game is that Person 1 should offer Person 2 the mininum and Person 2 must accept. Experimental results indicate that people, when put in the position of Person 1) propose something close to a 50-50 split and that, when taken the role of Person 2, reject sufficiently unequal offers (like 80-20).

• **Example.** Countries that negotiate trade agreements or trade unions and employers' organizations disputing over pay rises face ultimatum game type-situations.

Unintended consequences

Sometimes upgraded to the status of 'law of unintended consequences', the expression 'unintended consequences' refers to the observation that decisions and actions in general tend to have consequences not desired nor anticipated.

• **Remark.** Macroeconomic outcomes are the result of the aggregation of people's decisions. But people may make certain choices aiming at some consequence, result, or outcome and, in the end, the opposite of what was intended may come out. This creates a serious problem: how could one explain a result no one intended to achieve? Moreover, from the standpoint of the design of economic policy, how could one prevent the occurrence of unintended events?

• **Example 1. A positive unintended consequence: Adam Smith's invisible hand.** "By preferring the support of domestic to that of foreign industry, he [every individual employing his capital or labouring] intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention. […] By pursuing his own interest he frequently promotes that of the society more effectually than when he really intends to promote it." *Wealth of nations*, Book IV, Chapter 2. "It is not from the benevolence of the butcher, the brewer, or the baker, that we expect our dinner, but from their regard to their own interest." *Wealth of nations*, Book I, Chapter 2.

• **Definition 1.** A side effect of an action is an effect the action did not intend to generate. Side effects could be positive (favourable) or negative (unfavourable).

• **Definition 2.** A revenge (boomerang, blowback) effect of an action is an effect contrary to the one pursued when the action was taken. By definition, a revenge effect is negative.

• **Definition 3.** Side and revenge effects occur because new possibilities, devices, systems… interact and react with people in unforeseeable ways.

• **Example 2.** Imagine a drug helping to reduce weight. If the consumption of the drug in effect lowers the weight but, at the same time, changes the skin's colour, then the skin colour change is a side effect. If consuming the drug under stress turned out to accelerate weight gain, then that would constitute a revenge effect of the consumption of the drug.

• **Example 3.** Home washing machines were publicized as a means to free time for houseviwes. The widespread adoption of homewashing machines apparently created a side effect: the number of commercial laundries decreased. This forced housewives to do more washing at home, thereby generating a revenge effect: rather than reducing the time housewives spent on washing, washing machines increased it.

• **Example 4.** (An apparently well-planned project leading to a surprising adverse result; Helen Margetts et al. (2010): *Unintended consequences of public policy reform*). Eighteenth-century German scientific foresters recommended growing trees in seried ranks, to render the forests easily countable. But in creating forests without disorderly clusters and without fallen trees among the living ones, the ecosystem needed for healthy forest growth was destroyed. So the foresters unintentionally killed the forests they were attempting to manage.

• **Example 5.** "The only way to control unanticipated events is to have Washington [= the government] do as little as possible." Milton Friedman, quoted in W. A. Sherden (2011): *Tyranny of unintended consequences and how to avoid them*, p. 1. [Among the most radical of the orthodox economists, unintended consequences are attributed to public authorities, as if private agents were immaculate and free from the sin of making decisions causing unintended effects.]

The Jevons paradox

"It is wholly a confusion of ideas to suppose that the economical use of fuel is equivalent to a diminished consumption. The very contrary is the truth."

William Stanley Jevons (1865): *The coal question.*

• **Remark 1.** Jevons argued that if technological advance allowed a blast furnace to produce iron using less coal, then profits would go up, investment in iron production would be attracted, the price of iron would fall, and demand for coal would be stimulated. The technological improvement making it possible to produce iron with less coal (more efficiently) increases the total consumption of coal: even if each furnace diminishes the consumption of coal, the larger number of furnaces created by the new investments increases total consumption of coal.

