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METHOD IN THE MADNESS OF CROWDS?

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Kindleberger Cycles: Method in the Madness of Crowds?

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ABSTRACT

Corporate R&D has a social rate of return several times higher than its internal rate of return to innovating firms, and so is chronically underfunded from a social perspective. Kindleberger cycles of stock market manias, panics and crashes, prominent in financial history, also accord poorly with rationality. If episodes of mania 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.

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1. No Bubbles in the USSR

Kindleberger (1978) documents an irregular cycle of stock market manias, panics and crashes from the early 1600s on. In 2008, Fed chair Alan Greenspan mused “There were no bubbles in the Soviet Union” and posited that a cycle of manias, panics and crashes might underlie free market economies’ prosperity.¹ Seemingly unconnected stylized facts from different corners of economics coalesce to back this.

Technological progress, not increased inputs, explains most economic growth (Solow 1957). This is because innovation has very large positive externalities. This is because innovation has very large positive externalities. That is, one firm’s innovation often opens ways for others (external to the firm) to boost productivity too. Technological progress occurs as all these firms come to produce higher valued outputs from given inputs. Innovations with positive externalities spanning the entire economy, called general purpose technologies (GPTs), can generate vast new wealth (Bresnahan and Trajtenberg 1995; Bekar et al. 2018). Alexander Graham Bell made a decent return on the telephone, but others generated far more by finding valuable uses for instantaneous voice communication (Fischer 1994).

Large positive externalities lift innovation’s *social rate of return (SRR)* to the economy far above its *internal rate of return (IRR)* to the initial innovator (Hall et al. 2010; Jones and Summers 2020). Because profit maximizing firms only consider their own *IRRs*, much high-*SRR* R&D almost certainly lies latent. Actual R&D being a small fraction of socially optimal R&D is an epic market failure. Externality economics prescribes R&D subsidies and intellectual property (IP) to boost R&D to boost innovators’ *IRRs*; however, mounting evidence contests the efficacy of both policies (Jaffe and Lerner 2011).

Financial economics provides equations corporations and governments might use to govern investments in innovation. However, these problems are *procedurally transcomputational*, meaning no procedure exists for ascertaining the numbers needed to solve them. Behavioral economics shows that, in such situations, people learn by reinforcement, imitate others, and herd (Shiller 2020).

This behavior is associated with a second market failure of comparable importance, the irregular

¹ Quoted in Guha, Krishna. 2008. Greenspan urges focus on banks’ capitalization, *Financial Times* May 26, 2008

cycle of stock market manias, panics and crashes Kindleberger (1978) discerns throughout modern financial history. Each cycle begins with a disequilibrium, usually a hot new technology, sometimes a new market, with very high expected *IRRs*. A mania inflates stocks associated with the disequilibrium. A panic, crash and (sometimes) major downturn follow.

Economic evolution is multilevel and Lamarckian, and so might favor the survival and emulation of institutions that prevent wasteful wealth destruction. However, tough new regulations enacted after a crash readily fall aside in the next mania (Reinhart and Rogoff 2009; Dagher 2018). Moreover, mania-prone stock markets financed early industrializations of all large high-income economies (Morck and Steier 2005; Demirgüç-Kunt and Levine 2018), including Germany (Fohlin 2005) and Japan (Morck and Nakamura 2005), which subsequently gave banks prominence. Across countries, economic development historically tracks stock markets (Rosenberg and Birdzel 1986).

All this coalesces to suggest economic evolution favors mania-prone stock markets. Economies may prosper because their Kindleberger cycles inundate successive new technologies with capital, countering otherwise chronic underinvestment in innovation. Mania-prone stock markets may thus be a pivotal positive externality innovation. Consequently, rather than deplore investor irrationality, policy makers might seek to improve social benefit-cost ratios of Kindleberger cycles. Less credit expansion in manias better confines crashes within stock markets (Sufi and Taylor 2021) and may explain Samuelson's (1966) observation "the stock market has predicted nine of the past five downturns."²

2. Larger Social Returns than Private Returns to Innovation

2.1 Technological Progress Explains Most Economic Growth

Solow (1957) shows technological progress underlies most economic growth. 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: successions of new technologies displacing older ones, each producing higher-valued output from inputs of given costs.

² Newsweek, Sept. 9, 1966.

Endogenous growth theory affirms, formalizes and expands Solow’s insight (Akcigit and Nicholas 2019) and research into productivity growth relates Solow residuals to research and development (R&D) and various measures of patenting (Jones and Summers 2020). Figure 1 shows Solow residuals, approximated by cumulative multifactor productivity growth, larger where private-sector R&D is larger.

This is good news, in that ongoing prosperity depends on potentially unlimited new ideas, not on limited tangible inputs. Although Gordon (2016) concludes innovation is slowing markedly, Mokyr (2018) reports that the pace of innovation has fallen before, only to rise again. Trajtenberg (2018) and Choi (2018) see machine learning and 3D printing as nascent technologies with vast potential to increase productivity.

2.2 Chronic and Pervasive Underinvestment in Innovation

In general, corporate R&D has *IRR* of 10 to 15% and *SRRs* well over 40%. The *SRR* minus *IRR* gap varies across industries and over time. Griliches (1957) estimates *SRRs* of agricultural innovations at 35 to 40% versus a 10% *IRR* benchmark. Subsequent work, reviewed by Hall et al. (2010), affirms innovations having *SRRs* manifold higher than their 10 to 15% *IRRs*. Bloom et al. (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 to 101% in pharmaceuticals and by 49 to 62% in computers, but by little if anything in general machinery and equipment. Jones and Summers (2020) calculate that “under conservative assumptions, innovation efforts produce social benefits that are *many multiples of the investment costs*.”

