Beyond Mont Pèlerin: South African Physicist Bankers in a World Without Money

Efthimios Karayiannides

On 21 January 2025, in what will surely go down as one of the more bizarre episodes of the second Trump presidency, the site Doge.gov was registered by an employee of the United States' Cybersecurity and Infrastructure Security Agency in Los Angeles. Those who managed to visit the site before it was taken down would have been greeted with a banner informing them that they were indeed viewing 'an official website of the United States government'. The site had limited functionality, but it prominently displayed the crypto currency Dogecoin's logo—a Shiba-Inu framed by a gold coin. The value of the company immediately jumped 14% to a market capitalization of $58 billion. This boost likely further inflated the extravagant wealth of the new head of the Department of Government Efficiency (DOGE) and Trump patron-in-chief Elon Musk, a longtime promoter of the crypto currency.

The website could easily serve as an emblem of Musk's inchoate worldview. Its iconography fuses private wealth and public power, while at the same time shunning the established norms of both corporate America and the American political establishment. It preaches efficiency and professionalism in what is essentially a shitpost – a form of online engagement pioneered by the far-right to provoke and ridicule their liberal interlocutors. What exactly can we surmise about the man behind this website and his place within the Trump administration? Is this the culmination of the "neoliberal" revolution, the triumph of a social media fueled post-fascism, or just good old fashioned oligarchic state capture?

For some critics, it is Elon Musk's South African background—often used as a shorthand for his whiteness or some deep-seated settler mentality—which offers the key to understanding how his various views cohere. The flurry of opinion pieces which accompanied the 2024 US presidential elections included countless accounts of the supposed significance of the peculiarly large number of white South Africans among the dot-com moguls with a political affinity for Trump[1]. Four of the founders of PayPal—the "company that made the modern

[1] Simon Kuper, 'Musk, Thiel and the shadow of apartheid South Africa,' *Financial Times* (19 September 2024) https://www.ft.com/content/cfbfa1e8-d8f8-42b9-b74c-dae6cc6185a0; Chris McGreal, 'How the roots of the 'PayPal mafia' extend to apartheid South Africa,' *Guardian* (26 Jan 2025) https://www.theguardian.com/technology/2025/jan/26/elon-musk-peter-thiel-apartheid-south-africa; Caroline de Gruyter, 'Elon Musk Is America's Cecil Rhodes,' *Foreign Policy* (7 February 2025) https://www.theguardian.com/technology/2025/jan/26/elon-musk-peter-thiel-apartheid-south-africa

internet"—have some connection to Southern Africa[2]. Two of them, David Sacks and Elon Musk, have been appointed to advisory roles in the Trump administration. While Peter Thiel, venture capitalist and occasional interpreter of conservative political thought, declined to fund Trump's campaign in 2024, he was a key early backer of the political career of Trump's deputy JD Vance[3]. The fourth, Sequoia Capital CEO Roelof Botha, has probably cut the least conspicuous political figure, though his connection to the Apartheid regime is the most direct: his grandfather was the longest serving foreign minister under Apartheid.

Both popular and academic historians and social scientists have joined the chorus of journalists in insisting on the importance of these figures' South Africanness to understanding their motives in business and their affinity with Trump and other right Populists in politics. Quinn Slobodian has likened Musk's ambitions to colonise Mars to the Great Trek[4]. Both supposedly exemplify the politics of "escape": the attempt by a community to circumscribe or insulate themselves from democratic oversight and control. John Ganz, the author of a popular political and cultural history of the US's 1990s, has drawn parallels between Peter Thiel and Elon Musk's authoritarian approach to corporate governance and the Apartheid regime's white supremacist *baaskap* ideology[5]. For Ganz, the concept (which he translates as "bossism") incapsulates the particular cult of entrepreneurship and technocracy crystalizing around figures like Musk and Thiel; one that doesn't bother dressing itself in the language of meritocracy and unabashedly exalts hierarchy and authority for its own sake. More recently, Johnny Steinberg has drawn attention to the echoes between the proposed policy of remigration increasingly popular among far-right European political parties Musk has endorsed, and the high apartheid obsession with sorting and resorting urban residents according to their place of alleged ancestral origin[6].

---

[2] Jimmy Soni, *The Founders: Elon Musk, Peter Thiel and the Company that Made the Modern Internet* (New York, 2022)
[3] Peter Thiel, 'The Straussian Moment,' in Robert Hamerton-Kelly, ed., *Politics and Apocalypse* (East Lansing, 2007), 189 - 215
[4] Quinn Slobodian, 'Elon Musk's death drive,' *The New Statesman* (30 November 2023) https://www.newstatesman.com/culture/books/2023/11/elon-musk-death-drive
[5] John Ganz, 'The Emerging Tech-Lash: The Politics of Tech Oligarchy,' *Unpopular Front* (April 26, 2022) https://www.unpopularfront.news/p/the-emerging-tech-lash
[6] Johnny Steinberg, 'Is Musk's foray into right-wing politics rooted in apartheid?' Business Day (17 January 2025) https://www.businesslive.co.za/bd/opinion/columnists/2025-01-17-jonny-steinberg-is-musks-foray-into-right-wing-politics-rooted-in-apartheid/

Perhaps these pieces should be read less with an eye to their analytical precision than to their intended political effect. There is, however, at least some continuity between these interpretations of the South African emigres and recent shifts in the way in which historians and social theorists have come to understand neoliberalism. The past ten years has seen an effort to show continuities between the ideas of neoliberals who championed free-markets and globalization at the end of the twentieth century and the illiberal populist Right which emerged in the 2010s. Scholars like Wendy Brown, Melinda Cooper, Quinn Slobodian and many others have argued that, historically, there has been a strong affinity between neoliberals, social conservatives and political forces hostile to mass democracy[7].

