

The Economy That Keeps Becoming

Chapter Two of The Economy That Keeps Becoming

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A NOTE BEFORE YOU READ

This work is offered for education and leadership development. It is not legal, financial, accounting, investment, medical or psychological advice; take the advice of a qualified professional who knows your circumstances. Companies and events are described from the public record as the author understands it; characterisations are the author's analysis. Examples are illustrative, and no particular outcome is promised to any reader.

ABSTRACT

In 1983 an economist at Stanford finished a paper about why one technology wins over another. W. Brian Arthur was born in Belfast, trained in electrical engineering and operations research, and came to economics with an engineer's habit of asking what a system actually does rather than what it ought to do. The paper argued something that sounds harmless today. When a technology becomes more attractive the more people adopt it, small and accidental early events can decide which technology the whole market ends up using, and the winner need not be the better one. By Arthur's own later account, the leading American journals declined it for years. It appeared in The Economic Journal in March 1989, under the title "Competing Technologies, Increasing Returns, and Lock-In by Historical Events". The six-year wait is his story, told in the preface to his 1994 collection, and it is worth holding loosely; journals reject papers for many reasons. What is not in doubt is the paper itself, and what it asked economists to give up.

CHAPTER TWO

The Economy That Keeps Becoming



The Economy That Keeps Becoming

HAUTE LUMIÈRE · THE ECONOMY THAT KEEPS BECOMING · CHAPTER TWO

A paper in a drawer

In 1983 an economist at Stanford finished a paper about why one technology wins over another. W. Brian Arthur was born in Belfast, trained in electrical engineering and operations research, and came to economics with an engineer's habit of asking what a system actually does rather than what it ought to do. The paper argued something that sounds harmless today. When a technology becomes more attractive the more people adopt it, small and accidental early events can decide which technology the whole market ends up using, and the winner need not be the better one.

By Arthur's own later account, the leading American journals declined it for years. It appeared in *The Economic Journal* in March 1989, under the title "Competing Technologies, Increasing Returns, and Lock-In by Historical Events".[3] The six-year wait is his story, told in the preface to his 1994 collection, and it is worth holding loosely; journals reject papers for many reasons. What is not in doubt is the paper itself, and what it asked economists to give up.