Figure 2 summarizes. Profit-maximizing firms undertake R&D whose *IRR* exceeds its cost of capital, k . Plausible k estimate range from the riskfree rate r_f to r_f plus twice the market risk premium.³ The lower bound is near zero in recent years, the upper bound is in the 10% to 15% per year range, where

³ 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 riskfree 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 λ s. Welch (2020) provides β s for US stocks. Innovation is risky but, at least early on, also highly idiosyncratic (Pástor and Veronesi 2009), with successes cancelling failures. Consequently, some R&D can be essentially riskfree ($\beta = 0$) to diversified investors (Jørring et al. 2017). Systematically riskier R&D requires $\beta > 0$. Welch’s β s never exceed four and 98.4% are below two. Consequently, k ranges from r_f to $r_f + 4\lambda$, with most in the $[r_f, r_f + 2\lambda]$ interval and many at the lower bound of that interval.

Hall et al. (2010) put plausible *IRRs* for R&D. Bloom et al (2020) estimate median *SRRs* of listed firms' R&D ranging between 60% and 80% per year; rising in the early 1990s, as IT innovation gained salience, falling from the mid-1990s on as capital flooded in, and then stabilizing after the 2000 crash. Their lower 40% to 60% range for *SRRs* of aggregate R&D highlights the importance of stock markets in financing very high *SRR* innovation. Both *SRR* ranges far exceed estimated ranges for *IRR* and k . This is consistent with corporate R&D being, on average, profitable to innovating firms and being manifold more important to the economy as a whole.

Firms acting for society would do all R&D whose *SRR* exceeds k , including R&D with $IRR < k$. Indeed, Scherer (1999) argues much socially beneficial R&D has negative *IRR*. Consequently, the R&D profit maximizing firms do is chronically and profoundly short of what socially optimal R&D would be.

2.3 Problematic State Interventions

Externality economics (Pigou 1920) prescribes policy responses to such market failures, but each raises more problems. One response is intellectual property (IP) law. Stronger and longer patents and copyrights raise a firm's *IRR* from any given innovation, but may not accelerate aggregate innovation (Brown et al. 2017). First, larger or longer streams of profits from one innovation makes finding another less urgent. Second, stronger IP for initial innovators limits spin-off innovations by others (Caballero and Jaffe 1993). Third, *patent trolls* "game" IP, accumulating patents someone might someday infringe. A \$612.5 million lawsuit for violating a troll's "wireless e-mail" patent crippled Blackberry, a smartphone pioneer (Sweeny 2009). Accumulating evidence suggests intense political lobbying (Saperstein 1997; Drahos 2003) has increasingly reshaped US IT law to impede, rather than encourage, innovation (Jaffe and Lerner 2011).

A second policy response is state-subsidized R&D.⁴ Zúñiga-Vicente et al. (2014) summarize research into these policies as uneven, inconclusive, and reflecting "rising concern about the effectiveness of public subsidies." Two patterns are noteworthy: First, unlike private-sector R&D in Figure 1, public

⁴ 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 et al. 2017).

sector R&D is not clearly correlated with productivity growth (e.g. OECD 2003). Second, state-financed R&D appears to have lower *IRRs* and *SRRs* than private-sector R&D (Hall et al. 2010).

Several explanations are proposed. First, state-funded basic science R&D plausibly has social returns that spill over borders, take decades to commercialize, or advance medicine rather than GDP (Ahmadpoor and Jones 2017; Azoulay et al 2019, 2021). Second, as thermodynamics arose to explain working steam engines (Gillispie 1960, 357), some basic research may explain, not inspire, new technology (Edgerton 2004). Other explanations raise policy concerns. Corporations, universities and labs patent state-subsidized R&D, so dysfunctional IP law remains a problem (Lach and Schankermann 2004). Cash-strapped universities, selling state-subsidised patents, may even fatten patent trolls (Watkins 2014). Government officials have difficulty “picking winners” to subsidize (Beason and 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. University misgovernance may also misallocate state funding (Goolsbee 1998; Sokal and Bricmont 1999; Strevens 2013; Ioannidis et al. 2014), including in economics (Kwak 2017). State-subsidized R&D at large corporations, universities, and government labs elsewhere may even draw talent away from innovative new firms’ higher *SRR* R&D efforts (Goolsbie 1998; Lach 2002).

3. Evaluating Ideas

Corporations and governments assessing R&D spending both have intrinsically difficult problems. Understanding how people actually make such decisions illuminates how economies may actually counter the problem of chronic and pervasive underfunding of innovation

3.1 Procedurally transcomputational problems

Governments and corporations making such decisions find economists’ expectations of rationality daunting. Financial economics deems an R&D project viable to a firm if the *IRR* exceeds the cost of capital and worthy of state subsidies if the positive externalities exceed the negative, and provides exact equations for both. Looking back, assessing a new technology’s effect on a firm’s profits or an economy’s GDP is

merely difficult. But when investments are made, predicting *IRRs* requires either knowledge of or abstract assumptions about 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.⁵ Predicting *SRRs* requires all these numbers plus social values of all externalities. A few of these numbers are unreliably guestimatable; most are fundamentally unknowable.

Told to evaluate an investment project, students are given almost all these numbers and As for solving the equations. Alumni have almost none, yet make real decisions. Experience fills in numbers and justifies assumptions for familiar repeated investments. But innovations are literally new; their prospects often unknowable. Keynes' (1936) 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, the deeper our current ignorance and, the more outrageous the conceit that mathematical expectations provide insight. Keynes' critique is frequently elaborated and acknowledged (e.g. Simon 1957; Nelson and Winter 1982; King and Kay 2020), but business students memorize ever more intricate equations of mathematical expectations.