The neoliberal project, these authors explain, was not about "unfettering" markets, but rather about *encasing* them (usually at the sub-national or international level) and thus putting them out of reach of democratic oversight and control (usually at the level of the nation state). This has been an important interpretive move and has substantially deepened our understanding of the origins and diversity of various free market ideologies. However, it has led to an overwhelming focus on certain kinds of thinkers and political actors. While academic economists are not the sole focus of these studies, a handful of academic institutions (the universities of Chicago, Virginia and Freiburg) and intellectual networks (mostly the predecessors and successors to the Mont Pèlerin society) and their related think tanks are taken as the originators and disseminators of market ideologies[8].

South African academic economists and university departments feature prominently in these networks from the 1930s. Arnold Plant began his academic career as the inaugural professor of commerce at UCT before moving to the LSE. The general orientation of the South African Journal of Economics, established in 1933, was laissez-faire, and offered an important platform for liberal historians and economists to voice their criticisms for state-owned industries, which were viewed as both economically inefficient and vehicles for Afrikaner nationalist patronage politics[9]. It is precisely South African liberal economists' aversion to economic nationalism, both in its Afrikaner and post-colonial variant, which has been honed

[7] Wendy Brown, *Undoing the Demos: Neoliberalism's Stealth Revolution* (Cambridge MA, 2015), Quinn Slobodian, *Globalists: The End of Empire and the Birth of Neoliberalism* (Cambridge MA, 2018); Melinda Cooper, *Family Values: Between neoliberalism and the new social conservatism* (Cambridge MA, 2017)
[8] Angus Burgin, *The Great Persuasion* (Cambridge MA, 2012); Philip Mirowski and Dieter Plehwe, eds., *The Road to Mont Pèlerin* (Cambridge MA, 2015); Richard Cockett, *Thinking the Unthinkable: Think-Tanks and the Economic Counter-Revolution, 1931 – 1983* (London, 1993)
[9] David Yudelman, 'Industriaization, Race Relations and Change in South Africa: An Ideological and Academic Debate,' *African Affairs* 74/294 (1975): 82 – 96 at 88

in on by the new historiography of neoliberalism. The fact that W.H. Hutt could simultaneously critique the job colour bar while advocating for votes weighted by income and constitutional limitations on worker collective action is highlighted by Slobodian as characteristic of the neoliberal hostility to postcolonial popular self-determination[10]. Likewise, S.H. Frankel's debate with W.A. Lewis on the viability of import substitution industrialization as a motor for growth in post-colonial Africa has been interpreted by some historians as a defence of "neoliberal imperialism" in the face of post-colonial developmentalism and a precursor to the neoliberal turn in development economics[11].

The central claim of this paper is that the conspicuous links between South African economists and the Mont Pèlerin society is distracting and has had the effect of obscuring the much more important ways in which twentieth century South Africa supplied the intellectual resources that powered the market revolution at the end of the twentieth century. The South Africans who played the most active role in shifting the centre of gravity of the global economy to private financial markets were not academic economists. In fact, they had no formal academic training in economics and had very little to do with the modestly resourced humanities departments of the major South African universities. Instead, they were all beneficiaries of solid foundational undergraduate education (mostly at the University of Cape Town and the University of the Witwatersrand) in mathematics, engineering and physics in the 1960s.

From their founding, South African universities functioned primarily as the schools of the professions, with training in accountancy, medicine, engineering, law and teaching taking precedence over training in the humanities and social sciences. In the aftermath of World War II and under apartheid, the sciences attracted unprecedented prestige and funding. It is in this context that figures like Emanuel Derman, Andre Perold, Ron Dembo and Jonathan Berk obtained the training that would allow them to pursue graduate study in the United States and, a decade later, find themselves at the centre of the derivatives revolution on Wall Street. They would then go on to teach for many decades in some of the leading American business schools (Columbia, Harvard, Yale and Berkeley/Stanford respectively), training practitioners in quantitative finance who would enter industry both in the run up to and the immediate

[10] Slobodian, *Globalists*, 172 – 178
[11] Lars Cornellissen, 'Neoliberal imperialism,' *Politics* (2023) https://doi-org.ezp.lib.cam.ac.uk/10.1177/02633957231164035

aftermath of the 2008 financial crisis. They thus had incredible influence over how private finance understood its role in an economy undergoing rapid regulatory change. I will provide a sketch of the economic thought of the most influential of this cohort of scientist-bankers, Emanuel Derman, who headed up Goldman Sach's Quantitative Strategies Group in the 1990s, crafting derivatives products for the investment bank during the heyday of globalization. I will show that both his intellectual trajectory and his visions of free markets is quite unlike that of your run of the mill neoliberal.

