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Kindleberger Cycles: Method in the Madness of Crowds?

Randall Morck[1,2]

[1]Alberta School of Business, University of Alberta, Edmonton, Canada; email: rmorck@ualberta.ca

[2]National Bureau of Economic Research, Cambridge, Massachusetts, USA

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Abstract

Corporate R&D has a social return far above its internal rate of return to the innovating corporation, and so it is chronically underfunded from a social perspective. Kindleberger cycles, irregularly recurring stock market manias, panics, and crashes that are prominent in financial history, are also a major problem for mainstream economics. If manias inundating hot new technologies with capital sufficiently counter chronic underinvestment in innovation, economy-level selection may favor institutions and behavioral norms conducive to Kindleberger cycles despite individual agents' losses in panics and crashes.

1. NO BUBBLES IN THE U.S.S.R.

Kindleberger (1978) documents an irregular cycle of stock market manias, panics, and crashes from the early 1600s on. In 2008, Federal Reserve chair Alan Greenspan, musing "there were no bubbles in the Soviet Union," suggested this cycle might be unavoidable in prosperous free-market economies (Guha 2008). Combining several seemingly unconnected streams of economic research suggests that Kindleberger cycles are not merely necessary but essential to ongoing prosperity.

Economic growth theory research shows that technological progress, far more than increased inputs, explains rising living standards (Solow 1957). This is because innovation has very large positive externalities: One firm's innovation often opens ways for others (external to the firm) to boost productivity, too. Technological progress occurs as successive innovations diffuse across the economy. Innovations with positive externalities spanning the entire economy, called general purpose technologies (GPTs), historically generated vast new wealth (Bresnahan & Trajtenberg 1995; Bekar, Carlaw & Lipsey 2018). Alexander Graham Bell made a decent return on the telephone, but others throughout the economy earned far more by finding valuable uses for instantaneous voice communication (Fischer 1994).

Productivity research affirms that large positive externalities lift innovation's social rate of return (SRR) to the economy far above its private internal rate of return (IRR) to the innovator (Hall, Mairesse & Mohnen 2010; Jones & Summers 2022). Because profit-maximizing firms only consider their own IRRs, they almost surely forgo much high-SRR R&D.

Externality theory prescribes intellectual property (IP), R&D subsidies, and other interventions to boost innovators' IRRs; however, mounting evidence contests the efficacy of these responses (Jaffe & Lerner 2011). Actual R&D being a small fraction of socially optimal R&D is, for mainstream economics, a major market failure.

Behavioral finance research critiques mainstream economics for providing equations corporations and governments cannot actually use to direct investments in innovation. This disconnect arises because these problems are procedurally transcomputational, meaning no procedure exists for ascertaining the numbers needed to plug into these equations. Behavioral finance shows that, in such situations, people learn by reinforcement, imitate others, and move as a herd, all of which is behavior conducive to manias (Shiller 2020).

Financial history research affirms the importance of Kindleberger's recurring mania, panic, and crash cycles to all major high-income economies. Each cycle begins with a disequilibrium, usually a hot new technology, sometimes a new market, with very high expected IRRs. A mania inflates stocks thought favored by the disequilibrium. The bubble bursts, and a panic, crash, and (sometimes) socially costly economic downturn ensue. Market crashes, for mainstream economics, are another major market failure.

Evolutionary economics research argues competition culls inefficient institutions. However, tough new regulations enacted after a crash repeatedly fall aside for the next mania (Reinhart & Rogoff 2009; Dagher 2018). Indeed, mania-prone stock markets financed industrialization in one country after another (Rosenberg & Birdzell 1986; Morck & Steier 2005; Demirgüç-Kunt & Levine 2018), including now bank-centered Germany (Fohlin 2005) and Japan (Morck & Nakamura 2005).

These research streams intersect to suggest economic evolution might select for mania-prone stock markets. This might be because Kindleberger cycles draft human behavioral responses to inundate successive nascent technologies with capital, countering otherwise even worse chronic underinvestment in innovation and sustaining the technological progress that underlies economic growth. Mania-prone stock markets may themselves have been a crucial GPT that supports

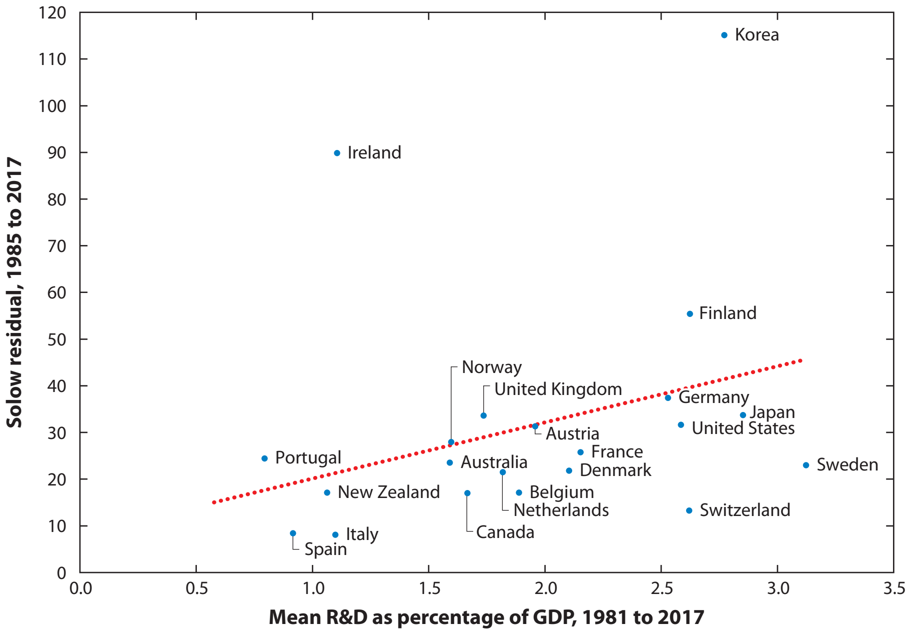

Figure 1

Solow residual versus R&D spending. Economies with higher R&D spending have faster economic growth primarily because they show evidence of greater cumulative multifactor productivity growth (one proxy for Solow residuals). Greater productivity growth reflects the faster and more complete adoption of new technologies, which lets firms produce ever more valuable outputs from given inputs. Data from the OECD data website (**https://data.oecd.org/**).

subsequent technological progress. Rather than deplore investor irrationality, policy makers might seek to improve Kindleberger cycles' social benefit–cost ratios. Constraining credit expansion during manias sometimes largely confines crashes within stock markets (Sufi & Taylor 2021), perhaps explaining Samuelson's (1966) reflection "the stock market has predicted nine of the past five downturns" (p. 92).