Mathematical problems whose solutions must exist, but require impossible computing power, are called *transcomputational* (Bremermann 1962). Grossman and Stiglitz (1980) distinguish *substantive rationality*, the optimization of standard economic theory, from *procedural rationality*, optimization of the

⁵ Business schools teach students to predict 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 (raw materials, intermediate goods, and categories of employees, for example), taxes due $\tau_{s,t}$, all in every future time t in every possible state of the world s , and the probabilities $\pi_{s,t}$ of the world being in possible each 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 $q_{m,s,t} = f_{m,s,t}(q_{1,s,t} \dots q_{n,s,t} \dots q_{N,s,t})$. The *IRR* is then compared to a cost of capital, obtained by predicting the project risk consequences to a diversified investor.

To predict a project's social rate of return, officials need only determine 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 states of the world at each future time and all other variables as in the *IRR* equation.

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. Evaluating the new technologies easily qualifies.

3.2 Behavioral finance, beauty contests and capital inundations

Facing procedurally transcomputational problems, people use Simon's (1957) *bounded rationality*. New problems stimulate 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 and Winter 1982; Kahneman 2011). Behavioral economics characterizes heuristics as *biases*, but King and Kay (2020) reject this term where procedurally transcomputationality leaves unbiased behavior undefinable.⁶ Rather, economic selection, like evolutionary algorithms in machine learning, hones heuristics towards decision-making with ever better outcomes (Lo 2019; Lo and Remorov 2021). Economic selection may thus “defeat the dark forces of time and ignorance which envelop our future,” Keynes' (1936) definition of investment success, where economic rationality cannot.

The heuristic “imitate those who likely knows what to do” has survival power. It is readily elicited in laboratories, evident in many real settings, and resonant with a human propensity to conform (Hirshleifer 2015, Bikhchandani et al. 2021). It persists because it often seems successful, but it can also cause overreactions in ways that plausibly drive 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 lift 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.

Any investors who realizes a bubble is inflating are caught in what Keynes (1936) calls an investment beauty contest.

⁶ Kahneman (2011) and Hirshleifer (2015) review this literature.

“It is not a case of choosing those [faces or investments] 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.”

Any rational investors who exist seek to buy stocks they expect heuristic-driven investors will soon deem more beautiful. Owning what others deem beautiful can also convey social status, further strengthening the positive feedback (Veblen 1899). Information cascades, turbo-charged by these effects, can escalate stock prices and inundate firms in sectors associated with high-profile innovations.

Stock market investing provide randomized rewards highly conducive to bubble formation (Smith et al. 2014). Volunteering extra taxes to promote state-funded innovation, has no analogous allure.

3.3 The social value of capital inundations

Bubbles can flood capital across innovations rational profit maximizing firms would shun; and in volumes government subsidies could not match. After the flood abates, the crash harms small investors, corporate acquirers (Moeller et al. 2005) and even venture capitalists (Kerr et al. 2014). But the technological progress that capital funded and its large positive externalities remain (Angeletos et al. 2010).

The Crash of 1929 destroyed the wealth of investors in electric power grids, but the power grids remained. The 2000 crash erased the wealth of dot.com investors, but the internet remained. As innovations spread, many – especially GPTs – have increasing returns to scale from positive network externalities (Katz and Shapiro 1985; Liebowitz and Margolis 1994). A telephone is a poor investment if yours is the only one, but grows increasingly valuable in an expanding telephone network. Investing in an innovation whose value depends on network externalities requires a leap of faith about what others will do. Information cascades and Keynesian beauty contests recast such leaps of faith as socially valuable heuristics.

This contrasts with the scolding for greed and folly bubble investors typically draw (MacKay 1841; Cole 1720; Chancellor 1999; Reinhart and Rogoff 2009; Goldfarb and Kirsch 2019). Financial manias have social benefits that might counterbalance the social costs of panics and crashes. Financial history illuminates

this trade-off.

4. Bubbles for Needham

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

Incomplete answers include natural resources or their absence (Sachs and Warner 2001; Morck and Nakamura 2018), and imperialism-plus-slavery (e.g. Baptist 2014). But abundant (or absent) natural resources are not unique to the countries that escaped; nor are imperialism and slavery. Answering Needham requires unique explanations.

Baumol (1990) describes major Chinese innovations sitting unused until rediscovered in the West and argues initially unique Western institutions encouraged economic application of innovations. Rosenberg and Birdzel (1986) describe countries escaping poverty in step with laws encouraging business corporations able to raise vast pools of capital in stock markets.⁷ But stock markets also allowed Kindleberger cycles that intermittently flooded hot new technologies with capital in countries that had them.

4.1 The first stock market and the first mania

In the early 1600s, new mathematics were revolutionizing oceanic navigation (Davids 2015, Levy-Eichel 2015). Amsterdam schools taught navigators Mercator projections, trigonometry, logarithms and 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 Indies 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 (including slaves) across oceans.

The first bubble also formed and popped in Amsterdam. By 1637, Dutch East Indies stock was up

⁷ Landes (1998) also highlights patents, invented in Venice, encouraging the development of innovation in the West; however, scarce knowledge not patent law, appears critical to early disequilibrium profits in many cases.

over 250% (Petram 2011, p. 297), oceanic trade investors were rich, and speculative investors sought high returns elsewhere. The bubble arose in tulips, a status luxury good, not stocks. 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 miniscule Netherlands, for a time, became a world power.

4.2 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 17th and early 18th century British shareholders avidly bought tech stocks in oceanic trading, steam engine pumps, and gas lighting, among others. Edmund Halley's actuarial tables formalized a risk-reward trade-off and revolutionized insurance.

