KINDLEBERGER CYCLES & ECONOMIC GROWTH:
METHOD IN THE MADNESS OF CROWDS?

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ABSTRACT

Because positive spillovers give investment in innovation a social rate of return several times higher than its internal rate of return to innovators, innovation is chronically underfunded. Recurrent manias, panics and crashes in stock markets inundate "hot" new technologies with capital. To the extent that manias compensate for chronic underinvestment in innovation, competition at the economy-level may favor institutions and behavioral norms conducive to innovation-related bubbles despite ultimately low returns to the hindmost investors.

Randall Morck
Faculty of Business
University of Alberta
Edmonton, AB T6G 2R6
CANADA
and NBER
randall.morck@ualberta.ca

1.   No Bubbles in the USSR

In 2008, US Federal Reserve chair Alan Greenspan told the Financial Times "There were no bubbles in the Soviet Union".[1] Challenging pundits' obituaries for free markets, Greenspan noted stock market manias, panics and crashes are nothing new, and ruminated they may even contribute to the historically unprecedentedly broad prosperity of free market economies. Several seemingly unconnected stylized facts from different corners of economics coalesce into strong supporting evidence for the thesis that stock markets might support prosperity precisely because they promote innovation-related bubbles.

In the 1970s, Soviet citizens slept on straw-filled mattresses, boiled unsafe tap water, and waited years to buy expensive but barely functional automobiles. Most of the history of all countries – and much of the world still – is set in poverty. In stark contrast, in the past few centuries, large middle classes arose in one country after another step with their adoptions of free market economics (Rosenberg and Birdzel 1986). Market economies deliver sustained prosperity that central planning has yet to match.[2]

Technological progress or *innovation* explains the greater part of economic growth in high-income market economies (Solow 1955, 1957). This is because innovation has positive *externalities*.[3] That is, a new technology provides the innovating firm a profitable *internal rate of return* (IRR) and also creates new economic opportunities elsewhere in the economy. For example, innovations in the information technology sector let Walmart computerize, and radically improve, its inventory management. Large positive externalities leave the average innovation with a *social rate of return* (SRR) some four to eight-fold higher than its IRR (Hall et al. 2010). New *general purpose technologies* (GPTs), such as electric power and the internet, which trigger economy-wide waves of follow-on innovation, have especially large positive externalities across most of the economy (Bresnahan and Trajtenberg 1995).[4] All thiss means free market economies of profit maximizing firms would underinvest in innovation from a social perspective.

Many innovations also have positive network externalities, which further exacerbates the gap between their early adopters' IRRs and their far higher SRRs (Liebowitz and Margolis 1994). A telephone is a poor investment if yours is the only one, but a good investment if many others also get them. Each existing telephone becomes more useful as the telephone network expands. Likewise, prior active research in narrow areas of the life sciences makes further research in those areas less costly (Henkel and Maurer 2010). Even economic development itself is a gigantic network externality (Rosenstein-Rodan 1943). A new venture in a low-income economy is an iffy investment if yours is the only one, but makes more sense if numerous other new businesses that supply your inputs and pay wages to your potential customers are also setting up operations there. Positive network externalities deter first movers and can prevent private firms from undertaking early stage innovations. Again, profit maximizing firms in a free market economy would underinvest in innovation.

The large positive externalities from innovation cause severe market failures, which severely impair free market economies:[5] society as a whole would better prosper if firms undertook far more innovation than

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

[2] China's rise from sub-Saharan poverty to Latin American living standards corresponds across provinces and over time to its staged rollout of market reforms. The Communist Party's reassertion of its economic power in the most recent Five-year Plan is a bold course change.

[3] Public finance theory describes externalities arising wherever the actions of one individual or firm have important repercussions on others. Pollution is a negative externality because one firm's effluents adversely affect others. Innovation have positive externalities if they benefit others.

[4] Bekar et al. (2018) review the literature on GPTs and conclude that criticisms of the concept are unpersuasive.

[5] A market failure occurs when free markets fail to deliver socially optimal outcomes

they actually do.[6] Public finance provides public policy instruments to counter externality market failures (Pigou 1949). Governments deploy intellectual property laws and R&D subsidies to lift total investment in innovation to something closer to the social optimum. However, deeper and more expansive state intervention increases the profitability of influencing those interventions (Krueger 1976, 1990). The potential losers from innovation, firms, workers and regions dependent on old-technology firms, invest in lobbying to block innovation, and successful ex-innovators lobby to block further innovation. A loss aversion bias in human behavior can bolster the odds of success to lobbying cast as status quo preserving. All this can leave firms investing more in lobbying and less in innovation. Public policy interventions designed to boost innovation may well actually reduce it (Wu 2010; Jaffe and Lerner 2011).

Yet market economies prospered by developing wave after wave of new technologies, while Soviet factories in the 1970s used pre-revolutionary technologies and Soviet central planners deemed innovation destabilizing and even subversive. Market economies, especially during times of rapid technology-driven development, rely heavily on stock markets to allocate resources (Rosenberg and Birdzel 1986).[7] Financial development and living standards rise hand-in-hand (King and Levine 1993; Demirgüç-Kunt and Levine 2018).

Stock markets, invented in the early 17th century, may be the mother of all GPTs. Stock markets let entrepreneurs with innovative ideas found and expand firms by raising potentially vast amounts of risk-tolerant equity via share issues. Stock markets can put individual investors' microeconomic savings under the command of entrepreneurs who can oversee the development and deployment of successive new technologies that keep raising living standards.

Yet severe market failures afflict stock markets. Wherever stock markets rise, investment manias, panics and crashes soon follow (Kindleberger 1978). Investment manias often center on a Big New Thing (BNT). The BNT is usually a hot new technology (Goldfarb and Kirsch 2019) such as canals in the 1790s and 1830s, railroads in the 1840s and 1860s, electric power, radio, and internal combustion engines in the 1920s, or information technology in the 1990s. Less often, the BNT is a new market, such as newly independent Latin American republics in the 1820s and newly rich East Asian "tiger economies" in the 1990s.

Each mania ends in a panic and crash, after which pundits scold investors' for greed and economists bemoan investors' irrationality (MacKay 1841; Cole 1720; Chancellor 1999; Reinhart and Rogoff 2009; Goldfarb and Kirsch 2019). Regulatory and credit cycles often run alongside. A regulatory cycle has unsophisticated investors first demanding deregulation to let them into the mania and then demanding tough new regulations after the crash (Dagher 2018). A credit cycle sees credit expansion pouring borrowed money into expanding the tech bubble, or into crating and expanding temporally adjacent bubbles in real estate or other investments. Credit cycles and regulatory cycles worsen the damage when the inevitable crash finally comes by triggering waves of bankruptcies and financial bailouts.

Moreover, important innovations appear to trigger these investment mania, panic and crash cycles. The IRR of something new and exciting, such as a new technology, is impossible to quantify. Confronted with unquantifiable problems, people needing nonetheless to make decisions fall back on behavioral biases (Simon 1986; Kahneman 2011). Economic selection can shape behavioral biases. Those that lead often enough to favorable outcomes and rarely to catastrophe attract emulators and spread (Nelson and Winter 1982). Imitating actions that appear to have worked out well for others appears to be a widespread

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[6] From a social perspective, profit maximizing firms overinvest in negative externality activities, such as those that cause pollution (because others bear the externality costs) and underinvest in positive externality activities, such as innovation (because others gain much of the benefits).

[7] Countries whose financial systems are now more reliant on banks, such as Germany and Japan, relied on stock markets historically (Fohlin 2005; Morck and Nakamura 2005).

behavioral bias that qualifies as optimal in this evolutionary sense (Welch 1992; Bikhchandani et al. 1998).

Having watched early investors in radio stocks grow rich, unsophisticated investors pour money into soaring radio stocks in the late 1920s and lost big the Crash of 1929. This obviously ended badly for those investors. However, enough investors pouring enough money into the mania let firms arise and expand to fill out multiple new industries. The economy got home radios, radio manufacturing plants, radio stations, radio program writers and actors, radio advertising, radio air traffic control, ship-to-ship radio, radar, radio dispatched police and emergency services, and other aftereffects that added up to a considerable social return (Bresnahan and Trajtenberg 1995; Lipsey et al. 1998). Reginald Fessenden, who invented the first reliable and mass-producible radio set, did well enough. The global economy got far more from his invention than he did.

Unlike biology (Wilson and Wilson 2008; Wilson 2012), economics has long accepted simultaneous multi-level competition (Nelson and Winter 1982). Competition can be between individuals, between firms, and between economies. A behavioral bias that leads individuals to lose money in investment manias surrounding "big new things" could persist and spread if the mania boosted overall economic growth sufficiently. Mania-prone investors lose money; but few lose their lives. If economies conducive to investment manias amassed enough wealth by accumulating more and better innovations, competition between economies might favor behavioral biases in individuals along these lines. This would occur, for example, if individuals living in the United States and losing money in stock market manias nonetheless ended up better off than individuals protected from stock market manias by living in the Soviet Union.

Economic selection between individuals, between firms, and between economies can conflict if externalities arise, and investment in innovation has huge positive externalities. The magnitude of an externality is its *social rate of return* (SRR), its return to the overall economy, minus its *internal rates of return* (IRR), its return to the firm doing the investment. Alexander Graham Bell's patents made Bell Telephone a very decent IRR; but this was only a miniscule fraction of the social returns telephone networks created. Telephones added value by letting people more easily acquire information, issue and receive instructions, and buy and sell goods and services in distant locations in real time (Fischer 1994). Telephone also destroyed wealth for some businesses – for example, telegraph firms. However, the social benefits greatly exceeded the social costs, so the SRR of the telephone turned out to be very high indeed. Abolishing telephones to restore the jobs of telegraphers now gets few votes.

Financial manias inundate "big new things – including "hot" new technologies– with capital. Manias, like patent and copyright laws or R&D subsidies, grants and tax credits, increase investment in innovation. Manias are costly and likely misallocate much capital, but whether they are more or less socially efficient than intellectual property laws, tax codes, and subsidy policies is at least debatable. Legions of individual investors lost money in electric home appliance stocks in 1929 and internet stocks in 2000, but economies came away with electric home appliances and the internet, respectively. Patent law and tax credits likely could not have managed this, but a stock market mania pulled it off.

Annual inundations of the Nile nurtured Egyptian civilization for millennia, though the floods also caused much damage each year. Egyptians stayed put and learned to cope with the inundations. Financial manias inundate high SRR investment opportunities with capital, but sweep away the small investors' savings; and high-income economies also stay put. Learning to cope better with the inundations appears to entail keeping banks out of investment manias and cushioning the losses of those whose wealth is swept away.

2.   Social Returns to Innovation Vastly Exceed Private Returns to Innovators

Schumpeter (1911) explains how innovation sustains economic growth. Solow (1955, 1957) shows that technological progress underlies most economic growth in developed economies. Romer (1986) models

innovative firms' investments in new technologies boost not only their own productivity, but also the productivity of other firms that copy, tweak, and elaborate the initial innovative firms' new technologies. The wealth created by these secondary actions can raise the SRR of an innovative firms' investment far above its IRRs to that firm. This section is about how investments in innovation can have an IRR too low to be viable to any firm, but a very high SRR nonetheless.

2.1   Chronic and Pervasive Underinvestment in Innovation

Many corporate investments affect the wealth welfare of others (Pigou 1920). These spillovers do not contribute to the IRR that firm earns on its investment, but do contribute to an SRR, which tallies up all the benefits and costs to the economy as a whole, differs from its IRR, which only considers the benefits and costs to the firm. Environmental damage can be a major negative spillover from many corporate investment decisions, and can depress a project's SRR far below its IRR. A government can discourage projects with negative spillovers with taxes and regulations to lower their IRRs towards their SRRs and stop such projects before they start.

The positive spillovers from investments in new technologies are known to have SRRs markedly higher than their IRRs. Grilliches' (1992, p. 43) summarizes the empirical literature as showing:

> "a significant number of reasonably well done studies all pointing in the same direction: R&D spillovers are present, their magnitude may be quite large, and social rates of return remain significantly above private rates."

Grilliches (1958) estimates SRRs of innovations in agriculture at 25 to 30 percentage points above his 10% IRR benchmark. Subsequent work argues about the magnitudes of the difference, but repeatedly replicates the basic finding: the SRR of investment in new technology far exceed its IRR (Hall et al. 2010).[8] For example, Jones and Williams (1998) conservatively put the social return of R&D at 30 percent and its IRR at 7 to 14%. Bloom et al. (2013) estimate the SRR of R&D to be 59%, identified via U.S. states' changes in R&D tax policy. In general, the IRR of corporate R&D falls in the 10 to 20% range; the SRR of corporate R&D averages well over 40%.

Figure 1 shows median SRRs on R&D spending varying over time. The SRR of R&D by listed firms, the dashed line, rises during the early 1990, as information technology innovations begin attracting attention, falls from the mid-1990s on, as the dot.com bubble expands and capital flows into innovations, and then levels off after the dot-come stock price crash in 2000. This is consistent with a capital flood from dot.com equity financing capitalizing technological innovations with steadily lower SRRs, many of which turned out *ex post* to have realized IRRs far below any reasonable hurdle rates for firms and shareholders buying into the bubble (Moller et al. 2004).

The SRRs for investments in innovation are difficult to estimate, but Figure 1 is nonetheless a useful illustrative exercise. Table 1 provides a sense of the uncertainties in SRR estimation by consolidating estimates of the gap between the IRRs firms in various industries earn on their R&D and the SRRs those same investment generate across high-income (O.E.C.D) economies for different industries.