2. POSITIVE EXTERNALITIES FROM INNOVATION EXPLAIN MOST ECONOMIC GROWTH

2.1. Technological Progress Explains Most Economic Growth

By showing that technological progress underlies most economic growth, Solow (1957) founded the field of economic growth theory.[1] Increased inputs (resources, capital, and labor) explain only a small fraction of economic growth in high-income countries. The unexplained greater part, called the Solow residual, reflects productivity growth: successive new technologies displacing older ones, each producing higher-valued outputs from given inputs. Tracking expanding Solow residuals with various productivity growth measures has become a major focus of policy makers and economic researchers (Jones & Summers 2022). **Figure 1** shows Solow residuals, approximated by cumulative multifactor productivity growth, larger where private sector R&D is larger.

[1] Akcigit & Nicholas (2019) and He & Tian (2020) provide comprehensive surveys.

This is good news, in that ongoing prosperity depends on potentially unlimited new ideas, more than limited tangible inputs. Although Gordon (2016) concludes innovation is slowing, Mokyr (2018) reports the pace of innovation has repeatedly fallen and risen again. Trajtenberg (2018) and Choi (2018) see machine learning and 3D printing as nascent GPTs with vast potential to increase productivity.

2.2. Chronic Underinvestment in Innovation

Productivity economics research shows corporate R&D having IRRs of 10–15% for the innovating firm and SRRs well over 40% for the overall economy.[2] The SRR minus IRR gap varies across industries and over time. Griliches (1957) estimates SRRs of agricultural innovations at 35–40% versus a 10% IRR benchmark. Subsequent work, reviewed by Jones & Williams (1998), Hall, Mairesse & Mohnen (2010), and others, affirms that innovations have SRRs manifold higher than their 10–15% IRRs. Bloom, Schankerman & Van Reenen (2013) identify an SRR of R&D of 59% using US states' changes in R&D taxes. Acharya (2008) finds the SRR of R&D exceeding its IRR by 90–101% in pharmaceuticals and by 49–62% in computers, but by little if anything in general machinery and equipment. Jones & Summers (2020) conclude in their abstract that "under conservative assumptions, innovation efforts produce social benefits that are many multiples of the investment costs." More specifically, Jones & Summers (2022) estimate that "even under very conservative assumptions, it is difficult to find an average return below $4 per $1 spent. Accounting for health benefits, inflation bias, or international spillovers can bring the social returns to over $20 per $1 spent" (p. 42).

Figure 2 summarizes social and private returns to R&D from Lucking, Bloom & Van Reenen (2019).[3] Profit-maximizing firms undertake R&D whose IRR exceeds its cost of capital, k. Plausible k estimates range from the riskless rate r_f to r_f plus various multiples of the market risk premium.[4] The lower bound is near zero in recent years, and the upper bound is in the 10–15% per year range, not far below the ranges for the private returns on R&D. In stark contrast, the SRRs of R&D range from 60% to 80%, rising in the early 1990s as information technology (IT) innovations diffused, falling from the mid-1990s on as capital flooded in, and then stabilizing after the Crash of 2000. Despite their large confidence intervals, social returns far exceed private returns and plausible costs of capital. That is, R&D is marginally profitable to innovating firms and manifold more valuable to the economy as a whole.

Firms acting for society would do all R&D projects with $SRR > k$, not just those with $IRR > k$. Scherer (1999) concludes much high-SRR R&D has low, even negative, IRRs. This is a major

[2] Jones & Summers (2022) survey and discuss estimation procedures.

[3] Lucking, Bloom & Van Reenen (2019) do not estimate *IRR*s directly, but use the methodology of Bloom, Schankerman & Van Reenen (2013), whose on-line appendix relates this to *IRR*s in an intertemporal model.

[4] To a first approximation, k is the return investors would require from the project were it a freestanding equity-financed firm. The capital asset pricing model defines $k = r_f + \beta\lambda$ with r_f the return investors require on riskless investments, λ the risk premium diversified investors require from the stock market as a whole, and β the project's risk to diversified investors relative to that of the market as a whole. T bond rates, the US government's long-term borrowing costs, proxy for r_f. Damodaran (2014) provides historical λs. Welch (2020) provides βs for US stocks. Innovation is risky but, at least early on, also highly idiosyncratic (Pástor &Veronesi 2009), with successes cancelling failures. Consequently, some R&D can be essentially riskless ($\beta = 0$) to diversified investors (Jørring et al. 2017). Systematically riskier R&D requires higher $\beta > 0$. Welch's βs never exceed four and 98.4% fall below two. Consequently, k ranges from r_f to $r_f + 4\lambda$, with most below $r_f + 2\lambda$ and many perhaps near r_f. Ewens, Jones & Rhodes-Kropf (2014) argue idiosyncratic risk can raise venture capital costs above these benchmarks. Kogan & Papanikolaou (2019) review related work.

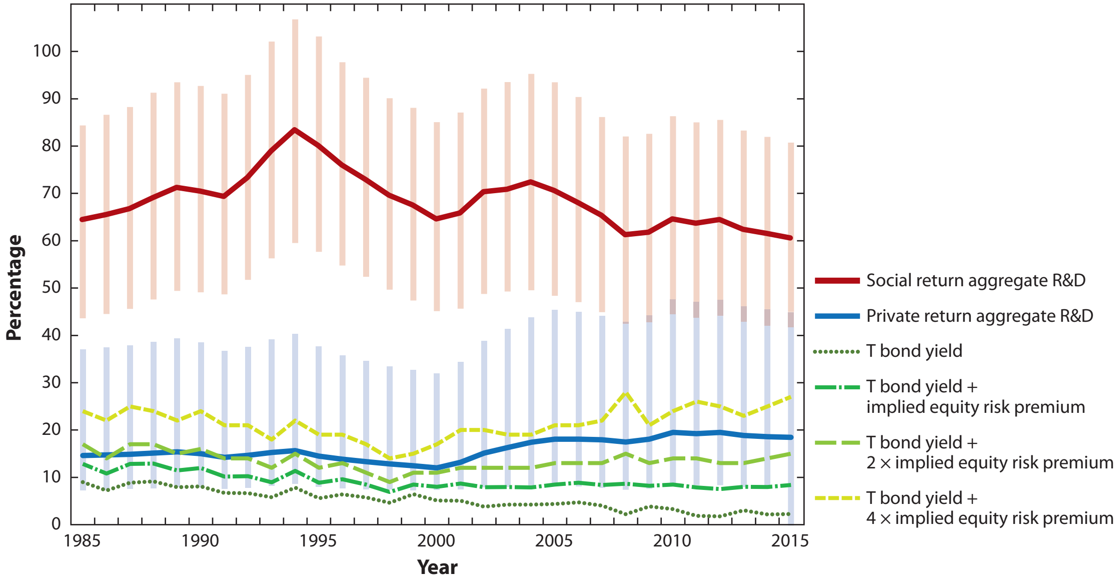

Figure 2

Social and private returns to R&D over time. The social and private returns to aggregate US R&D (*red* and *blue*, respectively, with 95% confidence intervals shown) compared to the cost of capital benchmarks for successively higher systematic risk (*successively lighter green dotted lines*) investments. Successively lighter green lines denote cost of capital benchmarks, ranging from the T bond rate for R&D without significant systematic risk (Jørring et al. 2017) to that plus the market risk premium for ventures with risk typical of generic stocks, plus double the equity risk premium for high-risk ventures (Damodaran 2014), and plus fourfold the equity risk premium for extreme risk venture (Welch 2020). Data sources: Social and private R&D returns are from Lucking, Bloom & Van Reenen (2019), approximated as described in the online appendix to Bloom, Schankerman & Van Reenen (2013), with vertical hairlines delimiting 95% confidence bounds.

market failure: Market forces generate R&D chronically and profoundly short of what socially optimal R&D would be.