As stocks rose, a wave of 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 et al. 2013) and Paris, where the Scottish escaped murderer John Law organized a stock market for his Mississippi Company (Murphy 2005). The fraudulent nature of Law's company, and of John Blunt's South Seas Co. in London (Balen 2002), brought on the Crash of 1720, ruining small investors in all three markets.

But afterwards, Britain had oceanic trading, insurance, mining, steam pumps and other new technologies (Carswell 1993). Britain also have a disruptive class of Whigs who "raised themselves from poverty to great wealth" (Davenant 1701) and pressed for liberal reforms.

4.3 New technology manias

Subsequent bubbles financed successive new technologies. In the early 1790s, British investors took to canals. Canal stocks rose and collapsed several times, but by the 1810s left Britain a network that connected previously isolated inland regions to ports. In the 1820s, new mining and textiles technologies lifted stock

prices. In January 1825 alone, seventy 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 1837 elsewhere, but left canal networks in America and Canada too.

A railway bubble burst in 1847 in Britain and 1848 elsewhere (Campbell 2012, 2013), but left railways throughout Britain, Europe, Canada and the US. A European bubble burst in 1857, but left industrial plant in place. Waves of breakthrough patents in the 1860s and 1880s (Kelly et al. 2021) heralded bull markets that crashed in 1873 and 1893, each leaving new technology– improved railroads, telegraph systems among the most important. The US emerged as a major economic power. Rapid settlement in southern Latin America pulled in capital and a second 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, and electric lighting, equipment, and transportation (Osullivan 2007). Stocks crashed and recovered as capital poured into Australia, Canada, Japan, Germany, Scandinavia and the US. Shareholders lost in each crash, but all these economies were left industrialized.

The Roaring 1920s bubble (Nicolas 2007) lifted -tech stocks such as Radio Corporation of America (radio), International Business Machines (adding machines), General Motors (automobiles), PanAm (airfreight), and RKO (motion pictures). Stock-financed power 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 making 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 the high inflation of the 1970s, but left aerospace, mainframe computers, passenger jets, plastics, solid-state electronics, plastics, and synthetic fabrics. 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.

4.4 Big new markets resemble big new technologies

Kindleberger (1978) reports most manias developing around new technologies, but some arising around promising new market economies: new Latin American republics in the 1820s; East Asian Tiger Economies in the 1990s. Rosenstein-Rodan (1943) explains that 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 potential suppliers and customers, which all need their own competing suppliers and customers. Each new firm helps fill out the network and make 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 bureaucrats and subsidies fail. Hirano and Yanagawa (2016) show country-level bubbles drawing capital into promising middle-income economies, but rarely into low-income economies. Allen (2001) argues 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 country mania remain to offset costs of the panic and crash.

5. Kindleberger Cycles

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

First, a big new technology, such as the internet, or (less often) a big 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 seemingly successful investors. Grappling with intrinsically unsolvable valuation problems, investors disagree and highest bids set prices (Hong and Stein 2007). As positive externalities spread, so does harmonious investor optimism (Pástor and Veronesi 2009). Information cascades arise (Angeletos et al. 2010). Adapting firms expand and proliferate as capital floods in. Demand lifts their 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 and 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 expansion keep bubbles inflating. Sometimes, a second Minsky moment is needed. After one market crashes, investors seek high returns elsewhere. Spin-off bubbles, often in highly leveraged real estate, inflate and, after their own Minsky moments, pop.

A panic and crash ensue. Investors, fearing others fear others no longer deem stock beautiful, rush to sell first, before prices fall. All investors running to sell first, a *market run*, crashes stocks (Bolton et al. 2011). If enough investors who borrowed to buy into the bubble then default, financial institutions are stressed and curtail regular lending. A recession can ensue.

A clean-up 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. Free market economics looks tainted. Angry investors demand tough new regulations. Pundits elegeize capitalism.

A secular stagnation era of sedate near-equilibrium growth follows, as investors adjust to equilibrium returns (Gordon 2015). Regulators are captured (Stigler 1971); ex-innovators become entrenched monopolists; the end of progress is proclaimed. Horgan's (1996) *The End of Science* rang in the IT boom. Gordon's (2016) *Rise and Fall of American Growth* remains for historians to judge.

After an irregular interval, another dislocation initiates a new Kindleberger cycle. Forgetting the misfortune of their elders, or former selves, it all happens again. High-income economies have been repeating this pattern for four centuries. This is no cause for despair if each cycle leaves productivity, if not stocks, at a new permanently higher plateau. Bubble investors' private losses are laudable sacrifices to enrich the overall economy.

6. Social Costs and Benefits

For economy-level selection to favor institutions prone to Kindleberger cycles, the social benefits must exceed the social costs. If investors who lose in bubbles are nonetheless better off by living in such an economy, the case is clinched. This section summarizes research into these social benefits and costs.

6.1 Manias Fund Innovation

Evidence that bubbles have social benefits is accumulating.⁸ Stock market bubbles coincide with sharply elevated corporate investment (Martin and Ventura 2018), especially by firms with more important patents (Haddad et al. 2020). This encourages CEOs to direct more investment to hot technologies (Dang and Xu 2018). Option value effects can also elevate tech stocks (Kerr et al. 2014), drawing in more capital. Innovations financed in the 1920s (Field 2003, 2011; Nicholas 2008) and 1990s (Dang and Xu 2018) bubbles are atypically important, implying larger positive externalities (Kogan et al. 2017; Shin and Subramanian 2019). Martin and 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 to unprofitable investments with large positive externalities.