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[8] See Nadiri (1993); Jones and William (1996); Verspagen (1997ab); Frantzen (2002); Grilliches (2000); Keller (2002a, 2004); Brynjolfsson and Hitt (2003); Fung (2004); Park (2004); Fraumeni and Okubo (2005); Hall, Jaffe and Trajtenberg (2005); Bloom, Sudun, and Van Reenan (2006); Sveikauskas (2007); and Acharya (2008). Scherer (1999) goes further, arguing that much R&D has large negative risk-adjusted rates of return to firms undertaking it, even if its social rate of return is large. For a comprehensive literature review, see Hall et al. (2009)

Figure 1. Social Rate of Return to Research and Development over Time

Social rate of return on aggregate US R&D (dotted line) and on research and development (R&D) by US listed (Compustat) firms (dashed line) from 1985 to 2015
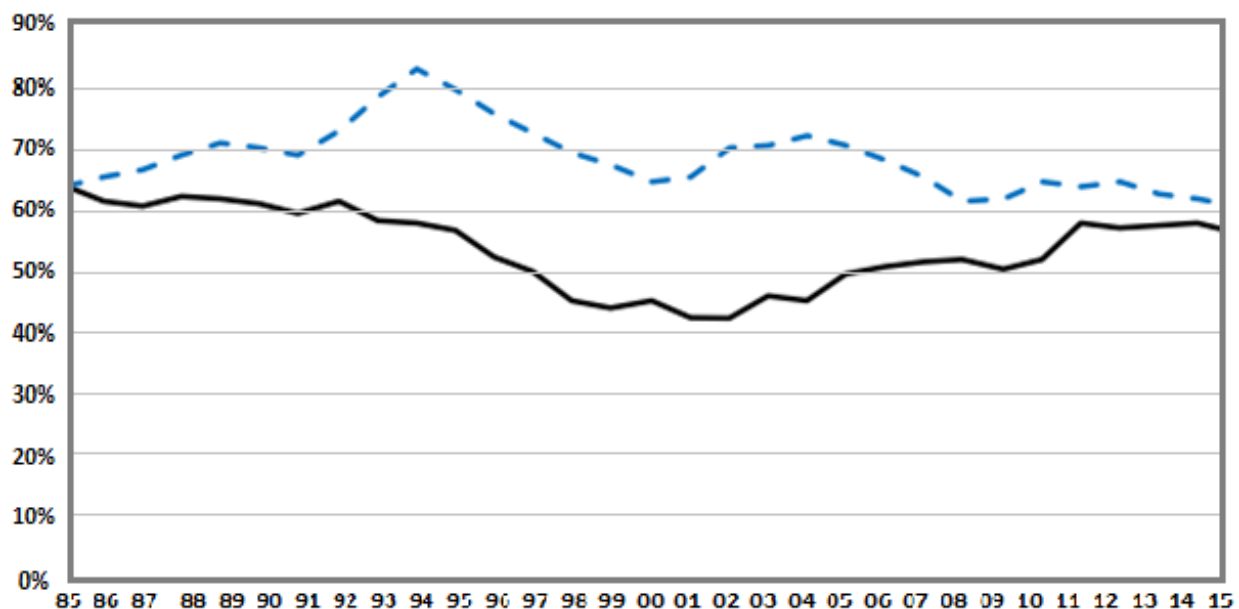
Source: Bloom et al. (2020)

Table 1. Ranges in Estimated Excess Social Returns from Research and Development

Excess social net rate of return is the social rate of return, SRR, to research and development (R&D) minus its internal rate of return, IRR, to the firm undertaking the investment. Figures are minima and maxima among four different estimation techniques (see Acharya 2008) estimated across all OECD countries from 1973 to 2002.

Sector	SRR exceeds IRR by
Aerospace	- 11 – 18%
Chemicals (excluding pharmaceuticals)	64 – 90%
Electrical machinery & apparatus	34 – 48%
Machinery & equipment	- 58 – 16%
Medical, precision & optical instruments	12 – 24%
Motor vehicles, trailers & semi-trailers	23 – 24%
Office, accounting & computing machinery	49 – 62%
Pharmaceuticals	90 – 101%
Radio, television & communication equipment	34 – 60%
Railroad & transportation equipment	27 – 33%

Source: Acharya (2008).

While the minima for aerospace and for machinery and equipment are negative, indicating private returns in excess of social returns, the worst-case social returns substantially exceed private returns in all other sectors. The maximal estimates of the excess net social returns to R&D are large and positive in all sectors. The econometric takeaway from Table 1 is that estimated gaps between SRRs and IRRs vary substantially within and across industries and over time, but that SRRs from R&D broadly and consistently exceed IRRs by substantial margins.

The economically significant takeaway from Figure 1 and Table 1 is strong evidence of a market failure of major importance. Economics teaches that private-sector firms undertake investments that cover their costs. A firm that needs its projects to earn an IRR above 10% undertakes all R&D with an expected risk-adjusted return above that hurdle rate. However, the economy prospers if all R&D projects with SRRs above such a hurdle rate are pursued. Figure 1 puts the SRR of R&D in the 40 to 85% range, some 20 to 75% higher than their typical 10 to 20% IRRs. Many – perhaps most – R&D projects' SRRs look good from the economy's point of view, but do not pass any individual firm's IRR threshold test.

Consequently, free-market economies surely vastly underinvest in R&D and in innovation generally. Jones and Williams (1998) estimate socially optimal R&D spending as a share of GDP at two to four times actual R&D spending. This market failure problem motivates two broad classes of government-intervention. Each makes fundamental sense (Brown et al. 2017), but each also comes with social costs.

2.2 The promise and problem of Intellectual property rights

One such form of state intervention is the strengthened intellectual property rights – stronger, longer or broader patents, copyrights, trademarks, industrial design rights and trade secrets – enacted in most developed economies in recent decades. Empirical studies suggest that important new technologies typically begin providing positive externalities to innovative firms' rivals within two years (Mansfield 1985; Caballero and Jaffe 1993), and stronger intellectual property rights let innovators charge higher rents to subsequent users of their innovations. These boost innovator's IRRs, but also lower their innovations' SSRs by constraining their diffusion. Strengthened intellectual property rights could also reduce innovators' incentives to devise yet more innovations.

Unfortunately, intellectual property rights laws can be gamed by interested parties and these abuses appear to have grown more common in recent decades (Wu 2010; Jaffe and Lerner 2011). Patent thicketers are firms that lay minefields of vast numbers of largely useless patents on all manner of processes related to an area of research. Where every move risks intellectual property infringement lawsuits, potential innovators rationally stay away. If the original thicketers are not successfully innovative, important areas can remain dormant for decades. Patent trolls are firms that buy huge numbers of seemingly useless patents in the hope that someone someday will inadvertently infringe one of them. A US court forced Research in Motion, the maker of the Blackberry, to pay S$612.5 M to NTP Incorporated, a US-based patent-holding company with a patent on the wireless transmission of e-mail (Sweeny 2009). Intellectual property squatters can earn rents from strong intellectual property rights, even as their economies stagnate at the resulting slow pace innovation.

These considerations suggest that overly strong intellectual property laws can be socially costly (Heller and Eisenberg 1998). Because the optimal strength of intellectual property law is unknown, lobbyists play a decisive role. Saperstein (1997) details the historical development of U.S. copyright laws and summarizes the role of lobbyists thus:

> *"What drove these changes in [US] federal copyright law? The legislative history demonstrates that industry specific interest groups were instrumental in driving the shift from copyright law based on misdemeanor penalties to one based on felony sanctions."*

Krueger (1974, 1990) argues that lobbying for favorable regulations and laws, called political rent-seeking, can have a higher return than investing in actual innovation. Intellectual property law reforms throughout the world are subject to remarkably intensive lobbying (Maurer 2017; Drahos 2003; Wu 2010). Boldrin and Levine (2002) argue that the costs of intellectual property rights exceed the cost of the market failure they address. An increasingly accepted academic literature now views intellectual property rights as potentially social welfare decreasing and rife with rent-seeking devices that enrich insiders and deter innovation.[9]

2.3   The promise and problem of government financed innovation

An alternative state intervention has governments subsidizing perceived inputs to technological progress to lift firms' IRRs upwards towards the new technologies anticipated SRRs. Most governments' tax codes allow tax credits for research and development (R&D) spending and accelerated depreciation for other investments, such as information technology, perceived to be innovation-related (Fazio et al. 2019). Many go further, generously subsidizing businesses that promise to invest in innovation (Lach 2002). University and research laboratory administrators justify public funding by promising spillovers from ideas generated on their campuses.

These policies make sense because innovations' SRRs exceed their IRRs. In some ways, government research grants might be preferable to strengthened intellectual property rights because they do not discourage subsequent diffusion and avoid problems associated with patent thickets and patent trolls. However, other downside make subsidies even more problematic a solution.

First, government officials must "pick winners" in allocating necessarily limited subsidies to numerous applicants. Government officials are notoriously poor at picking winners. Lacking the expertise to evaluate competing subsidy proposals, they understandably rely on subsidy applicants and third parties for critical information. Successful applicants must submit winning applications to the officials overseeing the program, whose decisions can be subject to political pressure or special interests lobbying. This can lead to the perverse outcome of grants flowing to the best-connected applicants, whose always-perfect applications yield ever-larger subsidies yet produce few or no commercially viable new technologies.[10]

Of course, if some positive spillovers do arise from such subsidies and are sufficiently large, these downsides can be bearable, but Gompers and Lerner (1999), after evaluating various countries' innovation subsidy programs conclude that few meet this test.[11] Competition for subsidies readily degenerates into competitive rent-seeking.

Second, bureaucrats understandably value meticulousness and punctuality: screening mechanisms whose effect is uncertain, or even perverse in this context. Government subsidies often thus flow to other large bureaucratic organizations with similar values - large universities, research laboratories. (Jaffe 1989; Mansfield 1985). Whether or not universities and research institutes should be able to patent government-financed innovations their researchers invent becomes a policy problem too. Letting such institutions profit by holding patents incentivizes their administrators to support useful research, but restricts access to taxpayer-financed innovation innovations (Mowery et al. 2002; Link and Siegal 2007; Friedman and Silberman 2003; Lach and Schankermann 2004). University patent offices often sell patents

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[9] See Lerner (1995); Lanjouw and Lerner (1996); Heller (1998, 2008); Buchanan and Yoon (2000); Maurer and Scotchmer (2002); Menell (2011); Wu (2010) and Maurer (2012).

[10] On innovation subsidies potential downsides in different countries, see Czarnitzki and Fier (2001); Hart 2003; Cantner, Uwe and Sarah Koesters (2011). See also Santarelli and Vivarelli (2007) and Fritsch (2008), Czarnitzki et al. (2011), Doern et al. (2016), and Fang et al. (2018).

[11] They cite that US Small Business Innovation Research program as one major exception.

to large corporations, rather than letting their researchers develop them. This provides a readier source of income to universities, but may also facilitate patent thicketing and patent trolling (Watkins 2014; hall et al. 2015).

The economics literature offers other innovative ways to boost the IRR of investment in new technology closer to its SRR. Governments might promise prizes for the successful development of important new technologies (Wright 1983) or purchase socially valuable intellectual property rights from innovators at taxpayers' expense (Kremer 1998), and then make the innovation freely available. Studies of the design problems in such tournaments reveal complexities whose administration would tax highly competent and disinterested government officials (Fullerton and McAfee 1999; Terwiesch and Xu 2008; Ales et al. 2017). Moreover, cross-country spillovers remain if national governments administer such solutions. Swedish firms could use innovations made publicly available by U.S. taxpayers, for example.

Overall, the IRR and SRR of government-financed R&D are both consistently lower than for private-sector R&D (Hall et al. 2010). The purpose of government is to do socially valuable things the private sector cannot, so lower IRRs for publicly funded R&D are unsurprising. The lower SRRs of publicly funded R&D raise concerns about these forms of boosting R&D. However, measuring the social contributions of basic research, such as that at university science departments, or medical research, such as that done at government labs, is econometrically difficult. However, yet other studies highlight waste and resource misallocation in research at universities (Sokal and Bricmont 1999; Ionnides 2005; Strevens 2013; Ionnides et al. 2014), including in economics (Kwak 2017).

In summary, evidence overwhelmingly points to chronic underinvestment in innovation. Intellectual property rights and state-financed research are both theoretically valid state interventions that could redress this underinvestment. Both probably do, to an extent. Many countries rolled out innovation policies amid the 1990s dot.com boom, for example, and these may have helped increase investment in innovation with high SRRs but low IRRs to private innovators. However, both intellectual property law and government financing of innovation also have costs of their own that can be large.

2.4   Innovation Drives Prosperity

Solow (1955, 1957) shows increased inputs (resources, capital and labor) explain only a small fraction of the economic growth in high-income countries. The unexplained greater part of economic growth, called the Solow Residual, arises from successions of new technologies displacing older ones. Each new technology permits the production of higher-valued output from familiar inputs or familiar outputs from lower-cost inputs or some mix of the two. Economic prosperity depends on ongoing technological progress, and can continue as long as valuable new ideas keep arising. Subsequent work affirming, formalizing and expanding Solow's insight built the new subdiscipline of endogenous growth theory (Romer 1986, 1990; Akcigit and Nicholas 2019).

This is good news, in that natural resource availability, aging populations, and fluctuating savings and capital investment rates, may all well be of secondary importance to sustained prosperity. However, the dependence of economic growth in high-income economies on innovation makes the cost of socially insufficient spending on innovation a first-order issue.

Private-sector innovation seems central to sustained prosperity in high-income economies. The Solow residual and the related concepts of total factor productivity (TFP) and multifactor productivity (MFP) growth, measuring how much more valuable output the economy's workforce and capital assets produce, as closely tied to the quantity and quality of R&D spending.