2.3. Government Interventions to Encourage Innovation Often Work Poorly

Externality economics (Pigou 1920) analyzes such market failures and prescribes possible policy responses, but each response begets problems.[5] IP law can strengthen and lengthen patents and copyrights, raising a firm's IRR from any given innovation, but may not accelerate aggregate innovation (Brown, Martinsson & Petersen 2017). First, larger or longer streams of profits from one innovation make finding another less urgent. Second, stronger IP for initial innovators limits spin-off innovations by others (Caballero & Jaffe 1993). Third, patent trolls game IP, accumulating patents someone might someday infringe. A $612.5 million lawsuit for violating a troll's wireless email patent crippled BlackBerry, a smartphone pioneer (Sweeny 2009). Accumulating evidence suggests intense political lobbying (Saperstein 1997; Drahos 2003) has increasingly reshaped US IP law to impede, more than encourage, innovation (Jaffe & Lerner 2011). Research productivity is consequently falling (Bloom et al. 2020).

[5]Externalities occur if one party's actions affect others' welfare. Negative externalities, e.g., one firm's pollution harming others, enters corporate social responsibility rankings. Positive externalities, e.g., one firm's innovation benefiting others, typically do not. On problems with policy responses, see Goolsbee & Jones (2022).

A second policy response is state-subsidized R&D.[6] Zúñiga-Vicente et al. (2014, pp. 59–60) summarize research into these policies as "mixed and inconclusive" and reflecting "rising concern about the effectiveness of public subsidies." Two patterns are noteworthy: (*a*) unlike private sector R&D in **Figure 1**, public sector R&D is not clearly correlated with productivity growth (e.g., OECD 2003) and (*b*) state-financed R&D appears to have lower IRRs and SRRs than private sector R&D (Hall, Mairesse & Mohnen 2010).

Several explanations are proposed. State-funded basic science R&D may have hard-to-measure social returns that spill over borders, take decades to commercialize, and advance life quality rather than GDP (Ahmadpoor & Jones 2017; Azoulay, Zivin & Li 2019; Azoulay, Greenblatt & Heggeness 2021). Other explanations allow less sanguinity. As thermodynamics arose to explain working steam engines (Gillispie 1960, p. 357), some basic research may explain, not inspire, new technology (Edgerton 2004). Corporations, universities, and laboratories also patent state-subsidized R&D, so dysfunctional IP law remains problematic (Lach & Schankerman 2004). Cash-strapped universities, selling state-subsidized patents, may even fatten patent trolls (Watkins 2014). Governments have difficulty picking winners to subsidize (Lerner 2009), even in Japan (Beason & Weinstein 1996). Bureaucrats may find more bureaucratic applicants' perfectly filled-out proposals more convincing (Jaffe 1989) and influential lobbyists' applications worthier (Lerner 2009) than those of actual innovators. Misgoverned universities and granting agencies may misallocate research funding (Goolsbee 1998; Sokal & Bricmont 1999; Strevens 2013; Ioannidis et al. 2014), including economics funding (Kwak 2017). State-subsidized R&D at large corporations, universities, and government laboratories may even draw talent away from innovative new firms' higher SRR R&D efforts (Goolsbee 1998; Lach 2002).

3. BEHAVIORAL FINANCE EXPLAINS INVESTMENT IN INNOVATION

Corporations and governments contemplating R&D spending confront effectively insolvable problems. Behavioral finance research explores people's behavior in such situations.[7]

3.1. Rational Agent Economics Meets Procedurally Transcomputational Problems

Actual decision makers can find economists' expectations of rationality daunting. Economics deems an investment viable to a firm or worthy of state subsidies if the IRR or SRR, respectively, exceeds a threshold and provides exact equations for both problems. Retrospectively, roughly estimating R&D's IRR or SRR is possible but subject to wide margins of error, as in **Figure 2**. When decisions are made, prospectively predicting IRRs requires hundreds of numbers: prices and quantities of all inputs and outputs and taxes due in every future time period and state of the world, and the probabilities of each state of the world in each time period.[8] Predicting SRRs requires all

[6]Yet other interventions—governments offering prizes for new technologies (Wright 1983) or buying patents and making technologies free (Kremer 1998)—are complicated by incentive problems (e.g., Ales, Cho & Körpeoğlu 2017).

[7]For a general survey, see Hirshleifer (2015).

[8]Business schools teach students to calculate a project's *IRR* by solving

$$-K + \sum_{s=1}^{S}\sum_{t=1}^{T}\pi_{s,t}e^{-IRR\times t}\left(\sum_{m=1}^{M}p_{m,s,t}q_{m,s,t} - \sum_{n=1}^{N}p_{n,s,t}q_{n,s,t} - \tau_{s,t}\right) = 0,$$

plugging in its setup cost K, prices $p_{m,s,t}$, and quantities $q_{m,s,t}$ of each of its M outputs, prices $p_{n,s,t}$ and quantities $q_{n,s,t}$ of each of its N inputs (e.g., raw materials, intermediate goods, and categories of employees), taxes due these plus social values of all externalities. A few of these numbers are unreliably guesstimatable; most are fundamentally unknowable.

Told to evaluate an investment project, students are given all these numbers (or abstract assumptions about them) and then As for solving the equations. Alumni must find meaningful values to plug in. Experience fills in some numbers and justifies assumptions for familiar repeated investments. However, innovations are literally new—their prospects often unknowable. Keynes's (1936, pp. 162–63) conclusion "human decisions affecting the future, whether personal or political or economic, cannot depend on strict mathematical expectation, since the basis for making such calculations does not exist" surely applies to innovations. The more profound the innovation, the more distant the time horizon, and the deeper our current ignorance, the more outrageous the conceit that our equations provide solutions. Keynes' critique is frequently elaborated and acknowledged (e.g., Simon 1957; Nelson & Winter 1982; King & Kay 2020), but business students nonetheless memorize evermore intricate equations.

Mathematical problems whose solutions must exist, but require impossible computing power, are called transcomputational (Bremermann 1962). Grossman & Stiglitz (1980) distinguish substantive rationality, the optimization in standard economic theory, from procedural rationality, the optimization of the decision-making procedure itself. Extending this distinction, a problem is procedurally transcomputational if an equation provides its solution but no procedure for finding numbers to plug into that equation exists.[9] Equations for making R&D investment and subsidy decisions easily qualify.