During bubbles, R&D rises more than capital investment (Dang and Xu 2018). R&D-intense firms, often young and without earnings histories or collateral, cannot borrow and therefore rely on stock markets

⁸ Macroeconomics (Martin and Ventura. 2018; Simsek 2021) and finance (Jarrow 2015) are rethinking bubbles, long deemed growth inhibiting. If underwriting fees, information costs or other frictions reduce corporate investment, bubbles that increase investment can have ambiguous growth implications. This revisionism is not universally accepted. Bosi and Pham (2016) propose taxing bubbles to subsidize innovation.

(Brown et al. 2012; Hsu et al. 2014; Acharya and Xu 2017). Such firms are exceptionally likely to list and issue more shares during bubbles (Brown et al. 2009; Aghion et al. 2012) to fund current and future R&D (Brown et al. 2009, 2012; Brown and Petersen 2011). As the bubble expands, takeovers of tech firms enrich their founders (Phillips and Zhdanov 2013). Early 20th century inventors (Nicholas 2010) and late 20th century venture capitalists and IT entrepreneurs (Gompers and Lerner 1999) often listed and sold to acquirers, locking in high returns for themselves and leaving the crash to others.

Flooding capital across whole sectors or economies allocates capital indiscriminately, not precisely. Still, Ashton (1948, p. 83-4) 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 centre 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 civilising influence.” Given the very high *SRRs* of innovation, precisely targeted chronic underinvestment is not obviously socially preferable to indiscriminate abundant investment.

6.32 Sandbagging Stock Markets

If the panic and crash ends the story, stock market investors are poorer but the 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 as well as dropping long-run GDP by two to ten percent (Sufi and Taylor 2021). More credit expansion during the mania heralds worse crises and downturns (Rerinhart and Rogoff 2009; Greenwood et al. 2020; Sufi and 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. Fundamentally sound firms halt 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 and Dybvig 1983), all their depositors running to withdraw their savings before the institution fails, which 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 et al. 2013; Fahlenbrach et al. 2018; Krishnamurthy and Muir 2016). 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 et al. 2013) and deregulate.

After crashes, governments bail out banks and shadow banks to prevent worse damage from a deeper financial crisis (Bernanke 1983). However, bailouts are expensive. Lucas (2019) puts 2008 US bailout costs at 3.5% of GDP. Kaminsky and Reinhart (1999) put mean bailout costs in financial crises at 5% to 13% of GDP. Overall, financial crises' macroeconomic costs, assessed as pre-crisis trend GDP growth minus actual GDP growth, range from 2.4 to 20% of GDP, with most clustering in the lower range.⁹ However, these estimates overstate social costs if, without Kindleberger cycles, baseline GDP growth would have been far lower.

6.3 Secondary Bubbles

Bubbles can ferment more bubbles. Bubbles spread from stock market to stock market, to real estate and even to consumer goods. Kapeller and 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 hot technology goods of their eras, – telephones, automobiles, cellphones, or Bitcoins – confer status, which increases demand for them, which further increases their prices and their Keynesian beauty (status goods signal status because others believe they do). Bubbles in status-signalling high-tech goods might thus also draw yet more money into innovation.

Other status good bubbles are not obviously socially beneficial. Status-seeking bourgeois investors

⁹ Sufi and Taylor (2021) review this literature, as well as financial crises associations with increased health problems, mistrust in institutions, and political polarization.

in 1630s Holland, enriched from investing in oceanic shipping, bid up tulip prices. A bubble in Beanie Babies, a pricy toy, expanded and popped alongside dot.com stocks (Bissonnette 2016). Neither has obvious positive externalities.

Rising inequality can inflate real estate, pricy properties being another status good. Price increases can broaden as investors, seeking high returns, emulate real estate investors' successes. Real estate bubbles have major social costs because banks and other financial institutions routinely accept real estate as collateral for loans. Credit therefore readily expands as real estate bubbles inflate. Chen and Wen (2017) describe initially high network externality returns falling as China's network of suppliers and customers filled out; and investors seeking continued high returns inflating a real estate bubble. Secondary real estate bubbles also accompanied rollouts of canal, railway, telegraph, and electric power networks. The 2008 financial crisis was plausibly secondary to the 1990s tech bubble. To stimulate their economies after stock market crashes, central banks often cut interest rates, potentially encouraging socially costly credit-fueled real estate bubbles in the wake of socially useful tech bubbles.

6.4 Social summations

Economic comparisons of these social gains and losses are remarkably rare. Lansing (2009) finds 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 social benefits outweigh social costs if the technology's *SRR* exceeds 2.5 times its *IRR*. Section 2.2 suggests the *SRR* of corporate R&D exceeds this. Historians (Perez 2002; Gross 2007; Janeway 2012) and, with considerable sophistication, marketing researchers Sorescu et al. (2018) also assess the social benefits of bubbles as outweighing their social costs.

Credit expansion can upset this balance. Larger credit expansions during manias might finance deeper capital floods, and thus more innovation, but they can greatly raise cleanup costs. Olivier (2000) models stock market tech bubbles as productivity-enhancing and credit expansion bubbles as productivity-diminishing. Janeway (2012) moves beyond a simple dichotomy, allowing credit expansions to magnify tech bubbles, and even boost innovation by boosting aggregate demand. Nonetheless, crashes that leave credit-granting institutions with large portfolios of non-performing loans herald financial crises and large

social costs (Aliber and Kindleberger 2015; Reinhart and Rogoff 2009).

Regulations that keep credit from deepening capital floodwaters during manias might therefore help make Kindleberger cycles more socially beneficial. Regulations enacted after a crash sometimes have this objective, as when the US imposed margin requirements on stock market investments after the 1929 crash. But post-crash regulations are in most cases hasty, readily eroded (Dagher(2018) and even, in the case of short-sale restrictions, conducive to the next manias (Hong and Stein 2007). This requires explanation.