Figure 2. 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 productivity growth, as measured by their Solow Residuals. 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.
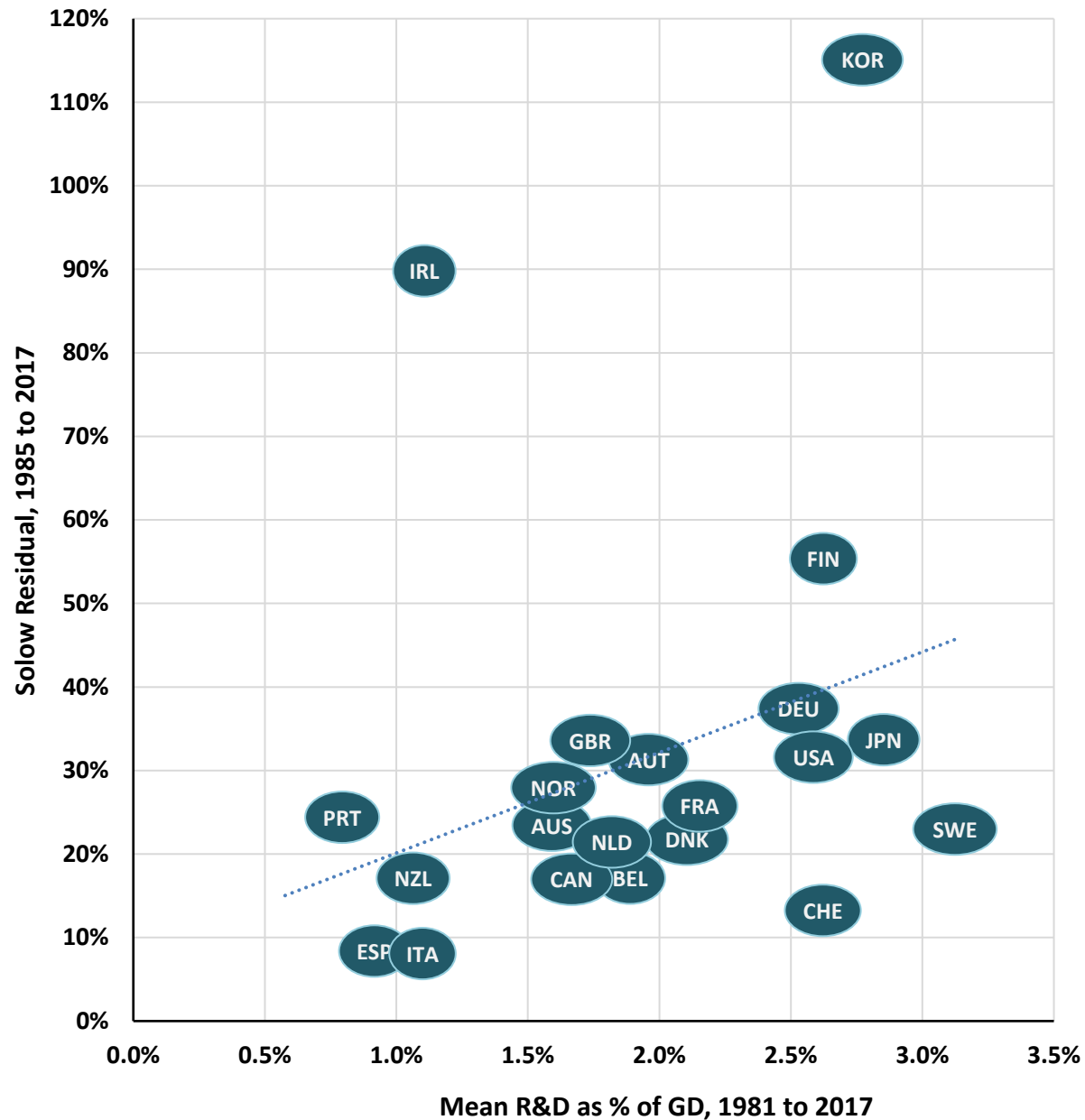
Source: Based on OECD data (available at OECD.org). Solow residual is cumulative multifactor productivity growth.

The O.E.C.D. (2003) reported that economy-level productivity rises significantly with private-sector R&D spending, but not public sector R&D spending. Research in academia and government labs often explains, rather than inspires, innovation in the private sector (Edgerton 2004; Ridley 2020). Historically, steam engines came first and scientists built theories to explain how they work. "Thermodynamics owes more to the steam engine than the steam engine owes to science."[12]

Perhaps because intellectual property rights and government-financed research are growing more dysfunctional, the pace of new idea generation may be falling (Gordon 2016). Investment in innovation is socially suboptimal because of a market failure: the typical investment in innovation earns the innovating firm an internal rate of return far short of the social rates of return to the economy overall. If government measures to counter this market failure grow less effective, or even counter-effective, overall growth can slow. Mokyr (2018) argues that the pace of innovation rises and falls in the short-run, but remains the primary engine of growth in the long-run; and that this long-run relationship is likely to persist. Trajtenberg (2018) argues that artificial intelligence shows early signs of becoming a GPT on the same scale as electrification and the internet.

3.   Ideas about Investment in Ideas

All of this reasoning depends on investor and firms behaving in ways economists deem *rational*. Living up to economists' standards of rationality can be challenging.

3.1   Rational investment decisions

To calculate the IRR of an investment project, economics charges corporate managers with forecasting that projects future cash flow in every future period. This requires forecasting the quantifies and prices of all the projects outputs and inputs, the wages and employment levels of all the different employees the project will require, and the taxes the project will encumber the firm with – and for every year of the project's expected lifetime. These forecasts are uncertain, so economists also expect corporate managers to repeat this exercise for all possible ways the future might unfold and to assign a probability to each unfolding. Multiplying the number of variables being forecast for each future time period by the number of future time period by the number of ways the future might unfold by the probabilities of these alternative futures unfolding charges corporate managers with estimating of thousands of numbers. Moreover, economics charges corporate managers with doing this for every project under consideration. Yet this charge seems humble beside the duty economists assign to investors – doing all of these things without any insider information about any firm, to price the stocks of *every* firm and update all of those prices in continuous time.

John Maynard Keynes (1936) explains that

> *"the social object of skilled investment should be to defeat the dark forces of time and ignorance which envelop our future."*

This often lies far beyond human capabilities, especially for investment in innovations. Over and above the uncertainties about owning an idea and the shortcomings of intellectual property law, investments in innovation are perhaps the longest of long-term investments and have the most uncertain payoffs. The more profound the innovation, the more distant the time horizon and the deeper our current ignorance.

3.2   An Animal Spirited Urge to Action

That is Keynes' point. Real world investment decisions are "leaps of faith", no matter how intricate the *ex-ante* analyses. Keynes' *General Theory* (1936, esp. c. 12) draws heavily on finance, and on the

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[12] Attributed to George Porter, Nobel Prize in Chemistry, 1967 (Manley 1997).

impracticality of actually getting enough information to solve real-world investment problems, to conclude that investment decisions are

> *"not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities. Enterprise only pretends to itself to be mainly actuated by the statements in its own prospectus, however candid and sincere. Only a little more than an expedition to the South Pole, is it based on an exact calculation of benefits to come."*

Instead, in a remarkably prescient anticipation of modern Behavioral Finance, Keynes posits (p. 64) that *animal* (Lat. "animating") *spirits* determine the level of capital investment by business corporations:

> *Most, probably, of our decisions to do something positive, the full consequences of which will be drawn out over many days to come, can only be taken as a result of animal spirits — of a spontaneous urge to action rather than inaction … Thus if the animal spirits are dimmed and the spontaneous optimism falters, leaving us to depend on nothing but a mathematical expectation, enterprise will fade and die; — though fears of loss may have a basis no more reasonable than hopes of profit had before."*

Appreciating the virtually insurmountable information requirements of our textbook decision-making rules, he concludes that

> *"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."*

This failed to catch on in economics departments and business schools, where professors compete to write down ever more intricate calculations of mathematical expectations.

Keynes is undeniably right in asserting that capital budgeting problems, if solvable in theory, are not solvable in practice because the costs of the necessary information and calculations are prohibitive, if not infinite. However, he may overstate the case for irrationality in capital investment.

3.3   Procedurally transcomputational problems

Problems whose solution exist, but that cannot in practice be solved are called *transcomputational*.[13] Grossman and Stiglitz (1980) distinguish *substantive rationality*, the optimization of standard economics and finance theory, from *procedural rationality*, optimization of the decision-making process itself. Rising marginal costs and falling marginal benefits of increasingly substantively rational decision-making means that procedural rationality implies a degree of substantive irrationality.

Extending this distinction, a problem can be called *procedurally transcomputational* if its solution is an equation, but the numbers to plug into that equation are largely unknowable. Most problems in economics and finance are procedurally transcomputational: they could be solved by neat equations, but actually cannot be. Gleaning anything more than a ghost of an idea about what numbers to plug into those neat equations is prohibitively costly at best, and undoable in many economically important contexts, such as decision-making about big new technologies.

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[13] Bremermann (1962) formally defines a problem as *trans-computational* if its solution requires processing over 10^{93} bits, arguing that the laws of physics and mass of the planet preclude a computer exceeding this capacity. Economic theory can assign probabilities to any abstract state space, but does not really answer these issues. Theories whose solution are procedurally transcomputational do not, in reality, have solutions. The stark limitations of economic theories have long concerned economists. Knight (1921), confusingly, distinguishes *risk*, in which probability distributions are known, from *uncertainty*, in which they are not. King and Kay (2020) expand the latter as *radical uncertainty*, posit that evolution honed behavioral responses to cope with radical uncertainty, and reject "bias" as a valid term for these responses.

Solving for the price of a stock can be procedurally transcomputational. We can write down an equation for a stock's price, but have little idea what numbers to plug to make use of that equation. The stock prices of new companies, especially, pop out of neat equations whose variables are all but unknowable.

The price of a stock is the present value of all future dividends and other payouts to investors, such as takeover premiums, spinoffs, and the like. With $D(s, \tau)$ the sum of all such payoffs in future time τ if state-of-the-world s occurs at that time, the price of the stock at time t is

$$P_t = \iint_{\tau=t+dt}^{\infty} \mu(s, \tau) e^{-r(s,\tau)} D(s, \tau) ds d\tau$$

where $\mu(s, \tau)$ is the probability that the world ends up in state s at time time τ and $r(s, \tau)$ is the discount rate at which market participants discount future disbursements at time τ should state s occur then. Obviously, almost nothing can be known about almost all of these numbers for a new company bringing forth a new technology.

Solving for a firm's optimal capital investment policy is likewise procedurally transcomputational. Finance courses teach that firms should invest in a new project if and only if its expected net present value

$$NPV(k)_t = \iint_{\tau=t+dt}^{\infty} \mu(s, \tau) e^{-r(s,\tau)} \left(\sum_{n=1}^{N} p_n(s, \tau) Q_n(s, \tau) - \sum_{m=1}^{M} p_m(s, \tau) X_m(s, \tau) - T(s, \tau) \right) ds d\tau$$

is positive. The additional numbers needed for this are the prices $p_n(s, \tau)$ and quantities $Q_n(s, \tau)$ of each of the N outputs the project would generate, the prices $p_m(s, \tau)$ and quantities $X_m(s, \tau)$ of each of the M inputs (each raw material, intermediate good, and category of employee, for example) the project would require, and the taxes $T(s, \tau)$ the project would incur at every future time τ should state-of-the-world s occur at that time. As above, $\mu(s, \tau)$ is the probability that the world ends up in state s at time time τ and $r(s, \tau)$ is the discount rate at which market participants discount future disbursements at time τ should state s occur then. Multiplying the number of variables by the number of time periods by the number of possible future states of nature generates an infeasibly large number of values needed to "solve" this equation. Again, almost nothing can be known about almost all these numbers, especially if the project involves a new technology.

Experience can fill in some of these unknowns for familiar and repeated investments and the equations above can sometimes provide helpful guidance, if not precise solutions. But innovations are, by definition, new. The uncertainty surrounding major new technologies makes stocks and investment projects all but impossible to value using the equations above.

Confronted with procedurally transcomputational problems, people who must nonetheless make decisions, resort to rules of thumb. Simon (1957) calls this *bounded rationality*. Decision-makers adopt rules-of-thumb that provide sufficiently right decisions sufficiently often that the marginal value of a more accurate solution falls short of the marginal cost of occasional wrong decisions. Rules of thumb that lead to better decisions are repeated and emulated. They spread and displace less successful rules of thumb in a process of economic selection that promotes the survival of the fittest rules of thumb (Nelson and Winter 1982).

Kahneman (2003) argues that behavioral biases in finance reflect selection for such rules of thumb. One very simple rule of thumb is to observe what other people are doing, and if they look knowledgeable, do the same thing – a rule of thumb that leads to what Welch (1992) calls an *information cascade*. Behavioral economics shows information cascades to occur spontaneously in the laboratory (Anderson and Holt

1996, 1997) and in the real world (Alevy et al. 2007).[14] This may reflect an innate propensity to reward conformity (Hung and Plot 2001). Information cascades occur in complex adaptive systems, such as financial markets (Hirshleifer and Teoh 2009; Mahdi and Perc 2017).

Information cascades especially arise as people grapple with procedurally transcomputational problems regarding new technologies because emulating the decisions of other often works out well. For example, if a new technology has positive network externalities – its IRR rises as others also adopt it (Katz and Shapiro 1985). Technologies with network externalities include telegraphs, telephones, radios, color televisions, cell phones, the internet, and computer operating systems, whose value to each user rises as the number of other users rises.

Financing network externalities can require a Leap of Faith – they will be successful only if they succeed. A tech-related investment bubble can commit an economy to a Leap of Faith by irreversibly committing capital to a new network that could never have attracted investment from individually rational savers or business from individually rational consumers.

3.4   Keynesian investment

The social object of investment may be to defeat the dark forces of time and ignorance, but Keynes' (1936) likens the private objective of a successful investor to judging a beauty contest, in which

> *"It is not a case of choosing those [faces, stocks or investment projects] 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."*

The trick is to know ahead of time which stocks other investors will think other investors will find most valuable, to buy them quickly and quietly, and to sell them before other investors think other investors find something else more attractive.

Kerr et al. (2014) reason that the returns to investment in innovation are especially difficult to analyze in terms of quantifiable probabilities and payoffs. The median innovation fails, and so has a minus 100% return, mitigated only by whatever used equipment is salvageable. A mere 10% of innovations provide 75% of the returns to innovation. Venture capital (VC) funds finance early-stage innovation and sell the few successful ones into public stock. VC funds' initial assessments of the innovations they finance are uncorrelated with ultimate success, so they appear to do an initial screening and then rely on diversification to achieve overall returns. Kerr et al. posit that stock market bubbles, into which VC funds sell successful investments, boost the funds' returns to financing innovation and promote faster technological progress. Intermittent tech bubbles may thus be important to the long-term viability of VC funds' business models.

At the economy-level, a Keynesian beauty contest can thus look much less loopy than the quote above implies. Investors who buy overvalued shares in high tech firms lose money, but those firms' founders and early stage financiers, including VC funds cashing out may make acceptably high returns. Most importantly, the Keynesian beauty contest can help the economy as a whole capture the innovation's often very high SRRs (Angeletos et al. 2010).

4.   Stock Market Bubbles and Economic Growth

In the years around 1600, a revolutionary development was underway in the Low Countries (now Belgium

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[14] See also Goeree et al. (2007) on how information cascades end.

and the Netherlands). The middle class, previously an unimportant stratum beneath the ruling aristocracy and above the vast subsistence agriculture underclass, became larger and more important. Bourgeoisie expansion and the beginnings of industrialization spread from the Low Countries to England, then to other parts of Europe, to European colonies, and to parts of East Asia (Rosenberg and Birdzell 1986).

Why this began where and when it did, rather than in Song China, the Islamic Caliphate, the Roman Empire, or Aztec Mexico is called Needham's Question, in honour of the British biochemist and sinologist Joseph Needham (2004), who wrote:

> "A continuing general and scientific progress manifested itself in traditional Chinese society but this was violently overtaken by the exponential growth of modern science after the Renaissance in Europe"

Needham's question remains incompletely answered. The development of corporation and securities law (Rosenberg and Birdzel 1986), openness to innovation (Landes 1998), and institutional developments favoring careers in business over government (Baumol 1990) likely all contributed. Natural resources or their absence are also posited as critical factors (Diamond 1997; Sachs and Warner 2001; Engerman and Solokoff 2012; Morck and Nakamura 2018). Western prosperity is also linked to imperialism and slavery (Lenin 1916; Williams 1944; Viner 1948; Engerman 1972; Davis et al. 1986; Eltis and Engerman 2000; Dilley 2011; Baptist 2014). But abundant (or absent) natural resources are not unique to these regions or times, nor are imperialism and slavery. The first stock markets and stock market bubbles, however, are. Moreover, these early bubble are much more than episodes of investor madness (Garber 1980, 1990).