3.2. How Behavioral Responses Inundate Innovations With Capital

Confronting procedurally transcomputational problems, people use Simon's (1957) bounded rationality. New problems evoke memories of similar problems and of experienced or observed responses. Stimulus-response pairings, called heuristics, that worked well are remembered and imitated (Bordalo et al. 2021).

Successful heuristics spread and displace less successful ones (Nelson & Winter 1982; Kahneman 2011). Behavioral finance characterizes heuristics as biases, but King & Kay (2020) reject this term where procedural transcomputationality leaves unbiased behavior undefinable.[10] Rather, economic selection, like evolutionary algorithms in machine learning, selects for heuristics with better outcomes (Lo 2017; Lo & Remorov 2021). Economic selection may thus do

$\tau_{s,t}$, all in every future time t in every possible state of the world s, and the probabilities $\pi_{s,\tau}$ of the world being in each possible state s at each future time t. Relating each output to its required inputs also requires knowing the M-dimensional time and state-dependent production function $q_{m,s,t} = f_{m,s,t}(q_{1,s,t} \ldots q_{n,s,t} \ldots q_{N,s,t})$. The *IRR* is then compared to a cost of capital, obtained by predicting the project risk consequences to a diversified investor.

To calculate a project's *SRR*, officials are to find the *SRR* that solves

$$-K + \sum_{s=1}^{S}\sum_{t=1}^{T} \pi_{s,t} e^{-SRR\times t}\left(\sum_{l=1}^{L} x_{l.s.t} + \sum_{m=1}^{M} p_{m,s,t}q_{m,s,t} - \sum_{n=1}^{N} p_{n,s,t}q_{n,s,t} - \tau_{s,t}\right) = 0,$$

the $x_{l.s.t}$ being social values, positive or negative, of all its externalities in each possible probability-weighted state of the world at each future time and all other variables as in the *IRR* equation. Even in estimating past private and social returns, only very rough approximations are econometrically feasible. Accurately assessing future private and social returns of current investments is highly problematic, especially for investments in innovation.

[9]This differs from ambiguity models (see Epstein & Schneider 2010), wherein agents know all parameters except state probabilities, to which they assign multiple stochastic priors.

[10]Kahneman (2011) and Hirshleifer (2015) review this literature.

what economic rationality cannot: "defeat the dark forces of time and ignorance which envelop our future," Keynes' (1936, p. 155) definition of investment success.

The heuristic "imitate those who likely know what to do" has survival power. It is readily elicited in laboratories, evident in many real settings, and resonates with a human propensity to conform (Hirshleifer 2015; Bikhchandani et al. 2021). This behavior persists because it often works, but it can also induce behavior that plausibly drives Kindleberger cycles. Early highly publicized successes investing in big new technologies, whose valuations are procedurally transcomputational, can evoke expanding rounds of imitation. Early success stimulates more investment, which lifts stocks, reinforcing perceptions of success and stimulating yet more investment. Called information cascades, such feedback loops can inflate securities prices in bubbles that ultimately burst. Bikhchandani et al. (2021) review this literature.

Rational investors who realize a bubble is inflating are caught in what Keynes (1936) calls an investment beauty contest:

> It is not a case of choosing those that, to the best of one's judgment, are really the prettiest, nor even those that average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practice the fourth, fifth and higher degrees. (p. 156)

Rational investors (if any exist) seek to buy stocks that they expect heuristic-driven investors will soon deem prettier. Owning what others deem beautiful can also convey social status, further strengthening the positive feedback (Veblen 1899). Stock market investing provides randomized rewards, which are especially conducive to reinforcement learning (Smith et al. 2014). Information cascades, turbocharged by these effects, can escalate stock prices and flood sectors associated with high-profile innovations with capital. Paying extra taxes to finance state-funded innovation has no comparable allure.

3.3. The Social Value of Capital Inundations

Bubbles can flood capital across innovations that rational investors would shun and in volumes that government programs could not match.[11] After the flood abates, the crash harms small investors, corporate acquirers (Moeller, Schlingemann & Stulz 2005), and even venture capitalists (Kerr, Nanda & Rhodes-Kropf 2014). But the technological progress that the capital funded and its large positive externalities remain (Angeletos, Lorenzoni & Pavan 2010). The Wall Street Crash of 1929 destroyed wealth for investors in electric power grids, but the power grids remained. The Crash of 2000 erased wealth for dot-com investors, but the Internet remained.

This may have special relevance for GPTs with positive network externalities (Katz & Shapiro 1985; Liebowitz & Margolis 1994). Recall that network externalities increase an innovation's value as more people adopt it: A telephone is a poor investment if yours is the only one but grows increasingly valuable in an expanding telephone network. Rational agents in mainstream economics avoid such investments because they cannot ensure others will invest, too. However, a Keynesian beauty contest generates the sort of leap of faith behavior necessary to roll out innovations with large network externalities.

If manias have these social benefits and if they outweigh the social costs of panics and crashes, economists' scolding bubble investors for irrationality may be overwrought (Cole 1720; MacKay

[11] Dicks & Fulghieri (2021) and Janeway, Ramana & Rhodes-Kropf (2021) survey behavioral finance research on investment booms in innovation during bubbles. See also the work by Frydman & Goldberg (2011) and Janeway (2018).

1841; Chancellor 1999; Reinhart & Rogoff 2009; Goldfarb & Kirsch 2019). Financial history illuminates this trade-off.

4. BUBBLES FOR NEEDHAM?

Two puzzles prominent in financial history research help organize the above work. The first is Needham's (2004) question: "Why did the West, and not China, get rich first?" (Shin 2018). The second is that irregularly recurring stock market bubbles are historically associated with surges in innovation and prosperity (Aliber & Kindleberger 2015; Janeway 2018).

4.1. Needham's Question

Until recent centuries, almost everyone everywhere lived in indistinguishably abysmal poverty (Bolt & van Zanden 2020). Then, beginning in the early 1600s, country after country escaped poverty (Deaton 2013). Science historian Joseph Needham (2004) documents China's historical technological superiority and asks "Why wasn't China first?"

Baumol (1990) describes Chinese innovations as sitting unused until rediscovered in the West and argues that initially unique Western institutions encouraged the use of innovations in business. Proposed institutions include natural resources wealth or absence (Sachs & Warner 2001; Morck & Nakamura 2018), imperialism-plus-slavery (e.g., Baptist 2014), and the patent, invented in renaissance Venice (Landes 1998). But abundant (or absent) natural resources are not unique to countries that escaped—nor are imperialism and slavery—and Moser (2016) concludes patents have, at best, an ambivalent contribution.

Rosenberg & Birdzell's (1986) finding that countries escaped poverty in step with the local rise of stock market financing suggests a fuller answer to Needham. If stock markets let Kindleberger cycles intermittently flood hot new technologies with capital to create positive externalities, country after country escaping poverty in the same sequence follows. This section reviews research specifically relevant to this hypothesis.