Therefore, this paper, is not, alas, about Elon Musk and the PayPal mafia. Rather, it is an attempt to begin exploring the connections between Apartheid South Africa and developments in the post-Bretton Woods American economy and society beyond mere analogy and psychoanalytic speculation. I inquire into some of the material links which explain the migration of South African technical expertise into American business from the 1960s onwards. My ultimate goal is not to tell a parochial story about a particular South African émigré, but to use Derman's intellectual trajectory to begin to rethink the global intellectual networks which brought about the market revolution in the final decades of the twentieth century.

Life as a Capetonian

Emanuel Derman, the son of Polish Jewish immigrants to South Africa, began his studies in physics and applied mathematics at the University of Cape Town in late February 1962. It was the height of high Apartheid, when racist social engineering was at its most ambitious and deranged. Just three years earlier the Apartheid government had passed separate university legislation barring all but a tiny number of Black people from most South African universities and making it all but impossible for them to receive training in science and engineering. For the Apartheid leader Hendrik Verwoerd there was, infamously, simply no need to teach mathematics to units of cheap labour that would never utilize it in practice. For Non-European Unity Movement activist and intellectual I.B. Tabata, and for many middle class Black South Africans, this was 'education for barbarism'[12].
Derman describes the cognitive dissonance of stepping foot on the UCT campus, where the student body, 'is mostly white, but anti-apartheid politics is everywhere.'[13] He describes the

[12] I.B. Tabata quoted in Saul Dubow, *Apartheid, 1948 – 1994* (Oxford, 2014)
[13] Emanuel Derman, *Brief Hours and Weeks: My Life as a Capetonian* (unpublished manuscript)

pantomime of Apartheid race classifications whereby the small number of Chinese students were not considered white, but the Japanese students were 'honorary whites because Japan has reputedly purchased tons of pig iron from us.'[14] He is candid about the fact that growing up in South Africa means that 'racism is in the molecules of the air I breathe' and that before university 'my interactions of Black people have always been based on differences in power'[15]. However, UCT's partial defiance of the separate universities legislation meant that he could now interact as peers with a few Black students admitted into the University in the same cohort as him, including the Pan-Africanist Congress activist Philip Kgosana who in March 1960 led a march of 30,000 people between Langa and Cape Town in protest of the country's pass laws. Though he admits that it is only once he emigrates to the United States for graduate study that he begins to socialize informally with people the apartheid regime would classify as nonwhites.

He is acquainted with white South Africans engaged in anti-apartheid activities, including Adrian Leftwich, the charismatic head of the National Union of South African Students in the early-1960s at UCT. His sister Shulamit, a social worker twelve years his senior, keeps liberal company. She is close friends with Albie Sachs, the anti-Apartheid lawyer, and Ronnie Segal, the editor of the anti-apartheid *Africa South* magazine. When Sachs is jailed without trial under the Emergency Act, Derman's mother keeps a copy of his prison diary locked in a shoebox of letters and other mementos from her parents. Notwithstanding his family's connections with these liberal currents within the Cape Tonian white community, Derman describes them as 'people who dislike but don't actively oppose apartheid'. They, 'admire Albie's courage and consistency, from a distance.'

Derman's formative rebellion was not against the unjust laws of Apartheid, but against what he saw as the stultifying communitarianism and puritanism of the socialist Zionist youth group he had been a part of for most of his childhood: 'around the age of nineteen…I departed the movement…They were scornful of people with different aspirations, accusing them of wrong thinking or hypocrisy; they were certain of the future and the justness of their argument, sufficiently so to humble anyone who didn't think their way.'[16] This was Derman's gateway to the 60s counterculture. He would go on to dabble in the Theosophical Society

[14] Ibid.
[15] Ibid.
[16] Emanuel Derman, *Models. Behaving. Badly* (New York 2011, 28)

while a postdoctoral researcher in physics at Oxford, and in Tibetan Buddhism while an assistant professor at the University of Colorado Boulder.

What of the academic influence at UCT? Derman entered the physics department just at a time when it was reaping the benefits of the Apartheid state's increased support to scientific and technological advance in the course of the 1950s. During the skillful tenure of Meiring Naudé (1952 – 1972), the national Council for Scientific and Industrial Research (CSIR) saw an expansion of its staff from 685 to more than 4,000, and the number of its national institutes grew from the original five to thirteen[17]. At the same time, a collaborative nuclear programme was established between the universities of Cape Town and Stellenbosch at the Southern Universities Nuclear Institute at Faure, using a 5.5 MV van der Graaff accelerator which facilitated both applied and basic particle research.