• **Remark 2.** Jevons' reasoning can be adapted to any resource, like oil. Suppose an industry learns to use a resource more efficiently: less amount needed to produce the same output. The price of the resource may decrease, as it becomes less necessary. The price fall might cause an aggregate increase in the use of the resource (new firms enter the industry or the resource is more used in other industries). As for oil, new methods for producing using less oil may not stimulate the adoption of alternative energy sources, but rather the opposite: oil could be more intensely consumed. (See David Owen (2012): *How scientific innovation can make climate problems worse*).

The Matthew effect

Coined by Robert K. Merton, the term refers to the fact (i) that eminent scientist appear to receive excessive credit in comparison to less well-known researchers, without the latter's work being significantly inferior in quality and (ii) that credit tends to be concentrated on famous researchers.

• **Remark.** By extension, the terms is also used to denote the phenomenon by which those having an advantage (fame, status, reputation, wealth) are more likely to accumulate more of that advantage. The Matthew effect is often identified with the expression "the rich get richer and the poor get poorer." ("For unto every one that hath shall be given, and he shall have abundance: but from him that hath not shall be taken even that which he hath." Matthew 25:29, King James Bible, https://en.wikisource.org/wiki/Bible_(King_James)/Matthew#25:29)

The Red Queen effect

Derived from a passage in Lewis Carroll's *Through the Looking-Glass* ('it takes all the running you can do, to keep in the same place') the Red Queen effect is the phenomenon according to which it is costly to simply stay in the same situation.

• **Example.** Firms have to invest in publicity just not to lose clients or market share. In an arms' race, one country must rise its military expenditure merely to not lag behind the rival country. In an escalator going down, you must walk up to remain stationary with respect to the ground. If predators evolve to become more lethal, preys need also evolve simply to survive.

Prisoner's dilemma

A prisoner's dilemma type game is a game situation in which cooperation between the participants yields a better result to all of them than selfish competition.

• **Definition.** The model of strategic, interactive decisions called 'game' consists of three elements. First, the agents (called 'players') that must make the decisions. Second, for each player, the set of decisions (called 'strategies') available to him and among which one must be chosen. And third, for each player and for each profile listing the strategies that each player picks, a numerical evaluation for the player (called his 'payoff') of the consequences arising from the implementation of the strategies in the profile.

• **Example.** The game on the right represents a prisoner's dilemma type-situation. There are two players, 1 and 2. Each player chooses between strategies *a* and *b*. What the strategies stand for is irrelevant. The first entry in each vector of numbers is player 1's payoff; the second, player 2's. For instance, if player 1 plays strategy and player 2 plays strategy, then player 1 gets payoff 3, whereas player 2 obtains a zero payoff (payoffs may represent anything: measures of welfare or happiness, money, market shares, exam scores, years of prison, costs, profits…).

		player 2	
		a	*b*
player 1	*a*	**2 2**	**0 3**
	b	**3 0**	**1 1**

• **Analysis.** For each player, *b* is a strongly dominant strategy: by choosing *b*, no matter what the opponent chooses, the player gets a higher payoff. Take, for example, player 1. If player 2 chooses *a*, the best for player 1 is to choose *b*; and if player 2 chooses *b*, the best for player 1 is also to choose *b*. Therefore, *b* is a dominant strategy. If both players pick their dominant strategies, the outcome is (1, 1). Nonetheless, there is an outcome which is better for both players: the outcome resulting when both select *a* instead of *b*.

• **Remark. Lessons of prisoner's dilemma games.** **Lesson 1**. They illustrate the limits of presuming that self-interested individuals make decisions that maximize the collective welfare: the invisible hand is not just invisible, but non-existent. **Lesson 2**. As players will try to develop institutions helping them to cooperatively obtain outcome (2, 2), prisoner's dilemma games also make evident that trying to explain macroeconomic outcomes only in terms of the behaviour of self-interested individuals may prove unsuccessful. **Lesson 3**. Unintended consequences of individual behaviour may be pervasive: by playing a dominant strategy, no player intended to reach an inefficient (improvable) collective outcome, but the outcome (1, 1) reached is inefficient.