6.5 Suspending Cardwell's Law

Cardwell's Law (1972, p. 210) is the historical regularity that societies are technologically innovative only briefly. Innovators are often political outsiders. Rapid innovation threatens the positions of individuals, firms and communities with old-technology skills or assets, who are often politically well connected. Schumpeter (1911) warns innovators of ostracism, condemnation, and even violence. Opponents of innovation, from 18th century Luddites to 21st century anti-GMO activists (Mazur 1975; Jones 2013; Juma 2016) successfully slow innovation (Mokyr 2000; Wu 2010; Jaffe and Lerner 2011).

Opposing innovation may resonate with basic behavioral heuristics. Prospect theory shows people fear losses more than they value gains of equal magnitude (Kahneman and Tversky 2013). This may have roots in Edmund Burke's (1790) *precautionary principle*, survival is precarious and change with even a miniscule risk of disaster is unwise, which motivates both political conservatism and environmental conservationism.

Kindleberger cycles may defeat Cardwell's Law by mobilizing offsetting 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). Thus, early movers' highly visible disequilibrium profits cue investors and CEOs into financing cascades of additional investment in similar things.

Group-level natural selection can favor novelty-seeking if lives saved by an expanded food supply exceeded deaths from tasting unfamiliar plants (Wilson and Wilson 2008; Williams and Taylor 2006) and

explain investor excitement with new technologies (Galor and Michalopoulos 2012). A “disposition to admire, and consequently to imitate, the rich and the great” (Smith 1759) has plausible survival value (Gibson and Hoglund 1992; Blackmore 1999, pp. 74 – 81; Bikhchandani et al 2021) and explain uninformed investors imitating successful investors (Bikhchandani et al. 2006). A “fear of missing out” effect may reinforce this (Janeway 2012; McGinnis 2020). Success begets optimism; emotion is contagious (Barsade 2002); and Keynes’ (1936) describes contagious optimism, or positive *animal spirits*, inflating stock market bubbles.

Economies with institutions that enlist these behavioral regularities to power Kindleberger cycles may, despite suffering panics and crashes, outcompete other economies by defying Cardwell’s Law. This perhaps explains high-income economies chronically failing to retain laws and regulations that suppress Kindleberger cycles. Indeed, economies that did successfully uphold such laws and regulations may cease being economically successful.

6.6 Economic Selection for Kindleberger Cycles

Mokyr (1994) posits economic selection favors economies that escape Cardwell’s Law and sustain ongoing innovation. This is plausible because economic selection can be multilevel, fast and discrete (Lo 2019).

Economic selection is multilevel (Nelson and Winter 1982): individuals compete with individuals, firms with firms, and economies with economies. IBM dominated computers until the 1980s, when its top executives, all mainframe computer engineers, opposed microcomputers to safeguard their positions, won the competition between individuals within IBM, but saw IBM sidelined in firm-level competition (Betz 1993). Rosenberg and Birdzell (1986, pp. 136-9) describe how economic competition between nations likewise trumps the conservative bias in human nature

“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”.

For example, the hot new technology of 1840s, railways and telegraphy (Standage 1998) accelerated trade and information from the speed of horses to the speeds of locomotives and electricity. Western European interstate competition intensified after the 16th century Wars of Religion, and more prosperous economies had larger tax bases to fund stronger militaries. British manias built canals and railroads, and individuals lost heavily in crashes; but railroad and telegraphs spanned the country. France, successfully damping stock speculation after the Mississippi bubble (Murphy 2005), had only 750 miles of wire by 1852 (Gross 2007). Prosperity gave Britain tax revenues to sustain a Royal Navy that soon ruled the waves.

Economic selection is fast. Natural selection is Darwinian: the unfit die, the fit survive and procreate; but economic selection is Lamarckian: the unfit imitate the fit. Patterns of economic behavior can spread without individuals, firms or economies dying. Governments actively abetted the imitation (theft) of foreign technologies as the military and soft power advantages of industrialization grew evident. The US industrialized rapidly by pirating European technology (Andreas 2013). Canada nullified foreign patents in its late 19th century industrialization (Bliss 1987). Japan sent students abroad in the 1870s to bring foreign technology home and became Asia's first industrialized economy by the early 20th century (Morck and Nakamura 2005). Other high-income economies followed similar paths. National governments banned technology exports, but failed to enforce foreign governments' bans (Harris 2017).

Economic selection can jump. Natural selection moves in small increments that find local optima. The vertebrate retina's blood supply is on the wrong side, the cephalopod eye is better designed (Lents 2018). Because no sequence of small improvements leads from one to the other, and 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 backward Tokugawa Japan to Asia's first industrialized economy (Morck and Nakamura 2005). Both transformations were large discrete jumps.

Thus, competition may do far more than eliminate dead-weight losses in standard economic models. Economy-level economic selection favoring institutions conducive to Kindleberger cycles may sustain the prosperity of the modern world.