The UCT physics department was a beneficiary of both of these developments. In 1964 the department appointed what was, in effect, its first professor in theoretical physics, the 38-year-old Wilhelm Frahn. He had been trained in mathematics at the Technische Hochschule in Aachen and had practical experience as a nuclear physicist at the CSIR. The head of Physics at the University of the Witwatersrand had little doubt that he would offer 'a better training for research students in theoretical nuclear physics than…any other man in South Africa.'[18] At the same time, the 33 year old Frank Brooks arrived from the Harwell Atomic Energy Research Establishment to assume UCT's new chair of nuclear physics just in time for the opening of UCT-Stellenbosch nuclear institute.

Derman would benefit directly from these developments. After winning the class medal in his third year he was invited to undertake a summer job assisting Brooks with his experimental research. It was the first time he would learn to code. The University had acquired an ICT 1301, a mainframe computer which runs programs that have been mechanically punched onto cards. Very high rates of return on investment in the 1960s encouraged a flood of foreign capital into South Africa, mostly from the United States. IBM and UK-based ICL dominated the supply of computers to the country in this period. Both companies were subject to prominent anti-Apartheid divestment campaigns in the 1970s and 1980s. In 1978, for

[17] Saul Dubow and William Beinart, *the Scientific Imagination in South Africa: 1700 to the present* (Cambridge 2021),
[18] F.R.N Nabarro quoted in Howard Philips, *UCT under Apartheid, Part I: From Onset to Sit-In, 1948 – 1968* (Cape Town, 2019), 49

instance, 2,000 ICL workers went on strike in the UK to protest the company's role in supplying computers to the South African police.

Derman's encounter with these machines was less sinister. Brooks had tasked him with writing a code to automate the plotting of curves related to his study of "resonances"—the state of a nucleus when it is bombarded with high energy charged particles. Derman soon got the hang of it, and when he finished plotting Brooks's curves, he decided to surreptitiously program the computer to produce multiple random poems. Priming the print statements with melancholy romantic words, he hoped to generate 'drearily sad love poetry.' Derman was a theorist at heart and failed to be wooed by the experimental work he had undertaken during his summer job. He was more attracted to the rigorous approach of the applied mathematics department, and completed a mini-thesis on Unified Field Theory under the eccentric Dr J.H.M Whiteman[19].

This theoretical foundation, alongside US soft-power diplomacy in the form of an Institute for International Education (IIE), was enough to secure Derman a place on the theoretical physics doctoral programme at Columbia University. He entered Columbia in 1966, at the high point of U.S. science funding. By the time he completed his doctorate in experimental particle physics it was 1973, the height of the oil crisis, and there were no permanent jobs available. He moved through a succession of two-year post-docs at Oxford, Pennsylvania, Rockefeller University and the University of Colorado Boulder before deciding that the end of the Vietnam War had broken the funding model of theoretical physics research.

He took a job as a programmer at Bell Laboratories, before realizing that the very same forces that led to the collapse of the academic job market for scientists opened opportunities for the employment of physicists and mathematicians on Wall Street. The 1973 oil crisis caused fuel prices to soar and interest rates to climb, and the fear of inflation propelled gold prices above $800 an ounce. Bonds, traditionally a conservative investment, became more volatile than ever. All of this created new demand for complex financial products that could provide protection against the proliferation of risk.

Measuring Risk and the emergence of the CAPM world

[19] Whiteman was denied promotion after it was discovered that most of his research time was dedicated writing books and articles on mysticism and psychical phenomena. See Philipps, *UCT under Apartheid*, 70

In order to understand why the skills of physicists like Derman proved so useful to an investment bank like Goldman Sachs, we need to place their interventions within the dramatic developments in monetary and financial history at the end of the twentieth century. The end of the Bretton Woods-era marked a shifting of boundaries from public to private and from state to market. One of the results of this shift was the massive migration of technical skills out of publicly funded institutions and initiatives and into the private sector. Another was an important shift in the object of financial and monetary thinking. Practitioners in both the public sector and private sector had to come to terms with a radically transformed financial system. Private finance played a relatively small role before the 1970s. Starting in the 1960s financial intermediaries like insurance companies and pension funds were rising in importance as suppliers of external funds to private firms. The 1970s saw the breakdown of the Bretton woods system, increasing deregulation, and the rise of mutual funds, global currency markets, the Eurodollar markets, junk bonds and securitization. Additionally, the persistent inflation of the 1970s eroded the value of treasury bonds which had, until then, been considered to be relatively risk-free.

Whether it was a mutual fund deciding how to allocate its investment, or an individual investor trying to protect their investments against the myriad new forms of risk, increasing theoretical attention was directed to the problem of intertemporal choice under uncertainty. From a financial modelling perspective, problems involving optimization over time and in the context of uncertainty could be tackled as what probability theory calls continuous time stochastic processes. These are processes in which a variable—like the price of an asset—moves continuously over time following a random path where price changes occur at every possible instant, not just at discrete intervals. Such problems would be familiar to physicists used to studying Brownian motion: the small, random, irregular and continuous motion of particles suspended in the medium as they are constantly bombarded by surrounding molecules and energy and momentum is continuously exchanged among them.

Economists trained in all the major schools of postwar American economics—whether the econometric approach of the Cowles Commission under Tjalling Koopman, the monetarism of the University of Chicago or the post-Keynesianism of MIT—began tackling these problems.