4.2. The First Stock Market and the First Mania

In the early 1600s, new mathematics revolutionized oceanic navigation (Davids 2015; Levy-Eichel 2015). Amsterdam navigation schools taught Mercator projections, trigonometry, logarithms, and the use of slide rules. Their alumni were the era's high-tech stars. Amsterdam also organized the modern world's first stock market to trade shares in the Dutch East India Company, whose spice trade made the city an entrepôt to other parts of Europe (Frentrop 2002). The stock market soon capitalized other companies that, using the new mathematics, moved high value-added goods (regrettably, including slaves) across oceans.

The first bubble also formed and popped in Amsterdam. By 1637, Dutch East India stock was up more than 250% (Petram 2011, p. 297), oceanic trade shareholders were rich, and investors sought high returns elsewhere. A prominent bubble arose in tulips, a status luxury good. In the 1630s, tulip prices soared and derivative securities priced notional tulips in quantities far outstripping their physical numbers. Tulips crashed in 1637, ruining speculators (scolded by moralists of subsequent ages) but leaving the economy largely undamaged (Goldgar 2008). Stocks recovered and resumed rising (Petram 2011, p. 98). The minuscule but technologically advanced Netherlands, for a time, became a world power.

4.3. The First International Mania

The 1688 Glorious Revolution, a Dutch intervention to oust Britain's Catholic king, brought Dutch finance—stock markets and joint stock companies—to London (Frentrop 2002; Barone

2007). Late seventeenth- and early eighteenth-century British shareholders avidly bought tech stocks in oceanic trading, steam engine pumps, and gas lights. Edmund Halley's actuarial tables formalized risk–reward trade-offs and revolutionized insurance.

As stocks rose, waves of initial public offerings (IPOs) floated trading, mining, manufacturing, mortgage, real estate, and pseudo high-tech companies, including possibly apocryphal "element transmutation" and "wheel of perpetual motion" firms (Mackay 1841). Stocks rose in London, Amsterdam (Frehen, Goetzmann & Rouwenhorst 2013), and Paris, where the Scottish escaped murderer John Law organized a stock market for his Mississippi Company (Murphy 2005). The sham nature of Law's company, and of John Blunt's South Seas Company in London (Balen 2002), brought on the Crash of 1720, ruining small investors in all three markets.

Afterward, however, Britain had oceanic trading, insurance, mining, steam pumps, and other new technologies (Carswell 1993). Britain also had a disruptive class of Whigs who "raised themselves from poverty to great wealth" (Davenant 1701) and pressed for liberal reforms. Britain's 1720 Bubble Act, requiring parliamentary charters for IPOs, lost traction over time as charters became routine. Holland also recovered, but France, suppressing its stock market longer and harder, fell behind (Murphy 2005).

4.4. New Technology Manias Throughout Financial History

Subsequent bubbles financed successive new technologies. In the 1790s, British investors took to canals. Canal stocks rose and collapsed several times, but by the 1810s, Britain's extensive canal network connected previously isolated inland regions to ports. In the 1820s, new mining and textiles technologies lifted stock prices. In January 1825 alone, 70 IPOs debuted. Speculation spread to bonds of the newly independent Latin American republics, each touted as the "next USA." Stocks crashed in December 1825 (Dagher 2018), and a Latin American debt crisis ensued. But the new technologies remained, and the new republics were established. Another canal bubble burst in 1836 in Britain and in 1837 elsewhere, but these bubbles left canal networks in America and Canada, too.

A railway bubble burst in 1847 in Britain and in 1848 elsewhere (Campbell 2012, 2013) but left railways throughout Britain, Europe, Canada, and the United States. A European bubble burst in 1857 but left industrial plants in place. Waves of breakthrough innovations in the 1860s and 1880s (Kelly et al. 2021) fueled bull markets that crashed in 1873 and 1893, each leaving new technologies in place—improved railroad and telegraph networks among the most important. The United States emerged as a new economic power. Rapid settlement in southern Latin America drew in capital, and another Latin American debt crisis in 1890 nearly destroyed Barings Bank.

Rising stocks from the mid-1890s into the early 1910s financed new technologies in cement, petroleum, steel, telephones, electric lighting, equipment, and transportation (O'Sullivan 2007). Stocks crashed and recovered, as capital poured into Australia, Canada, Japan, Germany, Scandinavia, and the United States. Each crash destroyed shareholder wealth but left industrialized economies.

The roaring twenties bubble (Nicholas 2007) lifted tech stocks such as Radio Corporation of America (radio), International Business Machines (adding machines), General Motors (automobiles), Pan Am (airfreight), and RKO (movies). Stock-financed electricity and telephone networks brought network externalities. Stocks crashed in 1929 but left all these new technologies in place. Sometimes under new ownership, tech firms continued commercializing major advances into the 1930s (Field 2003, 2011).

Tech bubbles also arose in the 1960s and 1990s. The 1960s bull market ended with a large real drop in stock prices, partly obscured by 1970s inflation, but left aerospace, mainframe computers, passenger jets, plastics, solid-state electronics, and synthetic fabrics industries in place. The 1990s dot-com bubble ended with the Crash of 2000 but left cell phones, the Internet, microcomputers, and software that increased productivity, including in many established industries.

4.5. Big New Markets Resemble Big New Technologies

Kindleberger (1978) describes most manias arising around new technologies but some around new markets, such as the new Latin American republics in the 1820s or East Asian Tiger Economies in the 1990s. Rosenstein-Rodan (1943) explains how economic development itself has huge network externalities. Like a telephone, a factory in a subsistence economy is an iffy investment if yours is the only one. A factory needs competing suppliers and customers, which all need their own competing suppliers and customers. Each new firm helps fill out the network and makes existing firms more viable.

Like patents and subsidies as innovation drivers, industrialization planning and foreign aid are problematic drivers of economic development (Easterly 2006). Here too, bubbles may succeed where rational agents and bureaucrats cannot. Hirano & Yanagawa (2016) show country-level bubbles drawing capital into promising middle-income economies but rarely into low-income economies. Allen (2001) argues that a threshold of domestic financial development is necessary for a bubble to form. Like the new technologies left in place after a tech bubble, the physical assets put in place during a new market economy mania remain to offset social costs of the panic and crash.

4.6. Kindleberger Cycles Draft One Market Failure to Defeat Another

Kindleberger (1978) discerns a common pattern in this centuries-long irregular cycle of manias, panics, and crashes. **Figure 3** summarizes, drawing connections to the research discussed above.

First, an exciting new technology, such as the Internet, or (less often) an exciting new market, causes a disequilibrium. With prices and costs misaligned, a few clever or lucky firms and investors earn large positive economic profits.

Other investors, finding valuing new technologies or markets procedurally transcomputational, mimic successful investors. Grappling with intrinsically unsolvable valuation problems, investors disagree and the highest bids set prices (Hong & Stein 2007). As positive externalities spread, so does general optimism (Pástor &Veronesi 2009). Information cascades arise (Angeletos, Lorenzoni & Pavan 2010). Adapting firms expand and proliferate as capital floods in. Rising investor demand lifts shares, further increasing investor demand. This positive feedback characterizes the cycle's bubble stage.