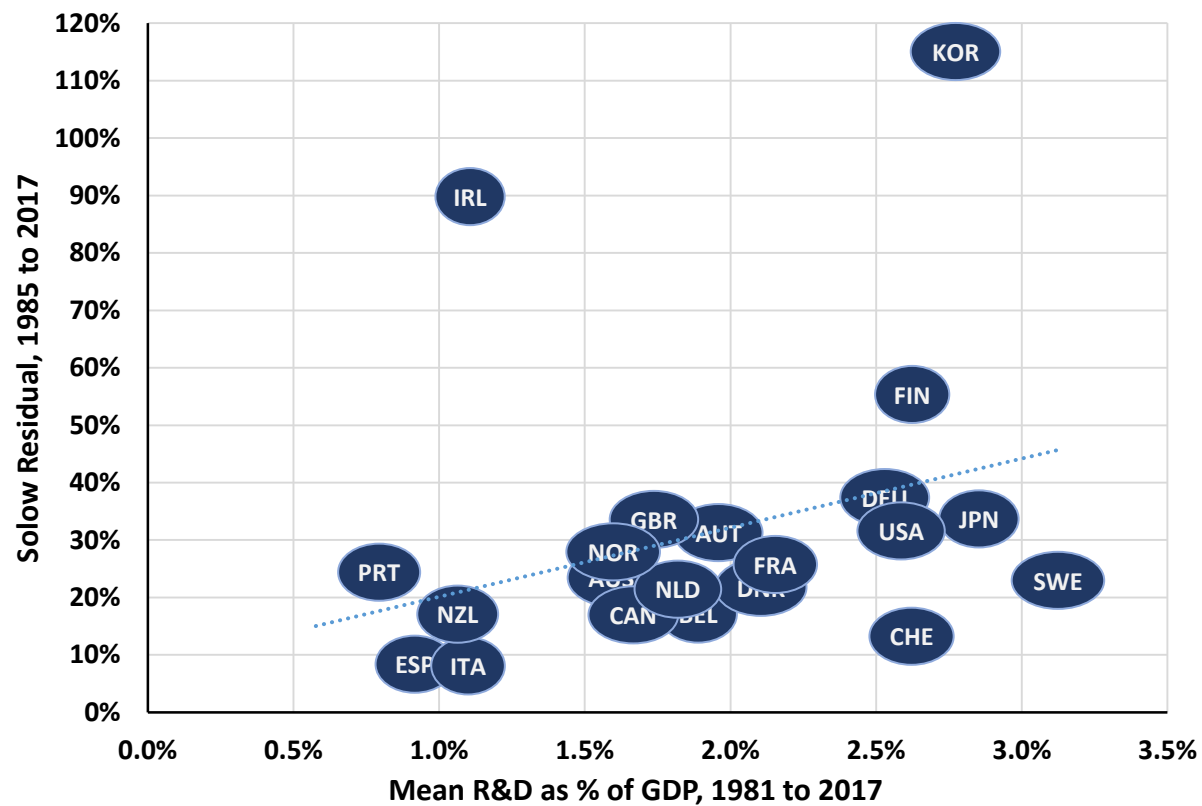
7. Capital Hydraulics

Irving Fisher build a model economy of pipes, pumps, valves, floaters and reservoirs of aqueous capital that inspired general equilibrium microeconomics (Brainard and Scarf 2005). Kindleberger cycles induce periodic inundations of capital that reroute the very channels money flows through and increase the total capacity of the economy. As Nile floods annually renewed Egypt, floods of capital across new technologies and markets renew the prosperity of the modern world. For four centuries, irregularly repeating Kindleberger cycles suppressed Cardwell's Law, permitting ever larger positive externalities from innovation, and ever increasing long-run prosperity.

To end annual flood damage, Egypt erected the Aswan dam and adopted chemical fertilizers. Ending capital floods seems risky: intellectual property rights and subsidies to innovators often work poorly. Ending capital floods has also not worked in high-income economies. Kindleberger cycles recur. Public policy might instead consider capital floods socially useful and attend to reducing their social costs.

Figure 1. Solow residual versus R&D spending

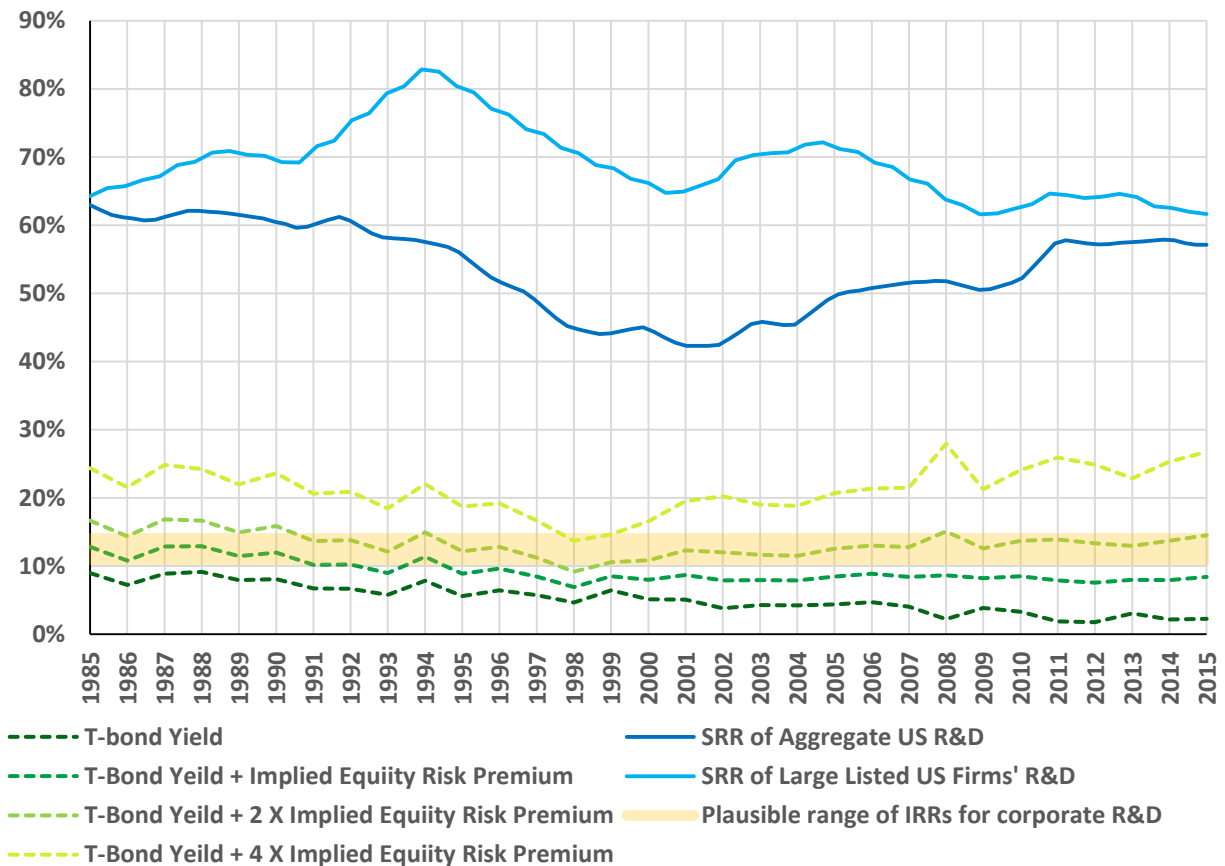
Economies with higher research and development (R&D) spending have faster economic growth primarily because they show evidence of greater cumulative multifactor productivity growth, as estimates of Solow Residuals. Greater productivity growth reflects the faster and more complete adoption of new technologies, which let firms produce ever more valuable outputs from proportionately ever less costly inputs.