We should, however, be careful not to narrate the rise to prominence of a particular branch of financial economics as an inevitable outcome of unstoppable market and technological forces. The "re-emergence of global finance" after the collapse of Bretton Woods was the outcome of deliberate state policy rather than a sign of state impotence in the face of savvy market operators evading state control and regulation[20]. As the well-known activism of Chicago futures exchange chairman Leo Melamed and his supporters in the Chicago economics department clearly demonstrates, the move to floating exchange rate, and the role financial markets would play in managing this new system, was the outcome of a lengthy ideological and political struggle waged by free-market ideologues[21].

While stressing contingency and agency, we should also not to overemphasize the influence of debates and shifting hegemonies in academic economics on the shift to private finance. Increasingly, historical sociologists are emphasizing the extent to which neoliberalism emerged as much out of contingent institutional conjunctures as grand ideological projects[22]. Since the 1970s, states have increasingly delegated difficult and political fraught decisions about resource allocation, wealth distribution, and the management of capital and currency flows to financial markets. The transferring of core capacities of the state to financial markets sees the empowerment of one technocratic elite at the expense of another: the investment banker—and practitioners of quantitative finance in particular—at the expense of the state bureaucrat, or at least the substantial blurring of the boundaries between the two.

To be sure, practitioners of quantitative finance are partly products of academic conjunctures. However, academic debates then to move slowly and often lag at registering changes in economic realities. The thinkers examined in this paper were at the coal face of rapidly changing economic and regulatory contexts. Contexts which were for the most part not captured by ready-to-hand economic paradigms, whether Keynesian or Monetarist. Practitioners thus had to partly improvise theories that could both make sense of these new contexts, and help them navigate their new found prominence in processes of macroeconomic management.

---

[20] Eric Helleiner, *States and the Re-emergence of Global Finance: From Bretton Woods to the 1990s* (Ithaca, 1994)

[21] Leo Melamed, *Man of the Futures: The Story of Leo Melamed* (Hoboken, 2021); *An Engine not a Camera* (Cambridge MA, 2008), chapter 1

[22] Greta Krippner, Greta Krippner, *Capitalizing on Crisis: The Political Origins of the Rise of Finance* (Harvard, 2012); Brent Cebul, *Illusions of Progress: Business, Poverty and Liberalism in the American Century* (Philadelphia, 2023), Amy C. Offner, *Sorting Out the Mixed Economy: The Rise and Fall of Welfare and Developmental States in the Americas* (Princeton, 2021)

Major developments in the emerging financial economics emerged, for instance, from the work of individuals like Fischer Black and Jack Treynor who, notwithstanding close connections to elite American universities, spent much of their careers employed in the banking and consultancy industries[23]. While financial economics tends to narrate its own intellectual history as a natural extension and application of the hegemonic academic paradigms of the period, early research in finance was generally treated with suspicion, and often pushed out of economic departments and into less prestigious adjoining business schools[24].

The memory of the Great Depression loomed large, and the study of asset pricing or the movement of stock pricing seemed to many economists of the period, including Milton Friedman, of more interest to speculators than to serious economists. The research that did get the stamp of approval from the academic establishment hewed closely to some of the theoretical and methodological orthodoxies that had characterized post-war American economics across the monetarist-Keynesian divide, especially when it came to the nature and determinants of the money supply. If we're after the most radical interpretation of the new financial economics, the one that reshaped the financial sector's own understanding of the economy as a whole, we need to look at the writing of thinkers with a degree of distance from the debates occurring in the corridors of American academic economic departments.

Conceptually, the preoccupations of the financial economics which gained traction in 1970s tracked the shifting boundaries between state to market. Post-war economics was essentially addressed to a world characterized by Depression and New Deal banking regulation, in which global capital mobility was limited by the Bretton Woods agreement. Both monetarists and Keynesians began with state-issued fiat currency and took the nation state as their unit of analysis. Money was conceptualized as a kind of paper gold—that is, an asset that is no one's

---

[23] For accounts of their role in shaping the world of investment banking in the 1970s see William W. Jahnke, 'The Development of Structural Portfolio Management: A Contextual View,' in Brian R. Bruce, ed., *Quantitative International Investing: A Handbook of Analytical and Modeling Techniques and Strategies* (Chicago, 1990): 153 – 181; Bernstein, Peter L. Bernstein, *Against the Gods: The Remarkable Story of Risk* (New York, 1998), chapter 12; Fischer Black and Myron Scholes, 'From Theory to a New Financial Product,' *Journal of Finance* 19: 299 – 412

[24] For the way the discipline narrates its own history see Peter L. Bernstein, *Against the Gods: The Remarkable Story of Risk* (New York, 1998). For outsider takes, see Donald Mackenzie, *An Engine not a Camera* (Cambridge MA, 2008) and Perry Mehrling, *Fisher Black and the Revolutionary Idea of Finance* (New York, 2005).

liability—issued by a central bank. Monetarists and Keynesians disagreed on the extent to which the monetary supply should be manipulated, but they broadly agreed on what fiat currency was, where it came from, that the overall money supply has some influence on income and prices, and that, since it is costless to produce, that the pertinent policy question when it came to money was how the quantity of its supply should be manipulated in order to maximize social benefit. They disagreed on the extent to which the state or central bank should manipulate the money supply in an attempt to smooth business cycles, but this was essentially an intramural dispute between antagonists who shared the same conception of money.