4.1   Amsterdam invents the stock market, and the bubble

By the early 1600s, two revolutionary things were happening in the United Provinces of the Netherlands. Developments in mathematics were revolutionizing navigation (Davids 2015, Levi-Eichel 2015). Key advances included Gerardus Mercator's 1569 cylindrical projection mapping, Bartholomaeus Pitiscus's 1595 *Trigonometria*, and Valentinus Otho's 1614 publication of accurate trigonometric tables, *Nova et Aucta Orbis Terrae Descriptio ad Usum Navigantium Emendate Accommodata*, which built on work by his teacher, Georg Joachim Rheticus de Porris, a student of Nicholas Copernicus. John Napier's 1614 invention of logarithms and Pierre Vernier 1631 invention of the slide-rule made trigonometric calculations practical. Navigators, especially those trained in these new techniques in the Netherlands, were the era's high tech workers. Second, the modern world's first stock market formed in 1602 in Amsterdam. The two are connected.

The stock exchange formed to formalize trading in the shares of the Dutch East Indies Company (Vereenigde Oost-Indische Compagnie, or VOC, est. 1602), which monopolized trade between East Asia and the Netherlands, an entrepôt to other parts of Europe. The stock market arose to capitalize the hot new technology companies of the day, trading companies that used revolutionary new navigation technologies to transport spices and other high value added goods (including slaves) between continents.[15]

Speculation buoyed Amsterdam stock prices, letting trading companies tap abundant capital. However, the first bubble formed around tulips, a highly sought-after luxury good, more than stocks. In the 1630s, tulip bulb prices soared to Copernican heights as speculators created derivative contracts to sell notional tulips in quantities far outstripping their physical numbers until the whole edifice collapsed in 1637. Tulip speculators were not merely ruined, but scolded by moralists of all subsequent ages. The stock market and economy were undamaged (Goldgar 2008).

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[15] For a more detailed rendition of these developments in the Netherlands and their transplantation to the United Kingdom, see Frentrop (2003).

Shares resumed their rise and the Netherlands became the financial center of Europe. Ultimately, a 1688 stock market crash, in which the Dutch West Indies Company played a key role, heralded the end of Dutch financial pre-eminence. Vega (1688, pf. 81) channels Keynes' beauty contests theory in the gathering bubble "it is not important that the basic value of the shares be practically nothing as long as there are other people willing to close their eyes and support those contradictions."

4.2   The first international high-tech boom and stock market crash

In 1688, London merchants invited William of Orange, Stadtholder of the United Provinces of the Netherlands, and his wife Mary Stewart, to invade Britain and seize the throne from the Catholic King James II. This *Glorious Revolution* also brought "Dutch finance" to London (Frentrop 2002; Barone 2007) and enriched a politically disruptive class of Whigs who had "raised themselves from poverty to great wealth, despise the advantages of birth" (Davenant 1701).

Late 17th century British shareholders capitalized long-distance trading companies, salvage companies, and companies organized around patented inventions: the Convex Lights Company to make gas lamps, the Sucking Worm Engine Company to make fire pumps, and so on. Edmund Halley's development of actuarial tables revolutionized insurance, and the concept or rewards offsetting risks gained salience. As stocks rose on increasingly speculative trading, a wave of IPOs floated trading, mining, manufacturing, mortgage, real estate and pseudo-high-tech firms, including one to sell a "wheel of perpetual motion" (Mackay 1841).[16]

Speculative trading associated with the genuinely transformational new navigation and insurance technologies inflated stock market bubbles and IPO booms in London, Paris and Amsterdam (Frehen et al. 2013). Some IPOs were notorious frauds - John Blunt's South Seas Company in London (Balen 2002) and John Law's Mississippi Company in Paris (Murphy 1997). Many listed in MacKay (1841), such as elemental transmutation and perpetual motion machines, look absurd. But others developed the new technologies. London Assurance and Royal Exchange applied new actuarial mathematics. Puckle's Machine Gun Company and Sir Richard's Fish Pool Company both featured ultimately viable new technologies. Despite the frauds and excesses, the stock market bubble, especially that in London, funded genuine technological progress (Carswell 1993, p. 243).

All three stock markets crashed in 1720 – Paris in May, London and Amsterdam in September. The British parliament responded to furious shareholders with the Bubble Act of 1720, which banned new joint stock companies. First proposed by the South Seas Company to limit entry by competing bubble companies, the Bubble Act remained on the books until 1825. By then, it had become a dead letter, as parliament had grown accustomed to chartering new joint stock companies by granting exemptions (Harris 1994).

4.3   A Pattern

Subsequent bubbles financed successive waves of new technology (Kindleberger 1978; Kindleberger and Alibur 2017). In the early 1790s, the British parliament took to granting Bubble Act exemptions to canal building companies. Canal stocks collapsed in 1795, but rose again. A series of booms and busts funded locks and canals that, by the 1810s, connected inland cities, previously only accessible by often impassible dirt trails, to trade centers on coasts, navigable rivers or surviving Imperial Roman roads.

A larger canal building bubble burst in 1836 in Britain and 1837 elsewhere, but its investors left Canada and the United States networks of canals and towpaths. An 1840s railway stock market bubble burst in 1847 in Britain and 1848 elsewhere (Campbell 2012, 2013), but left railways in Britain, Europe, Canada and the United States. Rail was a major improvement over canals where land was less level. Cotton prices

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[16] Some of the more bizarre scam stock offerings Mackay (1841) lists may be fabrications by later pundits.

tracked these episodes in the United States. A European bubble bust in 1857, but left new mills and more railways. Another stock market bubble ended in the global financial crisis and stock market crash of 1873, but left more and better railways, many with telegraph lines alongside.

Another general stock market run-up from the mid-1890s into the early 20th century financed the rollouts of new technologies in cement production, electric light, electric equipment, electric trolleys, petroleum refining, steel making, telephones, and other sectors (O'Sullivan 2007). US markets crashed in 1903, recovered, and crashed again in 1907. Markets elsewhere followed similar but not identical trajectories. For example, the Canadian bull market persisted until 1911.

The roaring twenties stock market was another high-tech boom (Nicolas 2007). High-tech companies of the era included Radio Corporation of America (RCA), International Business Machines (adding machines), General Motors (automobiles), Pan Am (airfreight), RKO (motion pictures) and many others. Public utilities grids vastly expanded access to electric power and telephone networks and all their network externalities. Telephones, electric lights, and electrical home appliances made the new technologies salient to large number of people. Shares, especially in high tech sectors, rose through the late 1920s despite many firms having no earnings. The market crashed in 1929, but left the physical plant of automakers, aviation, business machines, electric and telephone grids, motion pictures, and other technologies in place. New owners bought bankrupt firms' assets, but many firms capitalized in the 1920s bubble not only survived the crash, but continued making major advances into the 1930s, despite the Great Depression (Field 2011).

The 1960s and 1990s also qualify as high-tech booms, and both featured stock market bubbles. Major high-tech sectors in the "go-go" stock market of the 1960s included aerospace, mainframe computers, passenger jets, plastics, solid-state electronics, plastics, and synthetic fabrics. The 1990s dot.com bubble featured cell phones, the internet, microcomputers, and major advances in software. The 1960s bull market ended with a large drop in stock prices, partly obscured by the high inflation of the 1970s. The 1990s dot.com boom ended with the crash of 2000.

4.4   Kindleberger Cycles

Mill (1848), Schumpeter (1939), and many others discern a common pattern in such episodes. The discussion here follows Kindleberger (1978), whose depiction of a cycle of manias and panics is far clearer than Schumpeter's and far more complete than Mill's. For brevity, this recurring set of phenomena can be called a Kindleberger Cycle. Its essential dynamic is summarized in Figure 1.

First there is a dislocation: something changes to put the economy in disequilibrium. This can be changes in tastes, political developments that distort trade, or any other jolts to the status quo that leave the economy far enough out of equilibrium for large economic profit opportunities to arise. Most often, the dislocation is an important new technology. Thus, Schumpeter (1939, p. 250) describes the 1720 bubbles as like

> "later manias of this kind, induced by a preceding period of innovation which transformed the economic structure and upset the pre-existing state of things."

Intercontinental shipping, canals, telegraphy, railroads, electricity, the internet, and many other technological advances have played this role. The existence of the new technology makes previously unviable business ventures not just viable, but hugely profitable. Amid many failures, a first generation of successful innovators learn how to capture these economic profits, and make themselves and their financial backers immensely wealthy.

However, the rapid development of whole economies also creates dislocations - in both emerging and developed economies. Australia, Canada, Germany, Japan, Sweden, and the United States all created such

dislocation in the late 19th and early 20th centuries (Kindleberger 1976). So did Hong Kong, Singapore, South Korea and Taiwan in the post-World War II era. More global investment poured into rapidly industrializing Canada in 1895-1911 than into the United States, an economy tenfold larger. Investments in Canada in the 1890s or South Korea in the 1990s, were really bets that Rosenstein-Rodan's (1943) network externalities would come together, that where new steel mills rose, cement factories would rise alongside, and that insurance firms and shopping center developers would arise too, creating demand for steel and concrete. Investment manias in new market economies did not always end as well: Argentina looked as set as Australia or Canada for rapid industrialization in the 1890s (Tanzi 2007); and the Philippines and Indonesia seemed as ready for rapid development as Singapore and Korea in the 1960s (Lim and Morck 2021).

The next phase in Kindleberger's cycle has less well-informed investors seeing attempting to mimic investment strategies that enriched their former peers. This can be modelled as an information cascade, wherein costly information can make copying seemingly informed actors rationally preferable to acquiring information.[17] A flood of capital into the firms, sectors, or economies that feature the positive economic profits ensues, more or less just as introductory microeconomics predicts, and pushes the economy back to the competitive equilibrium. Private economic profits return to zero.

Nevertheless, zero profits do not stop the capital flood. Uninformed investors continue pouring their savings into erstwhile positive economic profit ventures and a mania or bubble arises. Demand for shares in these ventures pushes up their prices, which increases demand, which pushes up prices further in a positive feedback loop. Smith (1776) describes this positive feedback loop as overtrading.[18] Mill (1848, p. 542) summarizes a mania thus:

> *"Examples of rapid increases of fortune call forth numerous imitators and speculation not only goes much beyond what is justified by the original grounds for expecting a rise of price, but extends itself to articles in which there never was any such ground."*

Mill adds that "at periods of this kind, a great expansion in credit takes place". This is because bankers are seldom better informed than shareholders, and elevated financial securities prices make potential borrowers look more creditworthy than they would be if prices reflected fundamental values. Credit expansion happen in many cases, but not always. For example, banks had little role in financing the dot.com bubble of the 1990s.

The next phase begins when the mania ends. Kindleberger (1978) calls this instant of collective insight, when asset prices' celestial detachment from fundamental values becomes obvious a "Minsky moment", honoring Minsky's (1986) observation that the end of the bubble and onset of the crash often corresponds to little or no real new information.

Because no-one, and certainly no-one in government, wants the blame for ending the boom, many manias' Minsky moments are delayed. Pundits can help with what Shiller (2000) calls "new era stories" to justify ever more stratospheric share prices. Often-recycled themes include arguments that shares be

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[17] See Welch (1992) for essentials, and Alevy et al. (2007), Amihud et al. (2003) and others for elaborations.

[18] Although Adam Smith regarded overtrading as important, economic theory marginalized these idea in the mid-20th century, perhaps as the Crash of 1928 faded from living memory, until the Crash of 1987 and Dot.com Crash of 2000 reanimated the topic. See Le Roy (2004) for a literature survey. Bubbles can arise and expand if investors adhere to heterogeneous predictions, risk assessments or behavioral bias, especially if artificial barriers such as lock-ups or short sales prohibitions exclude important investor classes (Ofek and Richardson 2004). Investors with false beliefs can survive and even dominate financial markets under plausible conditions (De Long et al. 1990, 1991; Kyle and Want 1997; Scheinkman and Xiong 2003; Hirshleifer et al 2006; Koganm et al. 2006; Yan 2008; Coury and Sciubba 2012).

valued based on sales, rather than profits; that huge intangible assets justify cosmological market to book ratios; and so on. Accountants help with new relaxed or novel rules; and regulators help with abbreviated listing and reporting requirements. Bankers help perpetuate the mania with the floods of ready loans Mill (1848) noted, and governments can encourage this. Governments and central bankers help with policies that encourage banks to lend so as to prolong the good times past the next election. Financial engineers can help with new investment vehicles that promise high returns from new investment schemes – often highly leveraged real estate transactions.

All of this help tends to create space for fraudsters. Thus, while the ultimate Minsky moment could be almost anything, it is often the revelation of a fraud. The mania phase ends and the panic phase begins.

Uninformed investors realize the shares they own are overvalued and race to sell. A race to sell is triggered because everyone wants to sell before the price falls more, so everyone tries to sell at once. Kindleberger (1978) calls the resulting selling wave a *Torschlusspanik* (door-closing panic), a German word for people pushing to get out of room and all becoming stuck in the door, so none gets out.

The switch from mania to panic can require more than one Minsky moment. One mania over, subsidiary manias can develop. Investors, accustomed to high disequilibrium and mania returns, seek new high return alternative investments. New ways of investing in debt financed real estate bubbles arise. More than one Torschlusspanik may be needed to effect the switch.

Tosschlusspanik selling waves can push securities prices far below their fundamental values, so firms avoid issuing new shares and investors, feeling poor, cut back on consumption, which depresses business activity. Shell-shocked bankers, their balance sheets suddenly heavy with nonperforming loans, stop lending to anyone as they try to rebuild their banks' capital or reserves. Politically connected banks and firms turn to their central banks and governments for bailouts, effectively socializing their losses from fuelling and prolonging the mania. Ever more newly exposed frauds make forgotten risks again salient to investors. Investment, consumption, credit and business activity all drop, and the economy goes into recession or depression.