Credit expansion and deregulation ensue. Credit expands as investors borrow to invest even more. Small investors clamor for deregulation to get a piece of the action. Akerlof & Shiller (2010, p. 154) attribute US deregulation prior to 2008 to a "belief that the opportunities to take part in the housing boom were not being shared fairly." These effects are more extensive in some cycles than others. Small shareholders borrowed heavily in the 1920s bubble but not in the 1990s bubble.

Kindleberger (1978) calls the next stage, the instant of collective insight that stocks are celestially overvalued, the Minsky moment, honoring Minsky's (1986) observation that bubbles burst on days of little or no other news. Many forces combine to delay Minsky moments. Creative accounting touches up financial reports; larger frauds obscure earlier rule-bending. Financial engineers help with new ways of disguising high leverage, the conventional way of jacking up returns (Geanakoplos 2010). Deregulation and monetary expansions that prolong credit expansions keep bubbles inflating. Sometimes, a second Minsky moment is needed. After one market crashes, investors seek high returns elsewhere. Secondary bubbles, often in highly leveraged real estate, inflate and, after their own Minsky moments, burst.

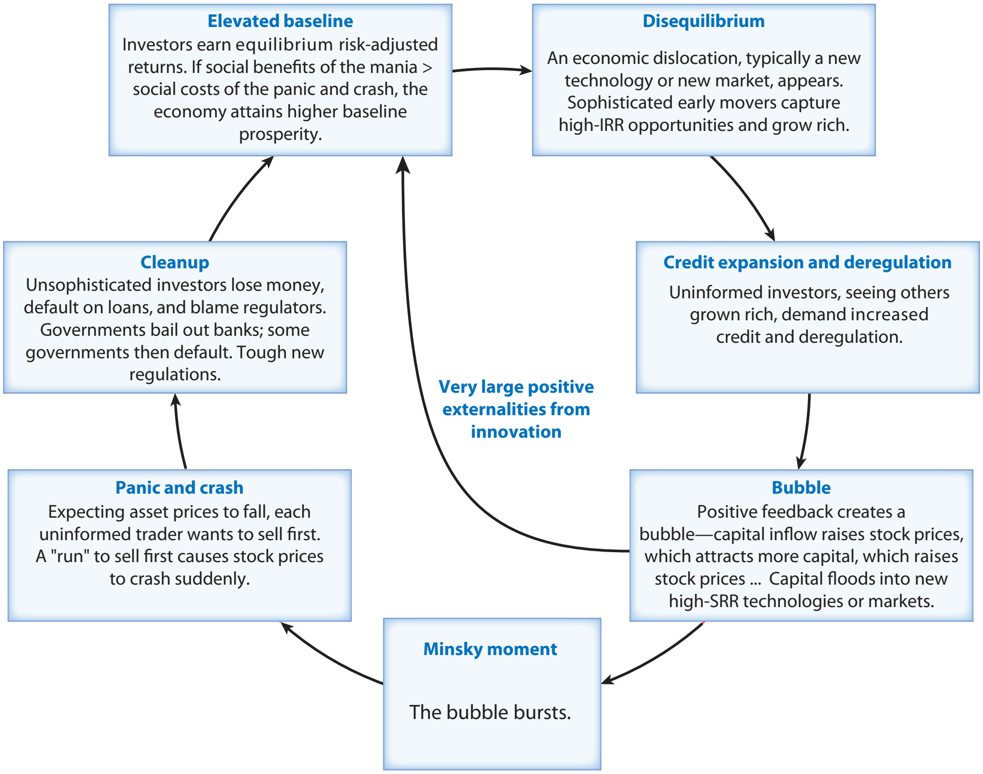

Figure 3

Kindleberger cycle growth engine. Kindleberger describes a historical cycle of financial manias, panics, and crashes following a common pattern, each preparing the way for the next, and most rolling out major new technologies or markets with large productivity-increasing positive externalities. Each completion of the cycle ratchets productivity up to a higher baseline level after the economy recovers from the panic and crash. Abbreviations: IRR, internal rate of return; SRR, social rate of return.

A panic and crash ensue. Investors, fearing others fear that others will no longer deem stocks beautiful, rush to sell first, before prices fall. All investors running to sell first, a market run, crashes stocks (Bolton, Santos & Scheinkman 2011). If enough investors who borrowed to buy into the bubble then default, stressed financial institutions curtail regular lending and a recession ensues (Reinhart & Rogoff 2009).

A cleanup stage follows. Frauds are exposed. Political calculations press governments and central banks to bail out large banks and firms. To pay for bailouts, governments hike taxes, print money, and borrow, sometimes risking their own financial stability. Angry voters demand tough new regulations. Free-market economics looks tainted, and alternative systems garner attention.

A secular stagnation era of near-equilibrium growth follows, paying investors sedate equilibrium returns (Gordon 2015). Over time, regulators succumb to lobbying (Stigler 1971), ex-innovators become entrenched monopolists, and the end of progress is proclaimed (Horgan 1996; Gordon 2016).

After an irregular interval, another dislocation initiates a new Kindleberger cycle. Forgetting the misfortunes of their elders, or former selves, people in high-income economies have been repeating this cycle for four centuries. If each cycle lifts productivity, albeit not stocks, to a new permanently higher plateau, this is no cause for despair, for bubble investors' private losses are laudable sacrifices for general prosperity.

5. EVOLUTIONARY ECONOMICS AND SELECTION FOR KINDLEBERGER CYCLES

Evolutionary economics, which replaces the rational maximization assumptions of mainstream economics with trial and error plus the survival and spread of what seems to work, can organize the above streams of research to answer Needham's question.[12] Economic selection is uncontroversially multilevel—simultaneously between individuals, firms, and economies. For economy-level selection to favor institutions prone to Kindleberger cycles, their social benefits must exceed their social costs. If investors who lose in bubbles are nonetheless better off by living in such an economy, the case is even firmer.

5.1. Social Gains from Mania-Financed Innovation

Evidence that bubbles have social benefits is accumulating.[13] Stock market bubbles coincide with sharply elevated corporate investment (Martin & Ventura 2018), especially by firms with important patents (Haddad, Ho & Loualiche 2020). This encourages CEOs to direct more investment to hot technologies (Dang & Xu 2018). Option valuation effects can also elevate tech stocks (Kerr, Nanda & Rhodes-Kropf 2014), drawing in more capital. Unusually important innovations were financed in the 1920s (Field 2003, 2011; Nicholas 2008) and 1990s (Dang & Xu 2018) bubbles, implying larger positive externalities (Kogan et al. 2017; Shin & Subramanian 2019). Martin & Ventura (2010), Tanaka (2011), Lansing (2012), and Takao (2017) model bubbles easing financing constraints and promoting investment. Eatwell (2004) describes bubbles allocating capital to profitable investments left unfunded by capital rationing or managerial myopia and unprofitable investments with large positive externalities.