By contrast, the finance theorists, especially those who worked within the finance industry, did not begin with state issued fiat currency, but with privately issued credit money. For them, money was not a form of paper gold, but a by-product of business finance: the short-term liabilities of financial intermediaries which stand between individuals with low risk tolerance, and thus hold relatively more of their wealth as bank deposits, and those with higher risk tolerance, who want to borrow in order to leverage their positions. The idea was that not only bank deposits but all forms of high-quality short-term debts are forms of money, even if they are not formally means of payments.

In order to understand how this view of money shaped understandings of the broader economy and the role of monetary authorities in it, we need to start with the foundational model of finance theory, the Capital Asset Pricing Model (CAPM, or "Cap-em"). The model was formulated independently by Jack Treynor, William F. Sharpe, John Lintner and Jan Mossin in the course of the 1960s[25]. All of these authors were concerned with determining the relationship between the risk of an investment and its expected return. They approached the problem from different angles; some took the perspective of an individual investor; others took the perspective of a company issuing shares. They also brought different methodological approaches to bear on the problem, whether it was the presupposition of efficient markets or that investment decisions are governed by liquidity preferences. However, they all arrived at the fundamental insight that a rational investor seeking to minimize risk and maximise

[25] Jack L. Treynor, 'Towards a Theory of Market Value of Risky Assets' in Robert A. Korajczyk, ed., *Asset Pricing and Portfolio Performance: Models, Strategy, and Performance Metrics* (London, 1999), 15 – 22 (originally written in 1962 but remained unpublished); William F. Sharpe, 'Capital asset prices: A theory of market equilibrium under conditions of risk,' *Journal of Finance* 19/3 (1964); John Lintner, 'Security Prices, Risk and Maximal Gains from Diversification,' *Journal of Finance* 20/4 (1965); Jan Mossin, 'Equilibrium in a Capital Asset Market,' *Econometrica* 34 (1966), 768 – 783

returns does not reach investment decisions by deciding whether or not to invest in one or other asset. Rather they are concerned with assembling an optimal *portfolio* of investments consistent with their risk/return preferences. Further, they discovered that once a set of simplifying assumptions are introduced, all rational investors will arrive at the same optimal portfolio, i.e., all investors' portfolios will contain the same assets in exactly the same proportions.

This portfolio will be the market portfolio, which will include investments in every asset available to investors in proportion to their market value. Investment in this market portfolio would allow investors to diversify away the idiosyncratic risk associated with holding a particular asset and expose themselves only to systematic risk, that is, the risk associated with the movement of the market as a whole. In the idealized world of CAPM, the decisions about one's risk exposure are radically simplified. One does not have to make decisions about which particular asset to invest in nor does one have to decide on the composition of one's portfolio. The market portfolio is the only fund that investors need to invest in. Risk exposure is adjusted simply by deciding the proportion of one's wealth one wishes to hold in a relatively risk-free asset, like government bonds or cash, versus the proportion one wishes to hold in the risky market portfolio. Risk averse investors will hold more of their wealth in risk free assets, thus reducing their overall exposure to systematic or market risk. Investors with a greater risk appetite will decide to hold more of their wealth in the market portfolio. They might even wish to borrow money and expose more than 100% of their wealth to market risk.

Most of the CAPM theorists did not consider the model a theory of the economy as a whole, much less a theory of money. Those, like William H. Sharpe and John Lintner, who produced the model primarily for an academic audience essentially conceived of it as a partial equilibrium equation. The model measures the expected return on a risky asset as the sum of two values: the risk-free rate of interest—the return associated with that proportion of an investor's wealth held in risk-free government bonds—and the price of risk—the return in excess of the risk-free rate of interest one gains by holding the market portfolio. For Sharpe and Lintner, the former—the risk-free rate of interest—was exogenously determined, that is, established by central bank policy. All that they claimed to be adding to economic theory was the (endogenous) market determination of the price of risk. For them CAPM was an appendage to post-war economics, one which didn't fundamentally question its understanding of fiat money.

By contrast, Jack Treynor developed his results while working for the consultancy firm Arthur D Little (ADL), and circulated them in the form of mimeographed manuscripts, rather than published articles. He was therefore not constrained by the same theoretical orthodoxies. Equilibrium was front and Centre of his attempt to determine the expected return an investor would require in order to embark on a risky investment. His starting point was to attempt to determine the market-clearing risk premiums which would determine the proportions of assets held in the market portfolio given the available supply of assets. His colleague at ADL, Fischer Black, learnt CAPM from Treynor rather than from the academics. He thus always read it as an equilibrium model, and, went further than Treynor still in suggesting that it could serve the basis for a general equilibrium model of the economy as a whole.