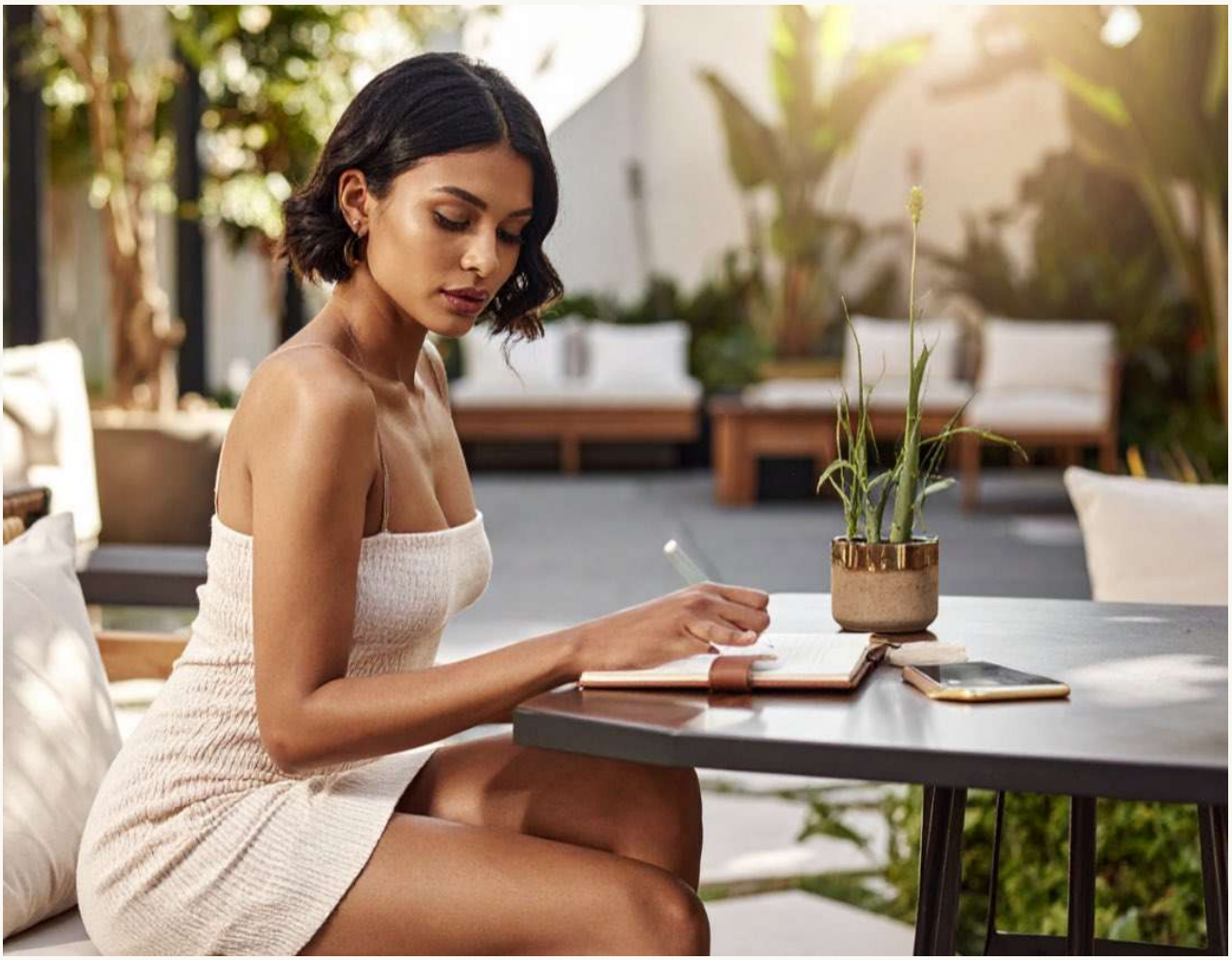
Most of the economics taught in the twentieth century rested on a quiet assumption: that markets tend toward an equilibrium, a single resting point that the forces of supply and demand will find, whatever the starting conditions. Arthur's paper described markets with more than one possible resting point, and with history choosing among them.

Ammanuel Santa Anna, the author of *Ecstatic Economics*, makes the same refusal from the side of ecology. Writing about what a regenerative enterprise might learn from a forest, he sets the old picture aside in two sentences:

> *A healthy ecosystem is not in equilibrium. It is in generative surplus*[4]

That sentence is the subject of this book. Complexity economics is the school of thought that examines it carefully, with models and evidence, and it is one of the strongest scientific supports the house has for reading an economy as a living thing. This chapter is about where the idea came from, what it changed, and the two myths that have grown around it. The chapters that follow take the fair critique (chapter 3), the living-systems reading (chapter 4), two public cases (chapters 5 and 6), a worked composite (chapter 7), and then the practice.

The claim of the book can be stated in one sentence. An economy is a system that keeps forming itself out of the choices of the people inside it, and a leader or a household that reads it that way will look for loops, not levers.



Older than Santa Fe

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Older than Santa Fe

The first myth is that complexity economics began in New Mexico in the late 1980s. It did not. Its central idea is older than any institute.

Alfred Marshall's *Principles of Economics*, first published in 1890, already discussed what he called the law of increasing return: the tendency, in many industries, for costs per unit to fall as output grows, because experience accumulates, suppliers cluster and skills concentrate in a district. Marshall saw the difficulty it made for his own system. If a firm's advantage grows with its size, there is no obvious reason for any rival to survive, and the tidy picture of many small competitors finding a common price begins to wobble. He kept increasing returns at the edge of his theory, as a fact he respected and could not fully fit.