During bubbles, R&D rises more than capital investment (Dang & Xu 2018). R&D-intense firms, often young and without earnings histories or collateral, cannot easily borrow and therefore rely on stock markets (Brown, Martinsson & Petersen 2012; Hsu, Tian & Xu 2014; Acharya & Xu 2017). Such firms are exceptionally likely to list and issue more shares during bubbles (Brown, Fazzari & Petersen 2009; Aghion et al. 2012) to fund current and future R&D (Brown, Fazzari & Petersen 2009; Brown & Petersen 2011; Brown, Martinsson & Petersen 2012). As the bubble expands, takeovers of tech firms enrich their founders (Phillips & Zhdanov 2013). Early twentieth-century inventors (Nicholas 2010) and late twentieth-century venture capitalists and IT entrepreneurs (Gompers & Lerner 1999) often listed and sold to acquirers, locking in high returns for themselves and leaving the crash to others.

Flooding capital across sectors or economies allocates capital indiscriminately, not precisely. Still, Ashton (1948, pp. 83–84) concludes that, although the British canal mania of the late 1770s "undoubtedly led to some waste of national resources," its benefits were greater because "agricultural regions which had been remote from the center were brought within the widening circle of exchange; the fear of local famine, of both food and fuel, was removed; and the closer contact with others, which the new means of communication afforded, had a civilizing influence." Given the high SRRs of innovation, precisely targeted chronic underinvestment is not obviously socially preferable to indiscriminate abundant investment.

[12] See Nelson et al. (2018) for a survey; see Lo (2017) and Lo & Remorov (2021) for connections to finance.
[13] Researchers in macroeconomics (Martin &Ventura 2018; Simsek 2021) and finance (Jarrow 2015, Dicks & Fulghieri 2021) are rethinking bubbles, long deemed to be growth inhibiting. If underwriting fees, information costs, or other frictions reduce investment, bubbles that increase investment can have at least ambiguous growth implications. This revisionism is not universally accepted. Bosi & Pham (2016) propose taxing bubbles to subsidize innovation.

5.2. Sandbagging Stock Markets to Contain Social Costs

If the panic and crash end the story, stock market investors are poorer but a wealthier economy moves on. If a financial crisis or major downturn ensues, social costs are larger. Financial crises worsen health outcomes, trust in institutions, and political polarization and reduce long-run trend GDP by 2–10% (Sufi & Taylor 2021). More credit expansion during the mania heralds worse crises and downturns (Reinhart & Rogoff 2009; Greenwood et al. 2020; Sufi & Taylor 2021).

More lending to mania investors leaves lenders' balance sheets heavier with nonperforming loans after the crash. This can trigger a chain reaction. Financial institutions, hoarding cash to rebuild their balance sheets, curtail normal lending to fundamentally sound firms. These firms must then cut investment, downsize, or even fail. Laid-off workers default on loans. Financial institutions' balance sheets weaken further, and the downward spiral intensifies. Financial institutions without deposit insurance fear bank runs (Diamond & Dybvig 1983), all their depositors running to withdraw their savings before the institution fails. This fear itself can cause those institutions to fail.

To prevent these outcomes, governments regulate banks and financial institutions to limit risky credit expansions. However, these regulations often falter as manias intensify (Jorda, Schularick & Taylor 2013; Krishnamurthy & Muir 2020; Fahlenbrach, Prilmeier & Stulz 2018). Regulators limiting credit to avid investors find little political support, and shadow banks, outside the gambit of bank regulators, arise to do what banks cannot. Bankers, losing business, lobby for deregulation. Like investors, government officials confronting procedurally transcomputational problems follow the herd (Bošković, Byrne & Magesan 2013) and deregulate.

After crashes, governments bail out banks and shadow banks to prevent a deeper financial crisis (Bernanke 1983). Bailouts are expensive. Lucas (2019) puts 2008 US bailout costs at 3.5% of GDP. Kaminsky & Reinhart (1999) put mean bailout costs in financial crises at 5–13% of GDP. Overall, financial crises' macroeconomic costs, assessed as precrisis trend minus actual GDP growth, range from 2.4% to 20% of GDP, with most clustering in the lower range.[14] However, these estimates overstate social costs if, without Kindleberger cycles, precrisis trend GDP growth would have been far lower.

5.3. Secondary Bubble Social Costs

Bubbles can ferment more bubbles. Bubbles spread from stock market to stock market, and to real estate and even consumer goods. Kapeller & Schütz (2014) argue that high returns in technology bubbles increase inequality and spending on goods that signal high social status (Veblen 1899). Shiller (2020) suggests that hot technology goods of their eras—telephones, automobiles, cell phones, or Bitcoin—confer status, which increases demand for them, further increasing their prices and Keynesian beauty (status goods signal status because others believe they do).

Bubbles in status-signaling high-tech goods can thus fund yet more money into innovation. Other status good bubbles are not obviously socially beneficial. Status-seeking bourgeois investors in 1630s Holland bid up tulip prices. A bubble in Beanie Babies, unprepossessing toys, inflated and popped alongside 1990s tech stocks (Bissonnette 2016).

Rising inequality can also inflate real estate, pricey properties being another status good. Real estate bubbles have major social costs because financial institutions routinely accept real estate as collateral for loans. Credit therefore readily expands as real estate bubbles inflate. Chen & Wen (2017) describe initially high network externality returns falling as China's networks of suppliers

[14]Sufi & Taylor (2021) review this literature as well as financial crises' associations with health problems, mistrust in institutions, and political polarization.

and customers filled out, and investors seeking continued high returns subsequently inflating a real estate bubble. Secondary real estate bubbles also accompanied rollouts of canal, railway, telegraph, and electric power networks. The 2008 global financial crisis was plausibly secondary to the 1990s tech bubble. To stimulate their economies after crashes, central banks often cut interest rates, risking socially costly credit-fueled real estate bubbles in the wake of socially useful tech bubbles.

5.4. Social Summations

Economic comparisons of these social gains and losses are remarkably rare. Lansing (2009) finds that the social benefits of increased investment exceed the social costs of increased volatility from bubbles. Lansing (2012) models tech bubbles with costly crashes and calculates that social benefits outweigh social costs if the technology's SRR exceeds 2.5 times its IRR. **Figure 2** suggests that SRRs of corporate R&D exceed this. Historians (Perez 2002; Gross 2007; Janeway 2018) and, with considerable sophistication, marketing researchers (Sorescu et al. 2018) also conclude the social benefits of bubbles exceed their social costs.

Olivier (2000) models stock market tech bubbles as productivity enhancing and credit expansion bubbles as productivity diminishing. Janeway (2018) sees credit expansions magnifying tech bubbles by funding more innovation and boosting aggregate demand. Nonetheless, crashes that leave credit-granting institutions with large nonperforming loan portfolios herald worse financial crises and more protracted downturns (Reinhart & Rogoff 2009; Aliber & Kindleberger 2015).