A general equilibrium model based on CAPM is what Black detailed in his first published academic paper, "Banking and Interest Rates in a World without Money" (1970)[26]. He imagined an economy comprised of only two financial institutions—index mutual funds and banks—and only two financial instruments: risky equity and riskless debt. Households would be able to invest in a diversified portfolio of equities issued by firms. There would thus be a natural role for index mutual funds to allow households to trade in a security that tracks the performance of the market as a whole, rather than in individual stocks. Following CAPM, Black then imagined households borrowing and lending among themselves at the riskless rate of interest through the intermediary of a bank to obtain their desired risk exposure. He argued that the aggregation of individual portfolio decisions would produce both an equilibrium price for risk *and*, in contrast to the academic economists, an equilibrium interest rate. In such a world, Black insisted, it was possible to conceptualize individuals interacting freely in market exchange without the need for the intervention of the government or central bank.

This model is clearly that of an idealized world, one that bore little resemblance to the reality of financial markets at the turn of the 1970s. However, it was clearly intended as an extrapolation of tendencies unleased by the collapse of the Bretton Woods system. Black's CAPM world was a world without capital controls and a world without any of the strict post-Depression regulation of the American financial sector. In fact, it is a world where the state played no role whatsoever in intermediating between various market actors. The role of

[26] Fischer Black, 'Banking and Interest Rates in a World Without Money: The Effects of Uncontrolled Banking,' in Fischer Black, *Business Cycles and Equilibrium* (Hoboken, 1987), 1 – 23

intermediation in Black's theory would be played entirely by the private financial system. In part, Black was anticipating the market-based financial systems which were beginning to develop in countries like Britain and the United States[27]. However, whereas the reality was a *relative* shift of the boundary between public and private, Black imagined a world in which the public management of financial markets would be made obsolete.

In the course of the 1970s, Black would look to this model, less as a thought experiment than a reality that was being brought into being by emerging market activities. In particular, Black would see in the model that made him famous the potential to move the real world in the direction of his idealized CAPM world. The Black-Scholes-Merton model describes a method to determine the theoretical value of an option. An option is a contract which offers its buyer the right, but not the obligation, to buy or sell an underlying stock at an agreed upon price, at or before an agreed upon date. The crucial partial differential equation which gives the theoretical value of how much a dealer should charge for an option was arrived at independently by Fischer Black and Myron Scholes (1973) and Robert C. Merton (1973, 1976)[28]. The development of the model earned Scholes and Merton the Nobel Memorial Prize in Economics in 1997 (Black received a commendation, but had died two years earlier and the prize is not awarded posthumously).

The two derived the equation using different methods. As ever, Black viewed the problem through equilibrium goggles. He reasoned that under ideal equilibrium conditions the prices of an option and its corresponding stock should each provide investors with the same expected return per unit of risk they carry. In this equilibrium condition, an investor would be impartial between buying the stock and buying its corresponding option. This equilibrium condition, written down mathematically, provided the eventual solution to the equation. By contrast, Robert Merton showed that it was possible to hold a combination of the underlying stock and cash called a "replicating portfolio", which, if its proportions were constantly adjusting proportions, would exactly mimic the pattern of returns on an option. The cost of assembling the initial "replicating portfolio", he concluded, must be the price of the option.

---

[27] Asli Demirguc-Kunt and Ross Eric Levine, *Bank-based and market-based financial systems – corss-country comparison*. Policy Research Working Paper no WPS 2143 (Washington D.C.,, 1999) http://documents.worldbank.org/curated/en/259341468739463577

[28] Fischer Black and Myron Scholes, The pricing of options and corporate liabilities,' *Journal of political economy* 81/3 (1973): 637 – 654; Robert C. Merton, 'An Intertemporal capital asset pricing model,' *Econometrica: Journal of Econometric Society* (1973): 867 – 887; Robert C. Merton, 'Option pricing when underlying stock returns are discontinuous,' *Journal of financial economics* 3/1 (1976)

The Black-Scholes was so revolutionary because it replaced the very imprecise valuation of an option based on a subjective determination of the volatility of the price of a stock by a trader with the notion that an option's value can be derived from the known prices of liquid securities.

At first Black did not attach much significance to the options-pricing equation which he had produced in the course of consulting work at ADL. Indeed, he dismissed it as a tool for speculation: an instrument likely to be used by market actors who wanted to gain a leveraged position on an individual stock. He did not share the enthusiasm of some Chicago economists at the opening of an options exchange in Chicago in 1971: 'Options are an exciting way to gamble, and the Chicago Board Options Exchange wants to act as the gambling house and take its cut. There's nothing wrong with that; but if we are to permit this form of gambling, it seems logical to tax it heavily, as the government taxes betting on horse races'[29]. His ideal world of CAPM, recall, was composed only of equity and debt, not options. More fundamentally, the CAPM world is one purged of uninformed speculation, and one in which there is no trading in individual shares. Rather, mutual funds sell shares in a diversified equity portfolio whose value is estimated through professional securities and accounting analysis. Black even envisaged using computers to further enhance the accuracy of valuation and to 'reduce or eliminate the need for specialists, market makers and block positioners.'[30] In other words, this is an economy with perfectly efficient markets.