Tragedy of the commons

The tragedy of the commons (tragedy of freedom in a commons) refers to the tendency to overexploit a free, shared resource: the maximization of individual gains comes at the expense of the exhaustion of the source of the gains whenever the interaction of individuals when they exploit the resource is unregulated.

• **Remark.** The tradedy is then that "Freedom in a commons brings ruin to all." Garrett Hardin (1968): "The Tragedy of the Commons," *Science* 162, p. 1244.

• **Example 1.** The tragedy may also appear if, instead of using a resource, the issue is the disposal of a waste (as in pollution problems, where costs are discharged on the commons, like the air).

• **Example 2.** As a prisoner's dilemma type-situation, the tragedy questions the assumption that the decisions made by individuals pursuing their own benefit constitute decisions that are desirable from a social or collective point of view. What is good for individuals is not good for society since the selfish, mutually independent actions by the individuals generate an unintended consequence: a negative externality.

Goodhart's law

Named for Charles Goodhart, a former chief advisor to the Bank of England, it was originally formulated in 1975 as "Any observed statistical regularity will tend to collapse once pressure is placed upon it for control purposes."

• **Remark 1.** Marilyn Strathern's formulation is "When a measure becomes a target, it ceases to be a good measure." Mario Biagioli ("Watch out for cheats in citation game," *Nature* 535 (7611), 201) states it as "When a feature of the economy is picked as an indicator of the economy, then it inexorably ceases to function as that indicator because people start to game it."

• **Remark 2.** Goodhart's law expresses for the social world what the Heisenberg principle expresses for the phyical world: the act of measuring reality changes reality. By Goodhart's law, an empirical regularity tends to vanish when it is used to control the evolution of the variables involved in the regularity.

• **Example 1.** Imagine that it is an empirical regularity that the students attending more than, say, 85% of the classes pass the course. To avoid the cost of setting and correcting exams, a teacher may use this regularity to, by controlling attendance, give a pass to those students coming to at least 85% of the classes. If students knew that policy, attendance would no longer be a good measure of the students' performance. Are you perverse enough to realize why?

• **Example 2. The Lucas critique.** Formulated by Nobel laureate Robert Lucas, Jr., the critique points out that changes in policies may alter the coefficients in macroeconometric models used to formulate the policies, so policies designed to have effects on one reality (the one without the policies) could end affecting a different reality (the one where the policies are applied). Therefore, when policies are designed, it should be taken into account how the policies alter reality.

• **Example 3.** Exams are indicators of knowledge. Exams are not the end, but a means. Yet, the very existence of exams induces students to focus on passing exams rather than to learning the subject evaluated.

• **Example 4.** Traditionally, relevant and important scientific contributions obtain many citations. Hence, citations could be selected as an indicator of the quality of scientific research. This may encourage researchers to do whatever they can to inflate their citations (see Biagioli in Remark 1 above) and disregard the quality of their research.

• **Remark 3.** By Goodhart's law, when some empirical regularity as a policymaking instrument, the regularity will tend to disappear. Empirical regularities link variables (course attendance and course performance in Example 1, citations and research quality in Example 4). If one of the variables is taken as target (performance, quality), the other variable (attendance, citations) may act as indicator. But taking the indicator as a measure of the target invalidates the indicator: controlling the indicator instead of the target destroys the empirical regularity, since people will tend to base their decisions on the indicator not the target.

• **Example 5.** "The most famous example of Goodhart's law should be the soviet factories which, when given targets on the basis of numbers of nails, produced many tiny useless nails and, when given targets on basis of weight, produced a few giant nails. Numbers and weight both correlated well in a pre-central plan scenario. After they are made targets (in different times and periods), they lose that value." http://lesswrong.com/lw/1ws/the_importance_of_goodharts_law/