Regulations that keep credit from deepening capital floodwaters during manias might in some cases render Kindleberger cycles less socially costly. Regulations enacted after a crash sometimes have this objective, as when the United States imposed margin requirements on stock market investments after the 1929 crash. But postcrash regulations are readily eroded (Dagher 2018) and some, notably short-sale restrictions, are actually conducive to future manias (Hong & Stein 2007). This regulatory timidity requires explanation.

5.5. Suspending Cardwell's Law

Cardwell's Law is the historical regularity that societies are technologically innovative only briefly (Cardwell 1972, p. 210). Innovators are often political outsiders. Rapid innovation threatens individuals, firms, and communities with old-technology skills or assets, who are often politically well connected. Schumpeter [1934 (1911)] warns innovators of ostracism, condemnation, and even violence. Opponents of innovation, from eighteenth century Luddites to twenty-first century anti-GMO activists (Mazur 1975; Jones 2013; Juma 2016), successfully slowed innovation (Mokyr 2000; Wu 2010; Jaffe & Lerner 2011).

Opposing innovation plausibly evokes basic behavioral heuristics. Prospect theory shows people fear losses more than they value gains of equal magnitude (Kahneman & Tversky 2013). This may reflect Edmund Burke's (1790) precautionary principle: Survival is precarious, and change with even a tiny risk of disaster is unwise, which motivates both political conservatism and environmental conservationism.

Kindleberger cycles plausibly check Cardwell's Law by evoking countervailing heuristics: fascination with novelty, success emulation, and comfort in following the herd. Novelty activates the brain's dopamine system: intermittent success, repeated or observed, elicits more repetition, optimism, and thus bubbles (Hirshleifer 2015; Bikhchandani et al. 2021). Early movers' highly visible disequilibrium profits thus cue investors and CEOs into financing cascades of additional investment in similar things.

Group-level natural selection can favor novelty-seeking if, for example, lives saved by an expanded food supply exceeds deaths from tasting unfamiliar plants (Williams & Taylor 2006; Wilson & Wilson 2008), perhaps explaining investor excitement with new technologies (Galor & Michalopoulos 2012). A "disposition to admire, and consequently to imitate, the rich and the great" (Smith 1759) also has plausible survival value (Gibson & Hoglund 1992; Blackmore 1999, pp. 74–81; Bikhchandani et al. 2021) and may explain uninformed investors imitating successful investors (Bikhchandani, Hirshleifer & Welch 2006). A fear of missing out may reinforce this (Janeway 2018; McGinnis 2020). A few high-profile winners thus make optimism contagious (Barsade 2002), as in Keynes's (1936) theory of animal spirits–driven stock markets.

Economies with institutions that enlist these heuristics to power Kindleberger cycles may, despite suffering panics and crashes, outcompete other economies by defying Cardwell's Law. This perhaps explains why high-income economies chronically failed to retain laws that suppress Kindleberger cycles; economies that did uphold such laws having ceased being successful.

5.6. Economic Selection for Kindleberger Cycles

Mokyr (1994) posits economic selection favoring economies that escape Cardwell's Law and sustain ongoing innovation. Economic selection being multilevel, fast and discrete (Lo 2017) may be important for Kindleberger cycle–prone institutions.

Economic selection is multilevel (Nelson & Winter 1982), pitting individuals against individuals, firms against firms, and economies against economies, with higher-level selection often overwhelming lower-level selection. IBM dominated computers until the 1980s, when its top executives, all mainframe engineers opposing microcomputers to safeguard their positions, won the competition between individuals within IBM, but saw IBM sidelined in firm-level competition (Betz 1993). In a similar vein, Rosenberg & Birdzell (1986, pp. 136–39) describe competition between nations suppressing Cardwell's Law:

> In the West, the individual centers of competing political power had a great deal to gain from introducing technological changes that promised commercial or industrial advantage. Once it was clear that one or another of these competing centers would always let the genie out of the bottle, the possibility of aligning political power with the economic status quo and against technological change more or less disappeared from the Western mind.

Nineteenth-century mania investors ruined by financing canal, railway, and telegraph networks (Standage 1998) left more productive economies for governments to tax in order to finance armies and navies. Some mania-financed technologies also had direct military spillovers. Railways accelerated troop movements and intelligence transmission from the speed of horses to those of locomotives and electricity. France, having dampened stock speculation after the Mississippi Company bubble (Murphy 2005), had only 750 miles of telegraph wire by 1852 (Gross 2007). Proliferating loopholes in Britain's contemporaneous Bubble Act let manias finance telegraphy and other innovations. Britain's larger tax base funded a Royal Navy to rule the waves.

Economic selection is fast. Natural selection is Darwinian: The unfit die, the fit survive to procreate. Economic selection is Lamarckian: The unfit imitate the fit. Heuristics spread without people, firms, or economies dying. Investment manias jump from country to country, spreading positive externalities of new technologies, abetted by governments failing to suppress speculation or enforce foreign patents.[15]

[15]For specific US, Canadian, and Japanese government policies, see Harris (2017) and Andreas (2013), Bliss (1987), and Morck & Nakamura (2005).

Economic selection can jump. Natural selection moves in small increments to local optima. Cephalopod eyes are better designed than vertebrate eyes, whose blood supply is on the front of the retina (Lents 2018). Because no sequence of small improvements leads from one to the other, humans cope with second-class eyes. In contrast, Kindleberger cycles and capital floods can raise entirely new technologies and wash away old ones. No sequence of small improvements led from horses to automobiles, nor from feudal Japan to Asia's first industrialized economy (Morck & Nakamura 2005). Such transformations are large discrete jumps.

In these ways, economic selection may be more powerful than natural selection. Multilevel economic selection may thus do far more than eliminate the dead-weight losses of standard economic models. Economic selection for institutions conducive to Kindleberger cycles may check Cardwell's Law.

6. CAPITAL HYDRAULICS

Irving Fisher built a model economy of pipes, pumps, valves, floaters, and reservoirs of aqueous capital that inspired general equilibrium economics (Brainard & Scarf 2005). Several seemingly disconnected streams of research suggest Kindleberger cycles induce periodic inundations of capital that disequilibrate that plumbing and increase its capacity. As annual Nile floods renewed Egypt, intermittent capital inundations may renew the prosperity of the modern world. If they finance high-SRR positive externalities from innovation and suspend Cardwell's Law, Kindleberger cycles are a critical advantage, not a troubling flaw, of free-market economies.

Economy-level selection is ongoing, and current institutions are works in progress. To end annual flood damage, Egypt built the Aswân High Dam and adopted chemical fertilizers. Ending capital floods seems untenable until much improved IP laws, innovation subsidies, or entirely new innovation-promotion policies can replace Kindleberger cycles. Meanwhile, policy makers might seek to accentuate the social benefits of manias and attenuate the social costs of panics and crashes.

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