For most of the following century the profession did roughly the same. Diminishing returns, where each extra unit of input yields a little less, produce stable equilibria and solvable equations. Increasing returns

produce several possible outcomes and an awkward dependence on history. The mathematics preferred the first, and so, for a long time, did the textbooks.

What changed in the 1980s was not the discovery of increasing returns. It was the arrival of tools that could take them seriously. Arthur and his collaborators used probability theory, in the form of what mathematicians call generalised urn processes, to show exactly how a market with self-reinforcing adoption behaves. Computers made it possible to run economies of many interacting agents and watch what happened, rather than solving for a single answer in advance.

The Santa Fe Institute, founded in 1984 as a home for the study of complex systems across disciplines, gave the work a room. In 1987 it convened physicists and economists together, with Kenneth Arrow and the physicist Philip Anderson among the organisers, and the following year Arthur directed its first economics programme. The proceedings were published as *The Economy as an Evolving Complex System*. The title is the whole argument, set in type.

Santa Anna, writing about economic thought in *Ecstatic Economics*, makes the same move from the other direction. He reads the history of economic paradigms not as a series of errors corrected but as a sequence still under way:

> *The neoliberal paradigm is not the end of economic evolution. It is a stage*[5]

The sentence is about ideologies rather than models, but it shares the complexity economist's first instinct. Nothing is final. The resting point is a moment, not a destination.

Four properties of lock-in

The 1989 paper is short and dense, and its most useful contribution for a reader who runs something is a list. Arthur showed that when adoption is self-reinforcing, the market acquires four properties that a market with diminishing returns does not have.[3]

It is not predictable in advance. Knowing the technologies and the preferences of the people who will choose among them is not enough to say which will win. The outcome depends on the order in which early adopters happen to arrive.

It can be inefficient. The technology that wins is not guaranteed to be the one that would have served everyone best. An early lead, gained by accident, can carry an inferior option to dominance.

It becomes inflexible. Once one option has a large enough lead, no reasonable subsidy or improvement to the other can reverse the outcome. The market is locked in.

It is path-dependent. Small events in the history of the market are not averaged away. They are remembered, in the structure of who uses what.

Arthur used the technical word *nonergodic* for the last property. An ergodic process forgets its past; given time, it ends up in the same place whatever happened along the way. A nonergodic one does not. That single word is perhaps the clearest line between the economics he inherited and the economics he helped to build.

The finer point for a leader is this. The four properties are not claims that every market locks in. They are a description of what follows *if* adoption reinforces itself strongly enough. Whether it does is an empirical question, asked market by market. The paper gives you the shape to look for, not the verdict.

Arthur took the argument to a wider audience in *Scientific American* in February 1990, in an essay called "Positive Feedbacks in the Economy".[6] There the engineering vocabulary is plain. Diminishing returns are negative feedback: a disturbance creates forces that push the system back. Increasing returns are positive feedback: a disturbance creates forces that push it further. An economy with both, he argued, is not a balance but a pattern of reinforcements and corrections, some of them local, some of them able to reshape an industry.



The economy that reacts to itself

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The economy that reacts to itself

In 1999 Arthur wrote a short essay in *Science* called "Complexity and the Economy".[7] It is the text most often credited with putting the phrase *complexity economics* into common use, and it moves the argument from technologies to the whole of economic life.

The core of it is a change of picture. In the standard picture, agents face a world and optimise against it. In Arthur's, agents face a world that their own choices are creating, and they adjust their strategies as the world they have created changes. Prices, expectations and institutions are not given in advance. They

emerge from the interaction of many agents, each acting on a partial view, and then feed back into how those same agents act.

The most famous illustration is a puzzle Arthur set out in 1994, about a bar in Santa Fe called El Farol.[8] One hundred people decide each week whether to go to the bar. If fewer than sixty go, it is pleasant and those who went are glad. If more than sixty go, it is crowded and those who went would rather have stayed home. No one can know in advance how many will attend. If everyone uses the same forecasting rule, the rule defeats itself: if it predicts a quiet night, everyone goes and the night is crowded. So the people in Arthur's simulation each hold several rough rules of thumb, use whichever has lately worked best, and drop the ones that fail.