As the downturn worsens, angry investors denounce unrestrained free markets and regulators respond with tough new rules. A mid-1690s exposure of high-profile frauds hammered share prices and, in 1697, parliament limited the number of stockjobbers to 100 and forbade their trading on their own accounts.[19] The Bubble Act of 1722 banned joint stock companies as a public nuisance, though listed were grandfathered (Harris 1994). After the Crash of 1929, the United States government raised taxes on the rich, peaking at 90% marginal rates in the 1960s, set the interest rates commercial banks could pay on checking and savings deposits by decree until 1979, limited the number of branches banks could have, drastically limited margin (debt-financed) stock purchases, and made stock jobbing a regulated monopoly.

A sometimes long period of near-equilibrium normalcy comes to prevail. Their anger vented, investors again come to expect normal returns, consistent with the economy's equilibrium growth rate. Hastily formed regulators are captured (Stigler 1971) by the banks and firms they were intended to regulate. Regulations are revised, replaced, dropped, or forgotten. Thus, soon after the Bubble Act, the flotation of new share issues resumed, first subject to case-by-case parliamentary approval and then subject to successively more limited regulatory oversight regimes.

Successful past innovators earn high cash-flows as their investment costs fade into the past and their market positions solidify. The freewheeling radio entrepreneurs of the 1920s sold their stations to a handful of national networks that could better deal with regulators. Local telephone networks, set up in
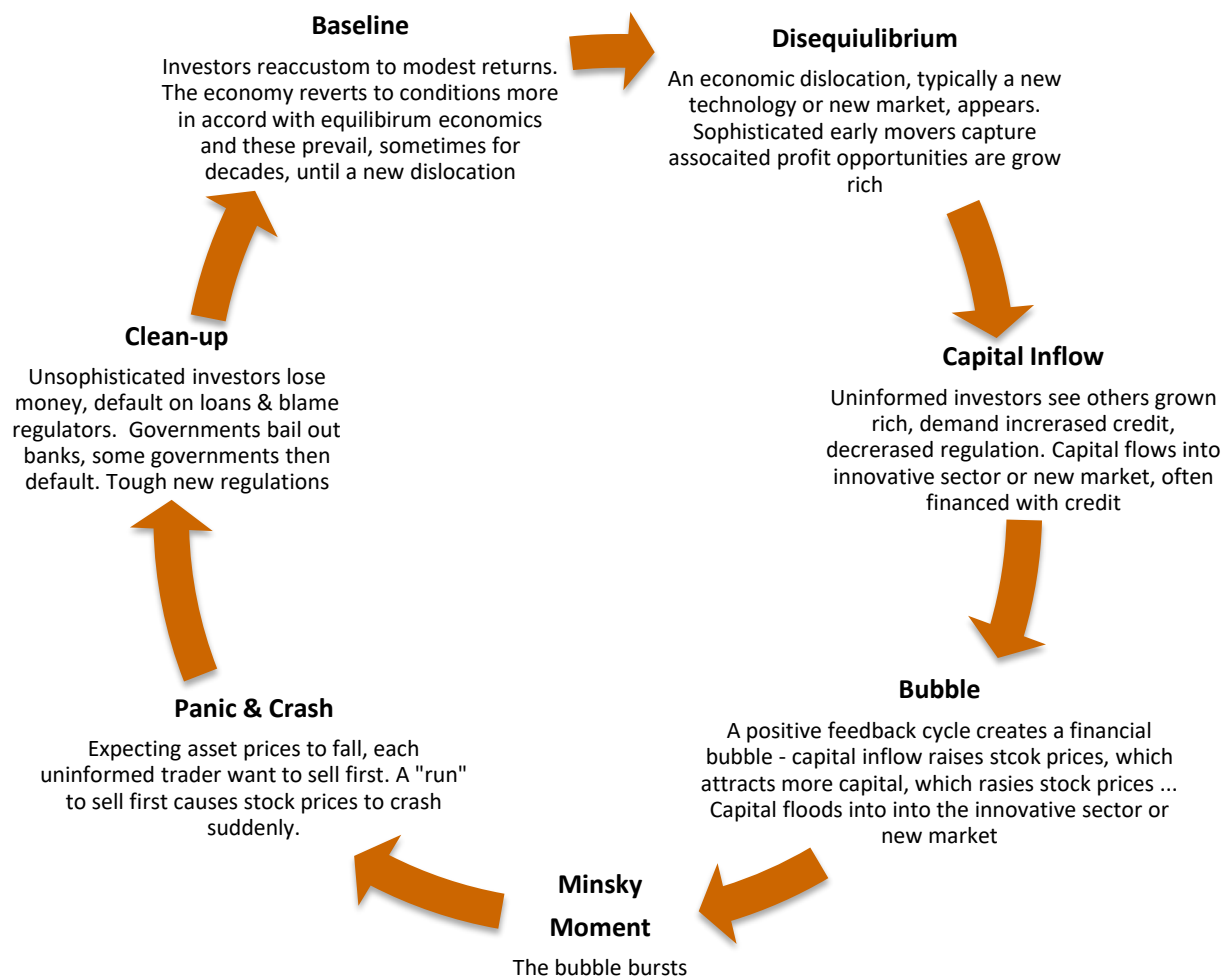
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[19] William III, 1696-7: An Act to restrained the Number and ill Practice of Brokers and Stock-Jobbers. [Chapter XXXII. Rot. Parl. 8 & 9 Gul. III. p.11.nu.1].

the US from the later 1800s through the 1920s, organized around a monopoly long-distance telephone company, AT&T. Over time, regulators set up to oversee these new high technology sectors found second careers at the companies they regulated. Envisioned as arms of the government reaching down into the industry, the regulatory agencies slowly morphed into arms of the industry reaching up into government. Regulators grew increasingly concerned about the health and prosperity of the industry in a transformation Stigler (1971) calls *regulatory capture*. Cell phone networks, internet service providers, and software companies that were dynamic start-ups in the 1990s likewise became accustomed to living of the cash flows from their past investments and aware of the importance of influencing government officials to protect those cash flows into the future. Investing in political influence grew increasingly more profitable than investing in yet more new technology.

Figure 3. Kindleberger Cycle

Kindleberger describes a historical cycle of financial manias, panics, and crashes following a common pattern, each preparing the way for the next.

Baseline

Investors reaccustom to modest returns. The economy reverts to conditions more in accord with equilibirum economics and these prevail, sometimes for decades, until a new dislocation

Disequiulibrium

An economic dislocation, typically a new technology or new market, appears. Sophisticated early movers capture assocaited profit opportunities are grow rich

Clean-up

Unsophisticated investors lose money, default on loans & blame regulators. Governments bail out banks, some governments then default. Tough new regulations

Capital Inflow

Uninformed investors see others grown rich, demand increased credit, decrerased regulation. Capital flows into innovative sector or new market, often financed with credit

Panic & Crash

Expecting asset prices to fall, each uninformed trader want to sell first. A "run" to sell first causes stock prices to crash suddenly.

Bubble

A positive feedback cycle creates a financial bubble - capital inflow raises stcok prices, which attracts more capital, which rasies stock prices ... Capital floods into into the innovative sector or new market

Minsky Moment

The bubble bursts

Based on Kindleberger (1978).

The economy adjusts to a slower, more normal pace of innovation or market expansion (Ramey 2020), but the store of knowledge is permanently increased, as are productivity levels (Scotchmer 1991). At this point, experts can chime in with dire pronouncements of the end of innovation. In 1875, two years after the 1973 financial crisis, the young Max Planck's professor warned him away from physics, a field with no prospect of new ideas (Weinberg 1992. P. 14). Hogan's (1996) announcement of the "end of science" rang in the information technology revolution. Gordon's (2016) finding that rapid innovation has ended remains for historians to judge.

Eventually, a new dislocation occurs in some other corner of the economy. Investors, having forgotten the financial misadventures of their elders, or their former selves, observe informed investors growing wealthy and demand deregulation to let ordinary people invest in the new technology, newly emerging markets, or whatever the new source of positive economic profits turns out to be. Financial deregulation remerges as a top political priority so overtrading can happen again. For example, in January of 1825, seventy IPOs were floated in London and the Bubble Act, by then perceived as pointless red tape, was repealed in June – just in time for ordinary investors to buy into a stock market bubble that burst in December (Dagher 2018).

4.5   Big new things other than new technologies

Many of the new technologies developed with funds from the bubbles describe above also created new markets. The 17th century trading companies used new mathematical discoveries to navigate the high seas, but also brought access to markets in Asia, Africa, and the Americas. Canals and railways were new technologies, but both technologies greatly reduced shipping costs to inland markets. In these cases, an extension of markets was likely a major part of the social return of the new technology produced.

For example, before canals, low-cost long-distance trade connected seaports with each other. Goods and services readily available in coastal markets were far more expensive inland. River boats were small and, traveling upstream, required oarsmen (except where prevailing pushed ships upstream as in Egypt). People not near navigable rivers, or a paved road built in Roman times, relied on the limited and expensive wares pedlars' wagons carried along bandit-ridden and often near impassible mud trails. Canal building manias, as in 1770s UK or 1830s Canada, let inland farmers and millers expand production and sell their surpluses in distant markets where prices were higher. Canals lifted inland land prices and made new farms and mills profitable. Railways and trucking each had similar market extension effects.

Some bubbles were purely about new markets. For example, many Spanish colonies became independent republics during the Napoleonic occupation of Spain. By then, the United States seemed an economic success and investors who gambled on its success grew rich. An 1820s mania in mining and textiles stocks, both big new technologies at the time, spread into an investment mania in Latin American bonds, touted as investments in the "next" United States. The first Latin American debt crisis ensued in 1825. Banks failed and bondholders lost, but the Latin American republics had become established nation states. The settlement of Argentina renewed the promise of the region and a second Latin American debt crisis in 1890 would have bankrupted Barring Brothers, but for a Bank of England bailout.

The 1997 East Asian economic crisis is another such episode. Investors flooded East Asian "Tiger Economies" – Hong Kong, South Korea, Taiwan and Singapore – with capital in the early to mid-1990s. These economies had invested heavily in education, infrastructure and the legal and regulatory reforms needed to support a market economy. Their financial systems had developed to channel domestic investors' savings relatively successfully into value-increasing uses (Allen 2001). Foreign investors, trying to emulate this success, poured funds into not just the "tiger economies," but also into nearby countries, such as Indonesia, the Philippines, and Thailand, that seemed similar to them. Stock markets throughout the region inflated and crashed in 1997. Brief recessions followed in the "tiger economies", but growth

soon resumed and their ascents to First World economy status were successful. Many investors had lost heavily, but the physical capital –buildings, machinery, and technology, though sometimes in new hands, remained where it had been built.

Hirano and Yanagawa (2016) show that country-level bubbles tend to arise around promising middle-income economies, as in Latin America and parts of Asia. Bubbles rarely develop around low-income economies and generally need big new technologies to form in high-income economies, though real estate bubbles fed by credit booms also arise in high-income economies. Allen (2001) argues that a minimum level of domestic financial development is necessary for a bubble to form. A degree of meaningful institutional development and early economic success might also be necessary to instill expectations of rapid continued development.

Like a big new technology, economic development can have a social rate of return far higher than the internal rates of return individual firms in that economy earn. This is because economic development has network externalities similar to those surrounding innovations such as the telephone or the internet. Just as a telephone is of little value if yours is the only one, a lone technologically up-to-date factory can be of little value if surrounded on all sides by a subsistence agriculture economy. Rosenstein-Rodan (1943) argues that *network externality* problems are a major barrier to economic development because every firm in a developed economy depends of the mere existence of countless other firms, including legions of firms with which it does no actual business. Each firm requires not just suppliers and customers, but enough rival potential suppliers and customers to prevent either from dictating prices. Each supplier and each customer requires the same, and without this entire ecosystem, no firm can flourish or perhaps even survive. Each firm helps fill out the network and so encourages the further development of existing firms and new ones.

Rosenstein-Rodan (1943) argued that stock markets, designed to capitalize individual firms, could not simultaneously capitalize the entire economy-spanning network of firms that made a high-income economy self-sustaining. They therefore laid out the mission of the World Bank: to provide massive floods of foreign aid finance a Big Push - the state-financed simultaneous construction of an economy-wide network of businesses all at once. Big Push policy failed amid endemic corruption wherever it was tried, including the Asian tiger economies in the immediate post-war decades (Easterly 2006).

South Korea, Hong Kong, Singapore and Taiwan had invested heavily in education public health, basic transportation and communications infrastructure, and functional government. Each had its own mix of state intervention, but by the 1980s all were fundamentally free market economies. When local entrepreneurs built small, and then larger, networks of firms, economic activity could accelerate. When foreign capital flooded in, these firms could expand and new ones could arise. A bubble of investment into these economies may well have been helpful on net.

4.6   Self-replicating Bubbles

Bubbles initially form around Big New Things, generally new technologies. Bubbles begin with genuine abnormally high-return investment opportunities that make early investors rich and both expand as copycat investors pour money in, hoping for more of the same. In both, this can have high social rates of return even though the copycat investors all lose money when the bubble bursts.

Bubbles can beget other bubbles. Investors can come to expect more of the same, even as the technology matures and genuinely high-return investments grow rare. US investors came to accept high returns as normal during the dot.com boom of the 1990s. After the crash of 2000, a historically ordinary return like those in the 1970s and early 1980s seemed uninviting. A new set of high-yield investments was wanted, but the economy had few correspondingly high profit opportunities in which firms could invest.

Financial entrepreneurs can ride to the rescue, offering high return-seeking investors new high-return investments (Geanakoplos 2010). Suppose investors became accustomed to returns of the order of 25% during a high tech bubble. Without a genuine big new thing with genuinely high returns, financial entrepreneurs can goose ordinary returns up into that range using the magic of leverage. Investing $1,000,000 in a real estate property that sells for $1,050,000 a year later provides a $50,000 profit – a 5% return. However, investing $200,000 plus $800,000 in borrowed money in the same real estate transaction recasts the same $50,000 profit as a 25% return on the initial $100,000.

The smaller the underlying return on the real investment, the more extreme the leverage needed to magnify returns up to the levels investors want. Investing $50,000 plus $950,000 in borrowed money to buy a $1,000,000 property that rises only 1.25% to $1,012,500 provides a $12,500 profit on a $50,000 initial investment – which also works out to a 25% return. An adjunctive bubble in real estate forms and expands. A mania can develop, with real estate prices rising because more investors are borrowing more to invest in real estate, which boosts real estate prices still more, and so on.

These numbers overstate the investor's returns if investors' borrowing costs are above zero percent, for the cost of repaying the loan must be subtracted out in each case. For example, if interest costs on the loan exceed $12,500 the last of the above transactions is unprofitable. Ever thinner real underlying profit margins also make highly leveraged transactions increasingly risky. For example, if the property fell by more than 1.25% instead of rising, the first of the above transactions becomes less profitable, but the second leads to bankruptcy.