Frédéric Bastiat's good and bad economist

"In the economic sphere an act, a habit, an institution, a law produces not only one effect, but a series of effects. Of these effects, the first alone is immediate; it appears simultaneously with its cause; *it is seen.* The other effects emerge only subsequently; *they are not seen;* we are fortunate if we *foresee* them. There is only one difference between a bad economist and a good one: the bad economist confines himself to the *visible* effect; the good economist takes into account both the effect that can be seen and those effects that must be *foreseen*. Yet this difference is tremendous; for it almost always happens that when the immediate consequence is favorable, the later consequences are disastrous, and vice versa. Whence it follows that the bad economist pursues a small present good that will be followed by a great evil to come, while the good economist pursues a great good to come, at the risk of a small present evil." F. Bastiat (1801-50) "What is seen and what is not seen" http://www.econlib.org/library/Bastiat/basEss1.html#Chapter%201

• **Remark.** Short-termism is the tendency to see or focus only on immediate effects of decisions and overlook longer and indirect consequences. It is a prevalent feature of human decisions: policy makers tend to prefer immediate effects to those taking time to become evident. But what is right or convenient in the short run may not be right or convenient in the long run. Spain has some airports without airplanes: construction companies and politicians seemed more interested in building the airports (short-term profits) than in operating them (long-run profits).

Hazlitt's economics in one lesson

"The whole of economics can be reduced to a single lesson, and that lesson can be reduced to a single sentence. *The art of economics consists in looking not merely at the immediate but at the longer effects of any act or policy; it consists in tracing the consequences of that policy not merely for one group but for all groups.*"

Henry Hazlitt (1988): *Economics in one lesson*, p. 5

• **Remark.** Suppose for every policy measure all effects have been identified (a lot to suppose). Is it not open to debate which course of action is preferable? Is it not part of the art of economics to evaluate consequences and make value judgements about them? Are not then two lessons needed: see consequences and evaluate/rank them? When the home currency loses value, exporters are favoured (it is cheaper for foreigners to buy what the exporter produces) and importers are harmed (it is more expensive for them to buy foreign goods). Does the lesson tell which group is to be favoured? One must not only tell what happens, but also if what happens is 'good' or not.

Occam's (or Ockham's) razor

Attributed to attributed to William of Ockham (1287–1347), Ockham's razor is the principle according to which the best explanation or solution to a problem is usually the simplest one (simple is not simplistic). As a methodological rule, it recommends explaining the most with the least.

• **Example 1.** Theoretical physicists have suggested the existence of parallel universes to interpret what occurs in our universe. Nevertheless, it is impossible to gather evidence from such other universes to confirm their existence, for otherwise they will not be parallel to our own universe.

• **Example 2.** Orthodox economists invariably model the behaviour of economic agents in terms of maximization of some objective function, typically presuming nearly complete information of their environment, unlimited computational abilities, and perfect identification of all the items over which there may be uncertainty. Agents following heuristic rules of thumb reacting to the most salient information look like a simpler and more realistic way of modelling their beahaviour.

• **Remark.** "For every complex problem there is a simple solution, and it is always wrong." Victor Herbert, quoted in Lajos Kovács et al. (2014): *100 chemical myths*, p. xi

Occam's broom

Occam's broom (Daniel Dennett, 2013) refers to the attempt to hide inconvenient facts by (dishonest) intellectuals to favour, no matter how, their own position.

• **Example 1. Flat Earth Society.** There are people still believing that the Earth is flat: all contrary evidence is presumed to be manipulated.

• **Example 2. Shermer's Hard Question (on debunking bunk and explaining the unexplained): Why do smart people believe weird things?** In *Why people believe weird things* (2002), Michael Shermer proposes the following answer: 'Smart people believe weird things because they are skilled at defending beliefs arrived at for non-smart reasons.' Much of the development of orthodox macroeconomics seems to be explained by this answer.

• **Example 3.** Creationists discard the evidence inconsistent with their theories, so that such theories may appear convincing when restricted to the selected evidence. Similarly, economists supporting the belief that financial markets work efficiently leave out the embarrassing evidence furnished by recurring bubbles and crashes.