What emerged in his computer runs was an attendance that hovered around sixty without settling there, an ecology of forecasting rules that kept changing, and no single correct way to think. Arthur called the reasoning involved *inductive*: people form hypotheses, test them against experience, and revise, rather than deducing the one right answer from complete information. The economy, in this view, is a population of hypotheses in competition.

Santa Anna's book gives the earlier economics its due before it departs from it. Of Adam Smith's insight into decentralised coordination, he writes:

> *The intelligence in Smith's observation was real: decentralized decision-making by individuals pursuing their own interests can coordinate complex economic activity more efficiently than central planning. Markets do possess a kind of distributed intelligence. This insight remains valuable.*[9]

That is the complexity economist's position almost exactly. Arthur did not argue that markets fail to coordinate. He argued that they coordinate in a way richer than equilibrium theory can describe: continuously, with learning, and sometimes into places nobody would have chosen.

The second myth, and a correction

The second myth runs the other way. It holds that complexity economics proves markets do not work, or that it is a fashionable word for chaos, or that it replaces the rest of economics with metaphor.

Arthur's own most complete statement, "Foundations of complexity economics", published in *Nature Reviews Physics* in 2021, is careful on all three counts.[11] He presents complexity economics as a broader framework in which the economy is not necessarily in equilibrium, and in which equilibrium, where it does occur, becomes one case among several rather than the assumption every model must begin with. Standard methods remain useful where their conditions hold. What changes is that those conditions are now something to be checked rather than presumed.

Nor is complexity the same as chaos. Chaos, in the mathematical sense, describes simple deterministic systems whose behaviour is acutely sensitive to their starting point. Complexity describes systems of many adaptive parts whose interactions produce patterns at a larger scale: patterns that are often quite stable, often recognisable, and not reducible to any single part. A city's neighbourhoods, a market's price history and a language's grammar are all complex in this sense, and none of them is chaotic.

The house's own writing uses the same distinction without the jargon. In the Luminous 100, his upgraded reading of the classical management frameworks, Santa Anna describes how a network of relationships comes to have a purpose of its own, which is emergence stated as a practitioner would meet it: living systems evolve

> *through mutual adaptation between organism and environment, where purpose emerges from the quality of relationship rather than being imposed in advance.*[10]

What the research cannot show, and the house should not claim on its behalf, is that complexity economics has a better record of forecasting than the economics it criticises. It has a different aim. It is more modest about prediction and more ambitious about understanding: about why outcomes cluster where they do, why some arrangements persist long after anyone would have chosen them, and where a small intervention can matter more than a large one. The next chapter takes the limits seriously, because they are real.



Reading your own organisation as still forming

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Reading your own organisation as still forming

The finer points of implementation begin here, with one change of habit.

A leader trained in the older picture asks of any decision: what is the right answer? A leader reading the economy as Arthur does asks first: what kind of system is this decision going into, and what will the system do with it? The second question is slower and more useful. It treats your organisation, your market and your household finances as things still forming, in which your choice becomes one of the conditions everyone else then adapts to.

Three practical consequences follow, and they recur through the rest of this book.

Look for what reinforces itself. In any organisation there are a handful of loops where success breeds success: a product that becomes more useful as more customers use it, a team whose reputation attracts the people who make it better, a supplier relationship that deepens with every order. These are your increasing returns. They are also where early, small choices carry the most weight. A loop of this kind deserves attention long before it shows up in the accounts.

Look for what is locked in. Every organisation also carries arrangements nobody would choose today: a file format, a pricing convention, a meeting, a system that everything else now depends on. Arthur's four properties apply to them. They are the product of history rather than design, and they are inflexible for reasons that have nothing to do with their merit. Naming them is not the same as removing them, but it changes the conversation from "this is how it is done" to "this is where we happen to have landed".