As the demand for loans rises, the cost of borrowing rises. The 1920s real estate bubble rose and popped as banks and mortgage financiers sought to match the high returns of call money and stocks (Nicholas and Scherbina. 2013). Short-term loans have lower rates than long-term loans, so investors take to borrowing at shorter and shorter terms and refinancing their loans increasingly frequently. Prior the 1997 East Asian crisis, banks in the region were borrowing at ever-shorter terms. Real estate investors in the US and parts of Europe were goosing up returns in these ways prior to the 2008 financial crisis.

Eventually, rising interest rates eventually put a stop to these sorts of leveraged transactions. Investors borrowing ever more to keep their returns up ultimately find themselves bankrupted if real estate prices fall even very slightly. Waves of bankruptcies of highly leveraged investors ensue and real estate prices collapse. The adjunctive bubble bursts.

Central banks often intervene to prolong such credit-fueled bubbles with expansionary monetary policies to keep interest rates low, putting off the day of reckoning by letting increasingly highly leveraged investments continue longer. In many cases, banks and other financial institutions grow enmeshed in these sorts of highly leveraged investments, so prolonging the bubble becomes a way of saving the banking system. Nobody likes a party pooper, and central bank presidents are rarely popular in any case. Moreover, banks and financial firms, grown wealthy using debt to goose up returns, can readily hire top lobbyists to attack any officials who contemplate higher short-term rates.

Credit expansion continues until short-term rates rise enough or real estate values fall enough to bankrupt the highly leverage investors. Their inability to repay their loans stresses banks and financial institutions. Some fail, but a complicated political economy calculation generally leads governments and central banks to bail out the stressed banks and financial institutions (Allen and Gale 2007). The alternative, letting banks and financial institutions fail, becomes economically damaging if near bankrupt banks curtail lending to sound borrowers, causing a credit crunch in which healthy businesses fail for want of working capital so business failures and unemployment rise.

Kaminsky and Reinhart (1999) put bailout costs in the range of 5% to 13% of GDP, with the higher range relevant if a currency crisis develops in tandem. If the credit crunch looks costlier, bailing out the banks

and financial institutions follows. Knowing this, the CEOs of banks and financial institutions lend aggressively into the real estate bubble because they rationally expect bailouts when it bursts. Increasingly aggressive lending makes the bubble bigger and the bailout costs after its collapse greater.

Politicians then deplore free market excesses and enact tough new regulations to make sure nothing like this can ever happen again. Investors grudgingly accept low sustainable returns on their savings. Normalcy returns. The economy grows, with minor ups-and-downs, until a new generation of investors sees a new cohort of early backers of the next big new technology or market. Stiffer regulations often include more binding short-sale restrictions, which may actually help the next bubble begin when investors' beliefs about the future next diverge (Harisson and Kreps 1978; Hong et al. 2006, 2008; Hong and Stein 2007).

4.7   Clean-up Costs after the Crash

Stock market bubbles that finance new technologies and newly developed market economies very plausibly have high social returns and, when they burst, do little overall damage to the economy, save hurting investors who bought late. In contrast, credit expansions to inflate or reflate bubbles seem far less socially useful. The credit expansion that collapsed in 2008 left much empty real estate in the US and Europe. The credit expansion that accompanied and perpetuated Japan's 1980s bubble economy did the same, and real estate prices in Japan remain depressed a generation later.

Economists' response to stock market bubbles is, with few exceptions, to scold investors for their irrationality and to propose ways governments might prevent future bubbles. The general reluctance of economic modellers to cast financial bubbles in a positive light is understandable because the costs of the credit crunches that often follow can be large. The 1930s Great Depression followed the Roaring '20s stock market bubble and 1970s stagflation followed the "go-go" 1960s stock market bubble. The recession following the 2008 real estate credit bubble was the worst since the Great Depression in the US, UK and several European economies.

Estimates of the cost of the average financial crisis depend starkly on assumptions about utility functions, production functions and frictions in models calibrated using short runs of auto-correlated macroeconomic data. In a literature review, Bartlevy (2004, 2005) reports estimates ranging from slightly below zero to over 20% of GDP. Barlevy's tabulated estimates have a grand mean of 2.4% and a standard error of 4.2%. The dispersion is substantial. Barro (2001) estimates the 1997 East Asian Crisis cut GDP growth 3% per year over three years. Hoggarth et al. (2002) and Hutchison and Noy (2005) both put the cost of a financial crisis at 10% of GDP. Demirguc-Kunt, Detragiache and Gupta (2006) report growth rates reduced by 4% on average during banking crises. Kroezner et al. (2007) show the negative effects to be especially concentrated in sectors whose firms depend on external financing. Boyd et al (2005) estimate the average financial crisis costing, depending on their calibration assumptions, 63% to 302% of current GDP by trimming about 8% off the present value of all future GDP. Ollivaud and Turner (2014) estimate the 2008 global financial crisis reduced potential GDP 3% in countries that had a domestic banking crisis and 2% in those that did not.[20]

In general, such studies assume that pre-crisis growth was a normal trend that would have continued but for the crisis. If the crisis followed the rollout of a major new technology or the opening of important new markets, the pre-crisis growth trend was a temporary abnormally that could not have persisted in any event. A pioneering study by Lansing (2009, 2013) calibrates models of a representative agent bubble that finances a new technology and then pops with a cost. Social benefits outweighing the bubble's social costs if the new technology's SRR is more than 2.5 times its IRR to individual firms, the extreme upper range of

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[20] Such problems may be less severe in normal business cycles, but a similarly wide range of welfare loss estimates are reported (e.g. Lucas 1987; Wolfers 2003; Alvarez and Jermann 2004; Barlevy 2004; Imrohoroglu 2008).

his macroeconomic calibration assumptions. Section 2.1 above puts the SRR of R&D spending at well over four times its IRR, and the endogenous growth literature broadly supports such estimates (see Section 2.1), so bubbles fueled by typical R&D investments would generally be social welfare increasing in that model.

The assumption that there is such a thing as a representative bubble, or a representative crisis, may also need relaxing. There is considerable heterogeneity in the circumstances surrounding bubbles and in the damage they do when they pop. The dot.com bubble imploded in 2000 and left only a minor recession in its wake. Downturns following earlier bubbles range from nothing much, as after the 1637 tulip crash, to economically important recessions, as after the gilded age bubble surrounding the turn of the 20th century, to prolonged depressions, as after the crashes of 1873 and 1929.

Using historical evidence, Kindleberger (1978) shows that the aftermath of a stock market mania depends almost entirely on the extent to which banks and other financial institutions got involved during the bubble years. Polar opposites illustrate the reasoning.

Banks played a major role in the 1920s stock market bubble, which rang in the Great Depression of the 1930s. Banks lent money to individual investors, direly or through brokers, to buy stocks on razor-thin margins. When stock prices collapsed, shareholders unable to meet margin calls found their positions closed and their shares sold the market, further depressing stock prices. Runs on stocks and general selling erased 90% of the value of the Dow Jones Industrials Average index portfolio from September 1929 to March 1932. Shareholders' non-performing loans submerged brokers and banks. Banks' panicked depositors raced to withdraw their life savings before their banks failed, and many were not fast enough (Diamond and Dybvig 1983). Evaporating stock portfolio values and vanished bank accounts dramatically reduced people's wealth. The U.S. started a global trade war in 1930 that triggered retaliatory tariffs cutting US farmers out of foreign markets. Agricultural commodity prices within the US collapsed and waves of farm mortgage defaults dealt another blow to US banks (Madsen 2001; O'Rourke 2009). The banking system frozen, trade credit became unavailable even to sound borrowers, who then also failed (Bernanki 1983). Unemployment rose and still more mortgage defaults hit banks. Inept central bank governance likely made matters worse (Friedman and Schwartz 1963).

In contrast, bank loans played almost no role in the dot.com bubble of the 1990s. High-tech firms raised money from venture capital fund that took them public, where the venture capital firms cashed out and public investors poured still more capital into their technologies. Most of these firms had little debt, especially to banks and individual investors were not buying high-tech stocks on thin margins. The stock market bubble inflated, flooding information technology firms with capital, and then exploded with little adverse impact on the rest of the economy.

These extremes are the endpoints of a pattern across past stock market bubbles. Those accompanied by a greater expansion of credit did more economic damage when they popped. Those that did not form around a new technology (or a new market expansion) had relatively little social benefit to offset the damage they left. The 1920s and 1990s both left important new technologies in place, but the 1920s bubble had terrible social costs and the 1990s bubble cost the world only a brief recession. The real estate bubble of the 2000s left increased housing stock, which surely has some social benefits, but not an economy raised to a higher level by huge technological advances. Its social costs almost surely dominate. The credit expansion and real estate speculation of Japan's 1980s bubble economy likewise left an over-expanded housing stock, and real estate prices there remain depressed a generation later.

The social benefits of bubbles appear to arise primarily from elevated stock prices. The social costs of bubbles appear to flow primarily from the credit expansions that sometimes, though not always, occur alongside stock market bubbles. If an "optimal bubble" might be conceivable, it would form around new

technologies or new markets, restrict itself to stock markets, and have no place for credit expansion or bankers.

Olivier (2005) shows technology related stock market bubbles need not precipitate credit crises. And if stock market bubbles intensify investment new technologies with very high social rate of return, bubbles would correspond to abnormally high economic growth as those returns are realized, which would not have occurred without the bubble and would not continue in any case.

The three decades following World War II were an era of rapid growth without financial manias, panics and crashes in high-income economies (Bordo et al. 2001). The era also featured unusually intense regulation - Bretton Woods capital controls, Depression era banking and stock market regulations, industrial policy taxes and subsidies, and very high tax rates. However, these decades followed the Great Depression and World War II, both having wrought unprecedented economic devastation. Rapid growth is far easier starting from a low baseline. Rebuilding cities destroyed by war (Vonyó 2008), applying a reservoir of potential innovations accumulated during the 1930s and 1940s (Gross et al. 2020), and (less unambiguously) dismantling Depression era trade barriers (Singh 2010) could fuel growth without renewed investment in innovation. Milionis and Vonyó (2016) attribute 40% of economic growth from 1950 to 1975 to reconstruction, and subtracting that leaves the era's growth rates no higher than in 1975 to 2000. Global devastation may be too steep price to justify repeating.

4.5   Models of Bubbly Economics

In theory, financial bubbles can arise if the growth rate exceeds the interest rate in the steady state without bubbles, but misallocate capital and slow growth (Tirole 1985; Saint Paul 1992; Grossman, and Yanagawa 1993; King and Ferguson 1993; Caballero et al. 2006). In these models, bubbles are unambiguously growth retarding; though Bosi and Pham (2016) argue that governments could tax bubbles to fund innovation subsidies.
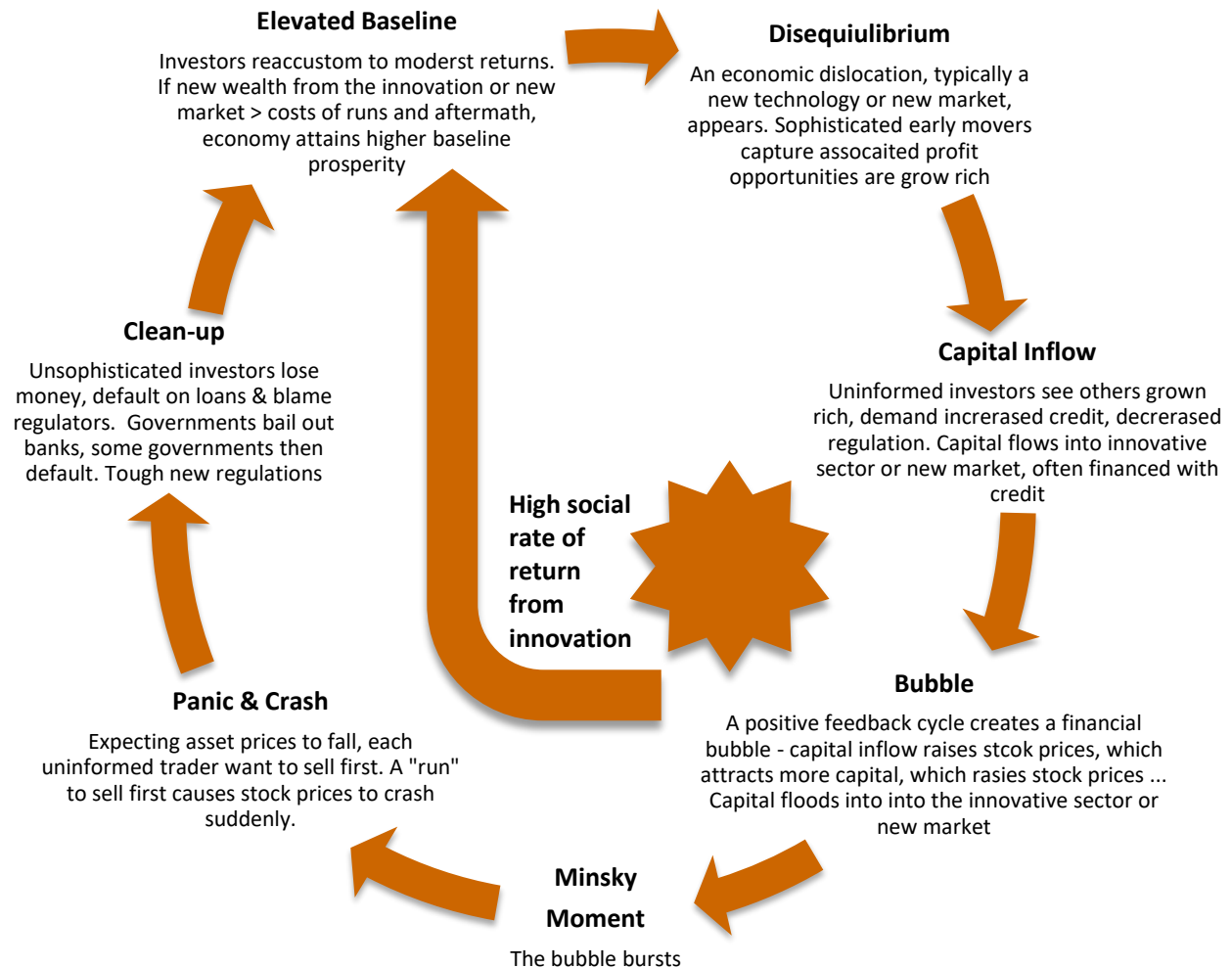
Pastor and Veronesi (2009) argue that the risk associated with radical innovations is initially firm-specific, but becomes systematic as the technology spreads and thus induced market-wide co-movement, which can be misinterpreted as a bubble. Consistent with this, Chun et al. (2008, 2011, 2016) report elevated firm-specific risk as the 1990s IT bubble developed and elevated systematic risk in its later stages and after it bust. They argue that creative destruction elevated firm-specific risk early on, as successful innovators' stock rose and their destroyed rivals' stocks fell; but that industry-wide and market-wide fluctuations came to predominate as noise traders came to dominate the market.