80/20 rule

Suggested by Vilfredo Pareto, the 80/20 rule (80/20 principle, Pareto principle, or Pareto law) states that, in many cases, approximately 80% of the effects (outcomes) stems from approximately 20% of the causes (inputs).

• **Remark.** Pareto inferred the rule from his finding that most of the wealth and incomes in many countries and many periods was owned and earned by a small minority (for instance, 80% of Italian land was in the hands of 20% of the population). Typically, most wealth in an economy is owned by a minority: wealth is not uniformly distributed.

• **Example.** For the world wide web, 5% of sites attract some 75% of visits; for movies, 1% of the movies account for 80% of the box office (Richard Koch, *The 80-20 Principle and 92 other powerful laws of nature*, 2013).

Power laws

A power law between two variables is a functional relationship that makes one the variables be a power of the other, as in $y = x^a$, for some constant a. This makes the relative changes in one variable proportional to the relative changes of the other.

• **Example 1.** There is a power law between the length l of a square and its area A, since $A = l^2$. In addition, given that $dA = 2 \cdot l \cdot dl$, it follows that

$$\frac{dA}{A} = \frac{2 \cdot l \cdot dl}{l^2} = 2 \cdot \frac{dl}{l}$$

which says that the relative change $\frac{dA}{A}$ in the area of a square is twice the relative change in the length $\frac{dl}{l}$ of the square. In short, for a square, the relative change in its area is proportional to the relative change in its length.

• **Example 2.** Newton's law of gravity is an inverse square rule stating that the gravitational force F between two bodies is proportional to the product of their masses, and inversely proportional to the square of the distance d between them: $F = k \cdot m \cdot m' \cdot d^{-2}$. For bodies with constant masses, $F \sim d^{-2}$: gravity is proportional to the inverse of the square of the distance between the bodies.

• **Example 3.** The 80/20 rule can also be viewed as a power law. Benford's law is a power law. The frequencies of words in most languages follow a power law: a few words are very common, whereas most words are infrequently used. The frequency with which a meteorite hits planet Earth is inversely proportional to the meteorite's size.

• **Example 4. Zipf's law (after George Kingsley Zipf).** Let a collection of items be ordered according to frequency (or some quantitative trait). For instance, in a given text, let words be ranking in decreasing frequency: the word with most occurrences is given rank 1, the second most frequent word rank 2, and so on. For a set of cities, the city with rank 1 is most populated city, the city with rank 2, the second most populated city, etc. Zipf's law states that the frequency of an item is inversely proportional to its rank. More specifically, the rank 1 item occurs twice as often as the rank 2 item, three times as frequently as the rank 3 item, and so on. For cities, Zipf's law asserts that population of a city is inversely proportional to its ranking: the second largest city has around half the population of the largest; the third largest, one third the populatin of the first…

• **Example 4. Richter scale.** The Richter scale used to seismologists makes the number of earthquakes of a certain intensity be proportional to their intensity: small quakes are the norm; big ones, the exception. The scale is logarithmic: jumping one position in the scale implies multiplying several times the intensity.

• **Example 5. Markets are riskier than orthodox economists think.** Benoît Mandelbrot, a pioneer of Econophysics, claims (in *The misbehavior of markets: A fractal view of financial turbulence*, 2004) that the behaviour of financial markets obey a power law. Concretely, price movements do not follow a bell curve, as assumed by orthodox financial economists. Rather, financial markets behave like earthquakes: small price changes are the norm, while big changes (a sharp increase or a crash) are rare. Trading is turbulent, like the weather: extreme events though infrequent, should be expected (contrary to orthodox thinking, for which extreme events are merely accidents).

• **Remark.** Power laws appear to be everywhere in the real world: physics, biology, geology, astronomy, psychology, economics, sociology… Some have contended that some claimed power laws does not exist: only distributions with a fat tail (abnormally large changes).

Sturgeon's law

Sturgeon's law (Ted Sturgeon, 1953) holds that 90% of everything is trash.