Act as an agent among agents. Your customers, rivals and staff are all forming hypotheses about what you will do, as you are about them. A strategy that works only if nobody responds to it is not a strategy. The El Farol puzzle is a good discipline here: before you commit to a forecast, ask what happens if everyone else holds it too.

The same habits apply at a kitchen table. A household's savings, its skills and its reputation in a community are all capable of reinforcing themselves, and a household's fixed costs, subscriptions and habits are all capable of locking in. A family that reviews its money once a year as a list of balances sees a snapshot. A family that asks which arrangements are growing on their own, and which ones it would not choose again, sees a system.

The instrument below is the first form of that habit. Chapter 7 works it through in full on a composite firm. For now it is enough to take an hour and draw the map.



The paper, and the drawer

HAUTE LUMIÈRE · THE ECONOMY THAT KEEPS BECOMING · CHAPTER TWO

The paper, and the drawer

There is one more reason the story of the 1989 paper matters to this house. Arthur's argument is itself an example of what it describes. An idea that did not fit the dominant equilibrium found no early adopters in the journals that mattered; it survived because a small, separate institution gave it a place to grow, and because the people who read it there began to use it. Today the Santa Fe Institute's economics work is cited across policy, finance and ecology. History chose, and history could have chosen otherwise.

Santa Anna's book is built on a related wager: that an economics organised around vitality rather than extraction is not a utopia waiting for permission but a set of practices that, once adopted by enough people in enough places, begin to reinforce themselves. The rest of the lineage examines that wager from several sides, from Elinor Ostrom's commons to the ecological limits of the doughnut. Complexity economics supplies the grammar of how such practices spread, and the honest warning of how they can stall.

The book from which this one grows is *Ecstatic Economics*.

In Stanford, in 1983, the paper sat in a drawer while the journals decided. Somewhere, in most organisations, there is a drawer like it: a small practice, a habit of one team, an arrangement on one account, that is quietly beginning to reinforce itself. The first task is to find the drawer.

The Tool: The First Map of Loops

One page, one hour, done alone first and then with two colleagues or the other adults in the household. Write in pencil; the map will change.

1 · The system you are mapping

Name the system in one line (a firm, a team, a product, a household):

Its edge: what is inside, and what is the environment it adapts to?

The date of this map:

2 · Reinforcing loops: what grows by itself List up to five. For each, write the loop as a sentence of the form *the more A, the more B, the more A*.

LOOP, WRITTEN AS A SENTENCE	EVIDENCE IT IS RUNNING (A FIGURE, WITH ITS SOURCE)	HOW LONG IT HAS RUN	IS IT HELPING OR HARMING?

3 · Lock-ins: what history chose List up to five arrangements that everything else now depends on.

ARRANGEMENT	WHEN AND HOW IT BEGAN	WHAT DEPENDS ON IT	WOULD YOU CHOOSE IT TODAY? YES / NO / UNSURE	COST OF SWITCHING, ROUGH

4 · Balancing loops: what corrects itself List up to three. *The more A, the less B, the less A.*

…

…

…

5 · The El Farol question

Your main forecast for the next twelve months:

If everyone you compete or cooperate with held the same forecast, what would they do?

- Would that make your forecast wrong? yes / no / unsure

6 · The drawer

One small practice that may be starting to reinforce itself, which nobody has yet named:

Who knows most about it:

The date you will look at it again:

Keep the page. Chapter 3 adds a column to it and chapter 4 a second page; chapter 7 fills it in for a worked case, and the workbook at the back gathers every page in one place.

A note on method

The Santa Fe Institute dates (founded 1984; the 1987 workshop; the 1988 economics programme) and the proceedings, Anderson, P. W., Arrow, K. J., & Pines, D. (eds.) (1988), *The Economy as an Evolving Complex System*, Addison-Wesley, are given from the institute's published histories and the proceedings' title page as commonly catalogued; they were not re-read from an archival record for this book. Marshall's discussion of increasing return is in *Principles of Economics* (Macmillan, 1890), Book IV.

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