Later models have financial bubbles easing underinvestment caused by a friction. In some, the friction is a collateral constraint on debt-financed investment (Caballero and Krishnamurthy 2006; Farhi and Tirole 2012; Martin and Ventura 2012, 2016; Kikuchi and Thepmongkol 2020; Ventura 2012; Miao and Wang 2014, 2018; Miao et al. 2015; Kunieda and Shibata 2016; Hirano and Yanagawa 2016; Hillebrand et al. 2018). In these studies, firms fail to invest in investment projects with IRRs that exceed what their hurdle rates would be in a frictionless world, and bubbles ease this underinvestment problem.

This reasoning resonates with empirical findings that the expected link between stock market valuations and corporate investment decisions is weak for many firms. Fazzari et al. (1988) show that many firms appear to be financially constrained in this sense. Morck, Shleifer and Vishny (1990) argue that overvalued stock markets can let such firms access capital by issuing overvalued shares. Baker et al. (2003) report that firms with limited borrowing capacity are especially likely to be financially constrained, justifying the focus on collateral limitations in many of the above-mentioned models of bubbles. Polk and Sapienza (2009) derive a rational manager's optimal investment increasing with the magnitude and duration of a shareholder value bubble and present supportive evidence. Thus, stock market manias are associated with unusually high investment (Kindleberger 1978; Martin and Ventura 2012).

Figure 4. Kindleberger 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 a major new technologies or market that increases productivity. Each completion of the cycle ratchets productivity up to a higher baseline level after the economy recovers from the panic and crash.

Elevated Baseline

Investors reaccustom to moderst returns. If new wealth from the innovation or new market > costs of runs and aftermath, economy attains higher baseline prosperity

Disequiulibrium

An economic dislocation, typically a new technology or new market, appears. Sophisticated early movers capture assocaited profit opportunities are grow rich

Clean-up

Unsophisticated investors lose money, default on loans & blame regulators. Governments bail out banks, some governments then default. Tough new regulations

High social rate of return from innovation

Capital Inflow

Uninformed investors see others grown rich, demand increrased credit, decrerased regulation. Capital flows into innovative sector or new market, often financed with credit

Panic & Crash

Expecting asset prices to fall, each uninformed trader want to sell first. A "run" to sell first causes stock prices to crash suddenly.

Bubble

A positive feedback cycle creates a financial bubble - capital inflow raises stcok prices, which attracts more capital, which rasies stock prices ... Capital floods into into the innovative sector or new market

Minsky Moment

The bubble bursts

Based on Kindleberger (1978).

R&D-intense firms, which tend to be young, without earnings from established operations, and without assets for collateralizing debt, rely heavily on stock markets for financing (Brown et al. 2012; Hsu et al. 2014; Acharya and Xu 2017). During periods of high stock market valuations, young and innovation-intense firms are unusually likely to list on stock markets and to issue additional shares (Brown et al. 2009; Aghion et al. 2012). Innovations financed by share issues in the 1920s continued coming on line well into the 1930s (Field 2003, 2011; Nanda and Nicholas 2014; Nicholas 2008). Innovations financed by share issues in the 1990s bubble also appear to be of unusually high quality (Xu and Dang 2018).

As the stock market bubble inflates, they issue shares to accumulate large cash reserves, which they then

run down over time to pay for R&D (Brown et al. 2009, 2012; Brown and Petersen 2011).[21] Stock valuations elevated by sentiment are especially likely to boost R&D spending, perhaps because the sentiment also causes corporate insiders to overestimate IRRs (Xi and Dang 2018). This makes larger and deeper stock markets, and the formal and informal institutions that sustain these markets, important to innovation (Brown et al. 2013). Stock market bubbles thus may have a fundamental role in speeding up innovation and faster productivity growth (Brown et al. 2009, 2017; Acharya and Xu 2017).

Stock market bubble tend to culminate in merger waves (Harford 2005; Rhodes-Kropf et al. 2004. 2005; Maksimovic et al. 2013), in which older firms buy innovative firms. Independent inventors in the early 20th century's high tech booms cashed in by selling to large firms (Nicholas 2010). The acquirers then lost value in the crash alongside small investors who bought high (Moeller et al. 2005). This process lets innovators and their early investors, typically venture capital funds, exit amid the bubble with high private rates of return (Philips and Zhadanov 2013). Acquirer firms emerge owning important the innovations (Nicholas 2003).

The huge margins by which the SRRs of investments in innovation exceeds their IRRs to the innovating firms themselves is tangential in much of this literature. The idea that financial bubbles might allow for something approaching socially optimal investment that is excessive from the perspective of a value maximizing firm has arisen in popular books (Gross 2007; Janeway 2012). Marketing research has also made this connection with considerable sophistication (Sorescu et al. 2018). Using historical episodes, Perez (2002) argues that financial bubbles finance new technologies and, after the ensuing crash fades, ring in golden ages.

Olivier (2000) explicitly models stock market bubbles elevating technology stocks as productivity enhancing, and credit bubbles elevating real estate prices as productivity diminishing. Janeway (2012) agrees regarding technology bubbles, but counters that even real estate credit bubbles might advance innovation by boosting aggregate demand. Shin and Subramanian (2019) explicitly model technological spillovers by letting an individual firm's innovations increase the productivity of an intermediate good used by other firms. Related research explains high tech firms' seemingly bubbly high stock valuations as an option valuation effect driven by the skewed and fat-tailed payoff distributions of experiments with new technologies (Nanda and Rhodes-Kropf 2013, 2017; Kerr et al. 2014; Manso 2016). All of this together suggests that economies with highly developed stock markets and intermittent high-tech bubbles might be especially prosperous.

What all of this suggests is that the Kindleberger cycle might better be thought of as an engine of economic growth. Each Kindleberger cycle floods capital into a Big New Thing – usually a new technology, sometimes a market, but usually something with large positive externalities, including network externalities. The completion of the cycle leaves the economy with those positive externalities minus the cleanup costs of the panic and crash and the costs of whatever capital misallocation occurred in the mania stage. If completion of the Kindleberger Cycle elevates aggregate productivity on net, the process might better be characterized as a Kindleberger engine.

4.5   Blowing Better Bubbles?

Bubbles have more potential to create wealth if they funnel savings into investments with social returns that are higher multiples of the private returns they pay to their buy and hold investors. Innovation is such

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[21] High market valuations associated with sentiment also boost ordinary investment (Loughran and Ritter 1995; Baker and Wurgler 2000; Chirinko and Schaller 2001; Baker, Stein, and Wurgler 2003; Sapienza 2004; Gilchrist, Himmelberg and Huberman 2005; and others), but boost R&D far more than it boosts via R&D appears to be far larger (Xu and Dang 2018).

an investment. R&D qualifies, but this can hardly invite spending on anything and everything under the rubric of R&D. R&D does have to be targeted at innovations with genuine social returns. Part of the problem with R&D subsidies and tax credits is that clever form fillers can find ways to present almost any use of funds as R&D. If bubbles flood sectors with capital, how are they any better?

One possible answer is that bubbles only occur after a credible signal that something new and potentially great lies just over the horizon. Kindleberger repeatedly shows that bubbles occur after a first set of entrepreneurs and early investors get very rich from something new that catches people's imagination. Navigation on the open ocean, canals, railways, telegraphs, steel making, radio, plastics and the internet all made early movers very conspicuously rich, had a bright aura of novelty, and looked like they could genuinely change the world. People got excited and, probably motivated by greed or, more likely, envy, wanted a piece of the action. If a purported innovation without these characteristics can't get a really big bubble going, bubbles might do a better job selecting promising innovations than can committees of industrial policy technocrats doling out subsidies.

Bubbles do form around frivolous investments. The Dutch tulip bubble of 1637 (Goldgar 2008) and US "beany baby" bubble of the 1990s (Bissonnette 2016) elevated the prices of tulip bulbs and a childrens doll, respectively. Both occurred as genuine new technologies – oceanic navigation in the early 1600s and information technology in the 1990s – were enriching entrepreneurs and investors funding genuinely socially valuable innovations. Economically useless bubbles perhaps form alongside floods of financing into genuinely socially useful investments.

5.   Economic Selection for Bubbles

Coddington (1976) refers unflatteringly to Neo-Keynesian macroeconomics as "hydraulic". But Irving Fisher (Brainard and Scarf 2005), William Phillips (Swade 2000), and other prominent economists built model economies from pipes, reservoirs, pumps, floaters, and valves. In these, water-as-capital flowed through the system elevating some sectors and sinking others until an equilibrium emerged where each component of the economy bobbed at its appropriate level. These models, Fisher's especially, provided the groundwork for general equilibrium microeconomics, in which private investment decisions coalesce into social welfare optimizing resource allocation according to the fundamental theorems of welfare economics.

Where there is water, there can be floods. Extending the metaphor, financial manias pour floods of capital over the economy, lifting all the floaters and spilling over into adjacent reservoirs. This seems sloppy compared to the tight logic of equilibrium economics; and it is. But rational economic decision-making leaves private investment in innovation chronically far below its socially optimal level, and intellectual property rights, subsidies and other "fixes" appear ineffective, perhaps and even perverse. If so, floods of capital that occasionally inundate hot new technologies with capital might be the lesser evil.

5.1   Escaping Cardwell's Law

The subversion of intellectual property rights law and state-financed innovation programs may reflect a deeper animosity to innovation. Cardwell (1972, p. 210) documents the historical regularity that societies become technologically creative only for short periods. Mokyr (1994) calls this Cardwell's Law and argues it reflects powerful forces that converge to quash rapid technological innovation.

One force is a conservative bias, evident in behavioral economics, associated with prospect theory, which shows people fear losses more than they value gains of equivalent magnitude. The downsides of change outweigh the upsides. Thus, Schumpeter (1911) promises innovators "the manifestation of condemnation [that] may even come to social ostracism and finally to physical prevention" (p. 87) and scorn "as an upstart, whose ways are readily laughed at." (p89). The conservative bias is not unique to the political

right, but is general feature of human nature. For example, the green (conservationist) movement is consistent with a conservative bias. Innovation avoidance can be summarized in the so-called precautionary principle: human survival is precarious and innovations in technologies, economic systems or ecologies are to be avoided because even a miniscule risk of unforeseen disaster is unacceptable. This may even have evolutionary roots if more innovation-embracing hominids went extinct because, however infrequent over the course of many millennia, one such disaster removed them from the gene pool. Of course, human behavior is complex and the conservative bias can be suppressed by rational decision-making or by other biases, such as novelty seeking or herding, discussed below.

A second force is vested interests, politically powerful constituencies favored by the status quo and therefore opposed to change. New technologies that obsolesce large established firms mobilize the owners of those firms against innovation. New technologies that reduce employee headcounts or require employees with different skills mobilize organized labor against innovation. New technologies that devalue natural resources found in specific regions mobilize citizens and governments of those regions against innovation. All of these constituencies seek to influence government policies to slow or stall technological progress. The conservative bias embedded in human behavior gives resonance to such lobbying in the halls of power. Subsidies, taxes, and intellectual property rights are revised, modified and adapted, often until they actively discourage innovation and subsidize the status quo (Wu 2010; Jaffe and Lerner 2011).

A third force, actually an extension of the second, is aging innovators avoiding creative self-destruction. Successful innovation creates huge wealth, so that aging ex-innovators and their heirs become powerful vested interests opposed to changes to the status quo such as those potentially caused by continued rapid innovation. IBM, an innovative electronic tabulator company built in the 1920s high-tech boom, came to dominate mid-20th century computers. But in the 1980s, IBM lost its dominant position when its top executives, all mainframe computer engineers, opposed personal computers to safeguard their status within the firm (Betz 1993). Aging ex-innovators and their heirs can become powerful vested interests lobbying governments for regulatory and financial sector reforms that block further innovation (Rajan and Zingales 2003).

Mokyr (1994) argues that, because of these forces, Cardwell's Law inexorably moves an economy to technological stagnation. These forces explain intense antagonism to innovation from 18th century Luddites to 21st century anti-vaccination and anti-GMO activists (Mazur 1975; Jones 2013; Juma 2016). They explain the mobilization of public policy to suppress rapid innovation and the pervasive failure of state-subsidized innovation programs (Mokyr 1992ab, 1994, 2000; Wu 2007; Jaffe and Lerner 2011).

Mokyr (1994) proposes that competition between economies can break Cardwell's law. This argument elaborates on an observation of Rosenberg and Birdzell (1986, pp. 136-9)

"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 . . . and much to lose from allowing others to introduce them first. 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".

The fragmented politics of the Western World, the power of subnational governments within federal states thus limited the repression of innovation because new technologies would pop up elsewhere if suppressed at home, and their positive externalities would spread abroad first. A fortuitous importance of sequential innovations in communications (printing, telegraphy, telephones, etc.) and communications (oceanic navigation, canals, railroads, etc.) that let ideas, people, and technologies move increasingly readily between polities may have factored in too.

For example, the Big New Thing of the 1840s was the telegraph network (Standage 1998). Before the telegraph, information moved at the speed of a horse or sailing ship. After the telegraph, information moved at the speed of electricity. A financial mania in the United States financed hosts of telegraphy ventures that expanded its telegraph network from 40 miles of wire in 1846 to 2,000 miles in 1848 to 23,283 miles 1852; a state-run telegraph rollout left France with 750 miles in 1952 (Gross 2007). Individual American investors lost vast wealth when their stock market collapse; while French investors, with no telegraphy investment opportunities, lost nothing. But, America had a vast telegraph system and France did not. Gross (2007) concludes that America came out on top. France had to scramble to catch up. Cardwell's Law failed and technological progress lived on.

Taxes on economic prosperity financed military power and industrial technology advances had externalities in weapons production. Businesses actively sought to steal new technologies from businesses in other countries as industrialization progressed and governments everywhere aided and abetted this. Britain sought to prohibit technology exports, but American entrepreneurs grew expert at smuggling disassembled machines across the Atlantic (Andreas 2013). Technologies seeped across European borders despite the best efforts of technology exporter governments and will the enthusiastic cooperation of importer governments (Harris 2017). After the end of its civil war, the United States became a major importer of pirated European technology as it rapidly industrialized. Canada made foreign patents unenforceable in its courts to facilitate technological catch up (Bliss 1987). As competition between states grew global, Japan (Morck and Nakamura 2005), South Korea and other non-Western polities also came to appreciate the national catastrophe of technological backwardness and actively promoted inward technology transfer. But continually relying on others to develop innovations leaves a country permanently behind. After each of these countries 'caught up" to the frontier, superior technological and productivity growth required domestic innovation. Competition between nation states worked to suppress Cardwell's Law.