• **Example 1.** 90% (at least) of what you will be told in this macroeconomics course is trash. 90% of everything you are going to do, eat, read, see, hear… in your life will be trash.

• **Example 2.** Scientific research, in general, and macroeconomic research, in particular, are also subject to Sturgeon's law. In "Why most published research findings are false," PloS Med 2: e124 (2005), John P.A. Ioannidis contends that this is in part due to the non-replicability of most empirical studies, which mechanically apply statistical methodology. Vested interests and prejudices also play their part.
http://reason.com/archives/2016/08/26/most-scientific-results-are-wrong-or-use

• **Example 3.** The Ig Nobel Prize (http://www.improb able.com/ig/). This prize is awarded each year to ten achievements that 'first make people laugh, and then make them think.' One of the 2012 prizes went to research showing that even a dead salmon has brain activity. The Economics prize in 2001 went to researchers holding that "Evidence from estate-tax returns suggests that some people will themselves to survive a bit longer if it will enrich their heirs." ("Dying to save taxes," *Review of Economics & Statistics* 85(2), 2003). In 2016, a prize was awarded for assessing the perceived personalities of rocks ("The brand personality of rocks," *Marketing Theory* 14(4), 2014).

• **Remark.** Sturgeon's law could be viewed as a refinement of the Pareto law: rather than 20% of inputs accounting for 80% of the value at least, it is at most 10% that accounts for the full 100%.

Black swans

A black swan is a rare event, having a large impact, and retrospectively (but not prospectively) explainable/predictable.

Nassim Nicholas Taleb (*The black swan: The impact of the highly improbable*, 2007)

• **Example 1.** Terrorist attack of September 11, 2001. Secret recipe to make a business successful.

• **Example 2.** Most discoveries and inventions of note have not arisen from design and planning: they are rare, have a large impact, and were unpredictable. They are black swans.

• **Remark.** "The reason free markets work is because they allow people to be lucky, thanks to aggressive trial and error, not by giving rewards or 'incentives' for skill. The strategy is to tinker as much as possible and try to collect as many Black Swan opportunities as you can." N. N. Taleb

The problem of silent evidence

The problem of silent evidence is that the information typically available to understand a phenomenon/result is biased in the sense that it has been diminished or filtered out by the phenomenon/result itself (selection effect).

• **Example 1. Survivorship bias.** Imagine someone wants to estimate whether praying makes people survive a plane crash. The problem: one can count only those passengers who prayed and surived but not those who prayed and did not survive. The latter constitute the silent evidence.

• **Example 2. Explaining professional success.** It is customary to explain the success of very rich people by listing the characteristics and behaviour of those people: they are hard-working, never give up, attempt new ways of doing things… The point is that millions of other individuals do the same but do not end up rich: that is the silent evidence. Consequently, one cannot ascribe success to those traits: it simply happened that, among the millions of individuals having those characteristics, a handful became rich (who could be considered black swans).

• **Example 3. Fallacy of confirmation.** In his "What is seen and what is not seen", Bastiat notices that one can see what governments do, but not the alternatives that they refuse to follow, which remain unseen. Despite the fact that the policy chosen may have alleviated the problem at which it was aimed, some alternative could have yielded a better result.

• **Example 4. Abraham Wald.** During WWII, the British Air Ministry attempted to improve the protection of bombers flying over enemy territory. Returning aircrafts were inspected and bullet holes recorded. It was found that the vital parts of the aircraft did not suffer the greatest damaged; rather, the damage was concentrated on the extremities of the planes. This evidence suggested adding armor to the extremities. Hungarian-born mathematician Abraham Wald recommended instead to add it on the bullet-free areas. The reason is that data was not compilled from the planes that crashed. And why did they crash? Because they were hit on engines and core fuselage areas. The data missing could be as important as the data present.
http://digitalroam.typepad.com/digital_roam/2006/03/the_hole_story_.html

The micro-foundations dogma

The microfoundations dogma is the claim that macroeconomics is properly done by aggregating the decisions taken by optimizing individuals that are subject to their intertemporal budget constraints under rational expectations of the future and who participate in competitive markets that always clear.