Source: [OECD data website](#).

Figure 2. Social Rate of Return (SSR) to Research and Development (R&D) over Time

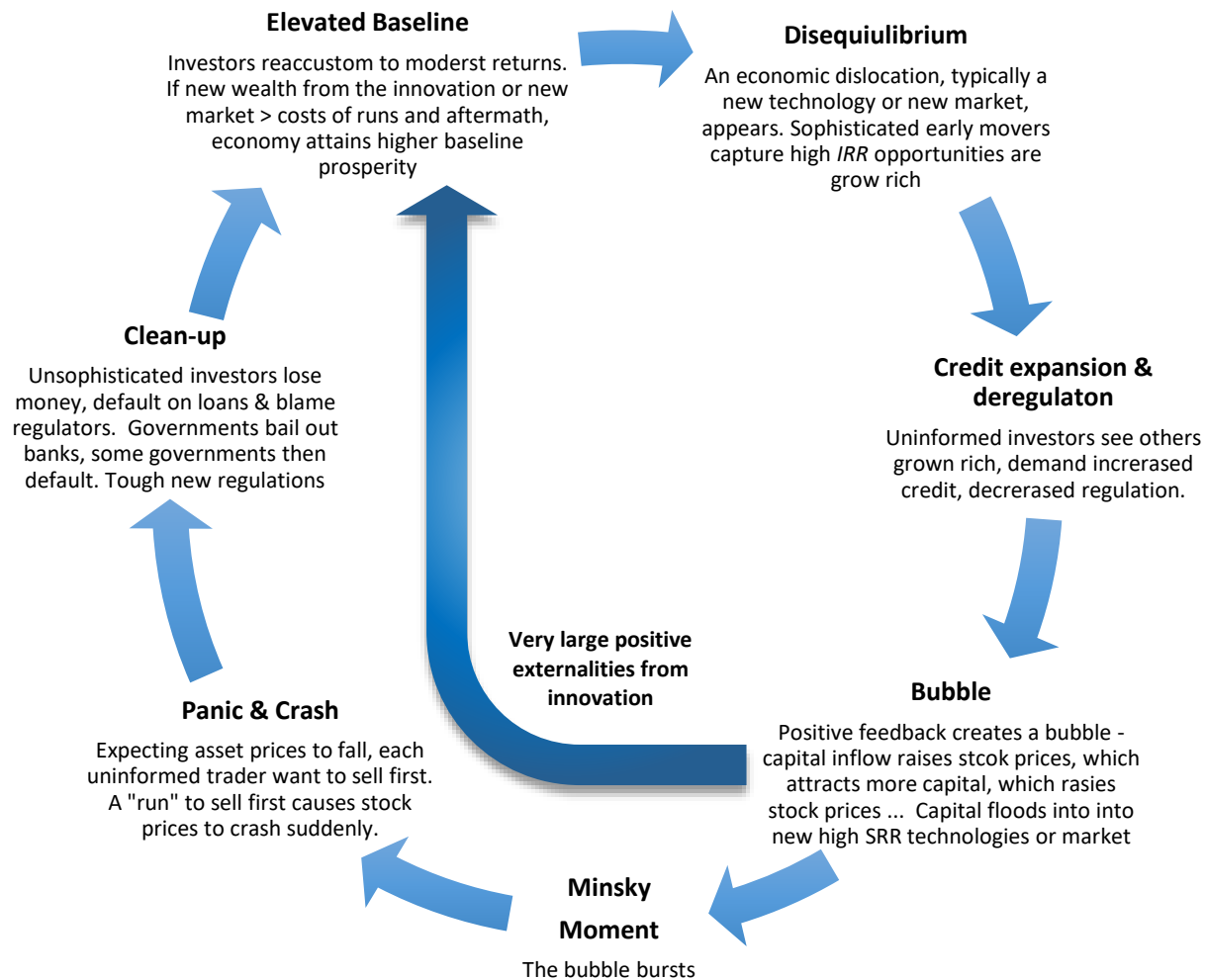
The *SSR* to aggregate US R&D (dark blue) and listed US firms' R&D (light blue) solid lines compared to cost of capital benchmarks for successively higher risk (successively lighter green dotted lines) investments and a benchmark range of *IRRs* for corporate R&D (yellow band)



Source: SSR estimates are from Bloom et al. (2020); IRR range from Hall al. (2010); plausible costs of capital range from the riskfree (T-bond) rate (Jørring et al. 2017) to under twice the equity risk premium (Damodaran 2014) higher, with extreme values less than fourfold the equity risk premium higher (Welch 2020).

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.



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