This reasoning suggests that economic openness may be of far greater importance than standard international trade and finance models allow. Openness may well achieve gains from comparative and absolute advantage; but its more important effect may be to check political pressures that would slow or halt innovation under autarky. The previous sections combine to suggest that one such institution, perhaps the most important, is a bubble-prone stock market.

5.2   Bubbles as Exercises in Economic Fitness

Economic selection culls away modes of behavior that are less advantageous to economic growth (Nelson and Winter 1982; Hayek 1988; King and Kay 2020). Might economic evolution select for patterns of behavior that lead to recurrent financial bubbles?

Economic selection is arguably faster and more powerful than natural selection. Natural selection is a competition for survival between selfish genes and can only operate at higher levels of aggregation (the survival of the herd) in limited circumstances (Wilson 2012). Economic selection occurs simultaneously at multiple levels, pitting individuals against each other for goods and employment; firms against each other for customers, suppliers, capital and labor; and economies compete with each other for capital and skilled labor. Natural selection is Darwinian: less fit variants of an organism eventually die, leaving more fit variants to survive and leave descendants. Economic selection is Lamarckian: individuals, firms, and governments whose policies are working less successfully can imitate what more successful individuals, firms, and countries are doing. Patterns of economic behavior can spread without individuals, firms or economies dying.

Cardwell's Law is fortified by loss aversion. Humans have a conservative bias. They prefer the status quo to change because they fear losses more than they value gains of equivalent magnitude. Any economically

rational hominid who happened to arise in the course of evolutionary history would have accepted small risks of disaster if its expected gains were positive. Disaster need only occur once for this trait to fall out of the gene pool. Loss aversion appears deeply embedded by natural selection. Fear of loss comes readily to mind and evokes instinctive reactions.

However, human behavior is more than loss aversion. Human nature also appears to include a number of behavioral predispositions conducive to financial bubbles. These include a fascination with novelty, a propensity to emulate others who seem to know what they're doing, and a comfort in following the herd.

Novelty-seeking is a hard-wired component of human nature arising from the brain's dopamine system, which seems exceptionally active in serial entrepreneurs (Zald et al. 2008). This suggests deep origins in natural selection. Novelty-seeking meets the test of group-level natural selection between hunter-gatherer bands if an urge to nibble on bright-colored berries expands the band's food supply enough to save more lives than are lost to poison berries (Williams and Taylor 2006). Economies with institutions that channel novelty-seeking into the discovery and financing of new technologies may likewise outcompete those that do not, even if individual entrepreneurs and investors lose money often (Bernardo and Welch 2001; Galor and Michalopoulos 2012).

In Theory of Moral Sentiments, Adam Smith (1759) noted "our disposition to admire, and consequently to imitate, the rich and the great." Imitative behavior also has plausible roots in natural selection (Gibson and Hoglund 1992; Blackmore 1999, pp. 74 – 81). Most economic problems are procedurally transcomputational, so economic selection at aggregate levels, such as competition between firms or economies, can favor the imitation of people who appear more successful if pathological outcomes for individuals are not too infrequent or catastrophic (Bikhchandani et al. 2005). Investors might buy into bubbles that have made earlier, seemingly smarter investors rich (Hirschleifer et al. 2003). A propensity to imitate success that manifests as an innate "fear of missing out" may attract investors to bubbles (Janeway 2012; McGinnis 2020).

Humans are social animals and may have a hard-wired disposition to move in herds (Trotter, 1916; Hayek 1988, p 17) and emotion is contagious in humans interacting as a group (Barsade 2002). This may reflect natural selection for hunter-gatherers that moved in bands, in which emotions such as fear spread rapidly. But contagious emotions are also the basis of Keynes' "animal spirits" lifting or depressing sentiment across business leaders and investors, a key to the initiation and expansion of stock market bubbles.

5.3   More Selective Bubbles?

All this leaves occasional stock price bubbles seeming oddly sensible, but this does not mean they are "optimal". Observing something does not make it optimal.

Darwin saw natural selection as having "general tends towards a maximum economy in the use of resources" (Howard 1982, p. 99). Natural selection can bring a species to a local optimum far inferior to the global optimum. The vertebrate retina's blood supply is on the wrong side, and the cephalopod eye is a much superior design (Lents 2018). Evolution, by a blind process of trial and error found a design in vertebrates that could not be improved with marginal tweaks, and humans live with second best eyes.

Economic evolution is capable of much larger and faster transformations. The institutions that shape economic behavior can be torn down, as in Mao's Revolution, and rebuilt, as in Deng Xiaoping's reforms. They can be rebuilt from within, as with America's New Deal of the 1930s, or from without, as by colonial overloads.

Could better technocratic policies eliminate stock market bubbles? Hayek (1988, p. 22) smiles at great scientists who "while conceding that everything has hitherto developed by a process of spontaneous order, call on human reason - now that things have become so complex - to seize the reins and control

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future development." He goes on to refute the idea "that reason, itself created in the course of evolution, should now be in a position to determine its own future evolution [as] inherently contradictory." Government officials, like CEOs and investors, confront procedurally transcomputational problems and seek solve them by pursuing shiny new ideas, imitating what others who appear more successful do, and gain comfort from moving in herds (Bošković et al. 2013).

Mao's China successfully avoid stock market bubbles, but his social engineering left Chinese among the poorest people in the world. Deng Xiaoping rescued China from Mao's heroic experiments by reigning in the planners and letting market forces reenergize economic selection. In the richest and most successful economies in the world, economic selection has favored institutions that promote occasional stock market bubbles around new technologies or new markets.

Perhaps reforms might increase the social efficiency of intellectual property rights or government innovation subsidy programs enough to render economies with institutions that foment stock market bubbles poorer, rather than richer. In the near-term future, multilevel competition seems to work against this outcome. Strong competition between firms favors patent thickets and strong competition between researchers favors those skilled at filling out complex forms. Competition between governments for faster productivity growth seems too weak to overwhelm these microeconomic forces.

Stock market bubbles, in contrast, may be unstoppable because they resonate so deeply with the novelty seeking aspects of human nature. Still, some bubbles end far more catastrophically than others. Stock market bubbles accompanied by a large expansion of credit may also have their blood supplies coming from the wrong place. Can institutions be redesigned to keep banks and other credit-granting institutions out of stock market bubbles?

The stock market crash of 1929 and the ensuing Great Depression brought about major banking reforms that barred banks from having anything to do with stock markets for decades. The New Deal banned commercial banks from dabbling in financial markets and limited margin buying through brokers. The technology-driven stock market run-ups of the 1960s and 1990s brought in solid state electronics and the internet, and then ended with merely unpleasant recessions.

Depression era regulations limiting the scope of bank activities were already in rapid retreat across the developed world in the 1990s, and banks were deeply enmeshed in speculative financial markets in the early 2000s. Competition between banks for high returns-on-equity may well have pushed major banks deeper into real estate speculation, fueled a real estate bubble, and precipitated a credit collapse that brought in the worst recession since the 1930s in the US and many other countries. Akerlof and Shiller (2009, p. 154) attribute the deregulation and expansion of U.S. mortgage-backed securities markets prior to 2008 to "the belief that the opportunities to take part in the housing boom were not being shared fairly." Deregulation let banks and other credit-granting institutions help unsophisticated investors participate the growing real estate bubble.

Government officials, like CEOs and investors, confront procedurally transcomputational problems and seek solve them by pursuing shiny new ideas, imitating what others who appear more successful are doing, and gain comfort from moving in herds. That rational technocrats might use the neat equations of economic theory to replace economic selection with technocratic administration is, according to Hayek (1988, p. 194) a "fatal conceit."

Aspirations to design a regulatory Aswan dam and to engineer fiscal fertilizers seem unlikely to eliminate our need for capital inundations. Economic selection, though, continues. Institutions might change to focus financial manias more narrowly on more socially valuable innovations and to mitigate collateral damage. Economies with better capital dykes and overflow reservoirs might prosper more and invite imitation.

6.   Less Inefficient Kindleberger Engines

Kindleberger's (1978) historical cycle of manias, panics and crashes often, though not always, arises around new technologies with large positive externalities, which investors and firms behaving in accord with conventional economic rationality would drastically underfund relative to their social returns. Free market economies with active stock markets and their supporting legal and other institutions may well have grown rich because they stumbled upon a way to overcome chronic underinvestment in innovation.

This sort of reasoning appears in the historical and economics literatures, albeit far less frequently than condemnations of stock market bubbles as irrational follies. Neal (1996, 155) sees the recurrence of financial manias as "less a tale about the perpetual folly of mankind and more one about financial markets' difficulties in adjusting to an array of innovations." Several models cast bubbles as arising when investors are especially prone to (Harisson and Kreps 1978; Hong et al. 2006, 2008; Hong and Stein 2007), a situation likely to coincide with the arrival of radical and incompletely understood new technologies.

Ashton (1948, p. 83-4) concludes that the British canal mania of the late 1770s "undoubtedly led to some waste of national resources," but was a net benefit 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." Angeletos et al. (2010) model a new technology elevating investors' uncertainty about stocks' fundamental values inducing a conventional neoclassical economy to resemble a Keynesian beauty contest that "look like irrational exuberance to an outside observer."

A few insufficiently cited models in which stock market bubbles counteract inefficiently low investment, such as investment in innovation, resonate with this. Jacques Olivier (2000) models 'growth enhancing' bubbles as confined to stock markets. These attract capital to productivity-boosting innovation and might even draw capital away from productivity depressing but individually profitable investments such as political rent seeking. Tanaka (2011), Lansing (2012), and Takao (2017) also model growth enhancing bubbles. Xu and Dang (2018) present empirical evidence that bubbly stock markets ease capital constraints and encourage R&D investment. Eatwell (2004) describes bubbles allocating capital to individually profitable investments left unfunded by capital rationing or managerial myopia and individually unprofitable investments whose positive externalities enhance social welfare. Eastwell concludes (p. 44) that "bubbles are not efficient, nor in any way optimal, nor in any interesting way rational, But they could be useful." Bubbles do not correspond to economic efficiency in conventional equilibrium models (e.g. Santos and Woodford 1997), but in real economies, bubbles may usefully compensate for such other far more socially costly distortions.

The large social costs event in the panic and crash phases understandably provoke condemnations of bubbles as irrational folly avoidable by better educating people to behave as equilibrium economic expects them to behave. Failing this, regulations are proposed to force people to behave rationally. Scheinkman (2014) associates bubbles with inefficient markets overvaluing tech stocks and proposes reforms to prevent this.

Recessions follow most bubbles, but some are far worse than others. The Roaring Twenties bubble, the Crash of 1929 and the ensuing Great Depression are historically unique. Mid 1930s unemployment rates surpassed 25% in many developed economies. The high-tech investments of the 1920s in power grids, electrification, radio, automobiles, cinema, and the other big new things of the era almost surely misallocated some capital, but the atypical vehemence of Great Depression suggests confounding factors: misguided interwar gold standard exchange rate policies (Eichengreen 1995); inept central bank policies (Ahamed 2009), trade wars (Irwin 2017), imprudent banking regulation (Kroesner and Strahan 2014), and other factors may have been worse follies than the 1920s bubble. Reparations were soon shelved, the

gold standard was replaced, central banking was professionalized, trade barriers were renegotiated down, and banking regulations were eased. But the electric power grids, radio stations, movie studios and automobile plants built in the 1920s capital food were not torn down. Electrified homes and businesses did not rip out their copper wires and revert to kerosene and steam. Nor were canals, railroads, or internet fibrotic networks ripped out after other high-tech bubbles. The lesson of the 1930s might better be that public policy can make a Kindleberger cycle very costly indeed.

If stock market manias alleviate, even partially and imperfectly, other more socially costly inefficiencies, preventing bubbles is not obviously optimal public policy. Rather, a weighing of social costs versus benefits is justified. Lansing (2009) balances speculation's social costs in magnifying volatility against its social benefits in countering underinvestment. However, the Great Depression suggests a role for public policy in minimizing the social costs of the panic and crash. Some 1930s reforms, notably deposit insurance and universal social welfare programs, were widely perceived as helpful in this regard and did not fall away in subsequent decades.

The thesis that stock market bubbles are a problem may thus need qualification. An abundance of circumstantial evidence suggests that the Kindleberger Cycle of recurring manias, often causing floods of investment into new technologies, panics and crashes (often ringing in economic downturns) could be beneficial to long term growth by increasing chronically socially suboptimal investment in innovation when important new technologies arise. Intermittent financial manias may solve this underinvestment problem more effectively than intellectual property rights and state-subsidy programs, both of which attract political rent-seeking that can cause socially costly distortions.

Rather than condemning Kindleberger's cycles of manias, panics and crashes as manifestations of people's stubborn irrationality and incurable folly, economists might consider public policy options to render bubbles more socially useful. Such policies might include measures to keep credit providing institutions, such as banks, as far from bubbles as possible. Bubbles in stock markets provide abundant capital to Big New Thing technologies and their crashes, like the 2000 dot.com crash, appear minimally socially costly. Bubbles in credit markets are less clearly associated with the financing of innovation, and their crashes, like the 2008 financial crisis, impose broad social costs. Debt-financed investment into stock market bubbles provides even more capital to Big New Thing technologies, but also renders the crash phase more socially costly.

The optimal flow of credit financing into stock market bubbles may thus be positive, but might tend to be socially excessive. Lending at relatively high rates to speculators buying into bubbles and speculating on their own accounts can look attractive to banks. The upside profits are clear and downside risk is limited by bailouts, justified as necessary to save the economy during the crash phase of the cycle. Such bank policies also advantage top bank executives incentivized to maximize bank return on equity, to which bank executive compensation is conventionally linked. Barring banks and near-banks from bubbles is conceptually simple, but challenging in practice because banks are politically influential and bank regulators appear prone to regulatory capture. Public policy-makers might weigh the social benefits of technology bubbles against the differing social costs of panics and crashes under different regulatory regimes.

That the Western World developed institutions conducive to periodic financial manias may actually be an important part of the answer to Needham's (2004) question "Why did the Industrial Revolution happen in the West, rather than in China?" The West developed stock markets and stock market bubbles that periodically finance vast waves of innovation, and high-income economies in East Asia have done the same. The periodic manias and panic have been costly, but may have been worth it.

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