• **Remark 1.** The dogma implies the disappearance of macroeconomics as an independent discipline: there is no longer a microeconomic and a macroeconomic theory, just economic theory.

• **Remark 2.** The dogma faces several difficulties. One is the fallacy of composition: aggregate results cannot always be explained in terms of what individuals intend to achieve nor inferred from how individuals behave. Another comes from the phenomenon of downward causation: the characteristics that define the individuals, which determine the decisions they make, are also affected by the dynamics of the entire economy. In that respect, it may be that microeconomics is in need of a macrofoundation. (JE King (2012): *The microfoundations delusion*, p. 9)

Cipolla's laws of human stupidity

Carlo Maria Cipolla's *Leggi Fondamentali della stupidità umana*, though representing a sarcastic analysis that some could not take seriously, are useful to make an important point: rationality, the basic microeconomic tenet, does not explain everything. Stupid people are unpredictable, their behaviour inexplicable, and everything emerging from them (us?) is an absolute unintended consequence.

• **First law.** "Always and inevitably everyone underestimates the number of stupid individuals in circulation."

• **Second law.** "The probability that a certain person be stupid is independent of any other characteristic of that person."

• **Third (and golden) law.** "A stupid person is a person who causes losses to another person or to a group of persons while himself deriving no gain and even possibly incurring losses."
[The helpless causes a loss to himself and a gain to others; the intelligent, a gain to himself and others; the bandit, a gain to himself and a loss to others.]

• **Fourth law.** "Non-stupid people always underestimate the damaging power of stupid individuals. In particular non-stupid people constantly forget that at all times and places and under any circumstances to deal and/or associate with stupid people infallibly turns out to be a costly mistake."

• **Fifth law.** "A stupid person is the most dangerous type of person." Corollary to the fifth law: "A stupid person is more dangerous than a bandit."

On the limits of the standard microeconomic approach to macroeconomics

In microeconomic models, demand functions are presumed decreasing. This property is justified on the basis of *ceteris paribus* clauses. When an aggregate demand function is defined, it is natural to just add up all microeconomic demand functions. The problem with this approach is that, at the macro level, it may not be legitimate to keep constant variables held constant under *ceteris paribus* when the microeconomic functions were constructed.

• **Example. Upward-sloping demand functions.** The following describes an extremely simple economy. There are two individuals, A and B. Individual A has exclusive access to a valuable resource X. Individual B has exclusive access to a valuable resource Y. Individual A would like to obtain Y from B, and B would like to obtain X from A. Each individual sets the price of the respective resource in terms of some unit of account. Let p_x designate the price for X set by A and by p_y the price for Y set by B. Suppose A demands Y_A units of Y and B demands X_B units of X.

Assume that what each individual spends in buying the resource to which the individual has no access coincides with the income the individual obtains from selling the resource the individual owns. Formally, assume that

$$\underbrace{p_x \cdot X_B}_{B\text{'s expenditure}} = \underbrace{p_y \cdot Y_A}_{B\text{'s income}} .$$

(A's income: $p_y \cdot Y_A$; A's expenditure: $p_x \cdot X_B$)

By solving for, for instance, X_B, it follows that

$$X_B = \frac{p_y \cdot Y_A}{p_x} . \tag{1}$$

Apparently, (1) indicates that the demand for X is a decreasing function of its own price p_x. But this conclusion depends on the presumption that income $p_y \cdot Y_A$ does not depend on p_x. Though that might be justifiable at a micro level, it is harder to sustain at a macro level.

Specifically, suppose that income $p_x \cdot X_B$ moves in the same direction as p_x (a conventional justification could be that the demand for X is inelastic). That is,

$$\uparrow p_x \ \Rightarrow \ \uparrow (p_x \cdot X_B) \tag{2}$$

and

$$\downarrow p_x \ \Rightarrow \ \downarrow (p_x \cdot X_B).$$

Assume as well that the demand for each resource increases with income (the resources are considered as normal goods). In particular,

$$\uparrow (p_x \cdot X_B) \ \Rightarrow \ \uparrow Y_A \tag{3}$$

and

$$\uparrow \left(p_y \cdot Y_A\right) \ \Rightarrow \ \uparrow X_B . \tag{4}$$

The chain below follows from the previous assumptions

$$\uparrow p_x \ \Rightarrow^{(2)} \ \uparrow (p_x \cdot X_B) \Rightarrow^{(3)} \ \uparrow Y_A \Rightarrow^{(*)} \ \uparrow p_y \cdot Y_A \ \Rightarrow^{(4)} \ \uparrow X_B$$

if step (*) is justified by the additional hypothesis that the price p_y of Y is not lowered when the price p_x of X is increased. The final conclusion is then that an increase in the price p_x of X leads to an increase in the demand for X when the prices of the resources do not move in opposite directions (the resources are, to some extent, complementary), the demand for X is sufficiently inelastic, and the resources constitute normal goods (have increasing Engel curves). If analogous postulates are made for Y, then all the demand functions in this simple economy are upward sloping.

What is the reason for having increasing demand functions despite the fact that (1) suggests that they are decreasing? Simply put: the price rise generates a multiplier effect, which increases income, which, in turn, stimulates demand so that a possible contraction in demand caused by the price rise is neutralized. This reasoning suggests that, rather than cutting prices and wages, a way to get out of an economic recession is to increase prices and wages.

The Doomsday argument

The Doomsday argument is a probabilistic justification of the claim that the end of humanity could be closer than we might think.

Nick Bostrom (2008): "The Doomsday argument," *Think* 6(17-18), 23-28

• **The argument.** Let all the people that have been born and may ever be born be linearly arranged in the order in which they are borne. Since it seems that all the human beings that have lived so far amount to some 100 billion, you occupy around the position 100 billion in the ordering. Suppose that only two hypothesis are feasible.

HE. Early extinction of humanity. The total number of persons that will be ever live is 200 billion.

HL. Late extinction of humanity. The total number of persons that will be ever live is 200 trillion.

The number of people in HE and HL stand in a relation of 1 to 1000: for each person alive under HE there are one thousand persons alive under HL. Thus, define $p(\text{HE}) = 1/1{,}000$ and $p(\text{HL}) = 999/1{,}000$ to be the a priori probabilities ascribed to HE and HL. Let x be the event that your birth rank in the history of mankind is 100 billion. If your rank is not special in the set of all ranks, it appears plausible to set $p(x \mid \text{HE}) = 100/200 = 1/2$, where $p(x \mid \text{HE})$ is the probability that you are alive now occupying birth rank 100 billions given that hypothesis HE holds. Similarly, set $p(x \mid \text{HL}) = 100/200{,}000 = 1/2{,}000$. Using Bayes' rule, it is possible to compute the probability of HE conditional on the fact that 100 billion human beings have been born:

$$p(\text{HE} \mid x) = \frac{p(x \mid \text{HE}) \cdot p(\text{HE})}{p(x)} = \frac{p(x \mid \text{HE}) \cdot p(\text{HE})}{p(x \mid \text{HE}) \cdot p(\text{HE}) + p(x \mid \text{HL}) \cdot p(\text{HL})} = \frac{\frac{1}{2} \cdot \frac{1}{1{,}000}}{\frac{1}{2} \cdot \frac{1}{1{,}000} + \frac{1}{2{,}000} \cdot \frac{999}{1{,}000}} =$$

$$= \frac{1}{1 + \frac{999}{1{,}000}} = \frac{1{,}000}{1{,}999} \approx \frac{1}{2} = 50\%.$$

Hence, given the current evidence (100 billion people have lived so far), the probability that humanity will become extinct relatively soon is nearly 50%.

• **Remark.** The Doomsday argument could be adapted to economic events of uncertain duration. For example, is the next national, regional, or global recession to occur relatively soon or relatively late? Is a stock market crash to be expected rather soon or rather late?