Black would substantially revise this picture when he left academia for good and joined Goldman Sachs in 1983. Observing the activities of traders, he specifically relaxed his assumptions about the efficiency of markets. In an infamous inaugural presidential address to the American finance association in 1987, he suggested that 'we might define an efficient market as one in which the price is within a factor of 2 of value, i.e., the price is more than half of value and less than twice value.' [31]What accounted for this massive discrepancy?

Black explained that, in actual markets, there are two kinds of traders, "noise traders" and "information traders". The former are speculators and opportunists who trade in "noise", pushing prices away from their equilibrium values. These traders attract, in turn, information

[29] Fischer Black quoted in Mehrling, *Fischer Black and the Revolutionary Idea of Finance*, 138
[30] Fischer Black, 'Toward a Fully Automated Stock Exchange,' Financial Analysts Journal 27/4 (1971): 28 - 35
[31] Fischer Black, 'Noise,' *The Journal of Finance* 41/3 (1986): 528 – 543

traders, who, trading on actual information, seek to exploit the inefficiencies produced by the noise traders to make profits through arbitrage (taking short positions on overpriced assets and long positions on underpriced assets). The noise traders make trading possible in that they produce inefficiencies that can be exploited for profit and add liquidity to the market by consistently generating trading volume through their impulsive trades, allowing other market participants to easily enter or exit positions without significantly impacting price. While information traders seek to, in effect, undo the work of noise traders by pushing prices towards their efficient values, Black argued that some noise would always remain in the market, and that this would inevitably be reflected in prices. In this sense, markets might be financially efficient insofar as there exist no opportunities for trading profits, while not being economically efficient because prices on aggregate will diverge from their real value. In this modified CAPM world of noisy trading and economically inefficient markets, Black saw a role for options and derivative securities more broadly.

Specifically, when he observed how traders actually used option pricing techniques in practice, he began to appreciate the extent to which they could be conceptualized as weapons in the arsenal of information traders. Traders were not primarily using the model to gain leverage on individual stock, but to manage their risk exposure. This allowed them to focus on arbitrage opportunities, rather than on the direction of a movement of a particular stock. In other words, it the formula allowed investors to do the work of moving prices towards Black's prized equilibrium, while shielding themselves from market fluctuations which would wipe them out before the job was done. Once these traders armed with their sophisticated pricing tools entered the scene, there was an observable movement of market prices towards those predicted by the model and that was an indication to Black that they were moving markets toward equilibrium. Already in the early-1970s, Black would look forward in an unpublished memo to 'a long term corporate bond' that,

> could actually be sold to three separate persons. One would supply the money for the bond; one would bear the interest rate risk; and one would bear the risk of default. The last two would not have to put up capital for the bonds, although they might have to post some form of capital[32].

[32] Fischer Black, 'Fundamentals of liquidty,' Mimeograph, Associates in Finance, June (1970

Black, was, in short, predicting the emergence of the derivatives revolution and he would have an important hand in ushering in this revolution in during his time at Goldman Sachs.

Derivatives, Feynman Diagrams and Post-Monetarism

One of Black's key lieutenants in crafting a raft of new derivatives products for Goldman Sachs was Emanuel Derman who had been headhunted from Bell labs in 1985. The importance of Derman's role at Goldman Sachs in the 1990s cannot be overstated. The global financial system was still in the process of putting itself together again after the collapse of Bretton Woods. State- and central bank-led initiatives like the Plaza Accord of 1985 and subsequent Louvre Accord of 1987, as well as the establishment of bi-lateral currency swap lines by the Federal Reserve in the 1990s were the most visible efforts to fill the void left by the Nixon Shock. However, the Wall Street quants played an underappreciated role in constructing a framework to manage the volatility caused by floating exchange rates and the removal of capital controls. Their hedging instruments allowed investors to navigate volatile interest rates and facilitated the global movement of capital despite substantial exchange rate volatility and the risk of capital flight. This is also the period in which the revolving door between Wall Steet—and Goldman Sachs in particular—and top positions within the Treasury and Federal Reserve first became a prominent feature of the American political system[33]. Derman's thought thus provides an important insight into one of the important architects of the post-Bretton Woods financial order.

Derman had originally been employed on the basis of the programming skills he had attained at Bell Labs. His time there coincided with the development of the C programming language and UNIX operating system by Brian Kerninghan, Dennis Ritchie and their associates at the Lab's Murray Hill Campus. These developments ushered in a new programming credo—inspired, in part, by Kernighan and Plauger's *The Elements of Programming Style*—which emphasized simplicity, readability and useability over both brute functionality and abstruse displays of mathematical sophistication[34]. Imbibing this programming

[33] Nelson Lichtenstein and Judith Stein, *Fabulous Failure. The Clinton Presidency and the Transformation of American Capitalism* (Princeton, 2023); David Stein, 'The Austerity Imperative: Democratic Deficit Hawks and the Crisis of Keynesianism,' in Brent Cebul and Lily Geismer, eds., *Mastery and Drift: Professional Class Liberals since the 1960s* (Chicago, 2025): 237 – 259

[34] Brian W. Kerninghan and P.J. Plauger, *The Elements of Programming Style* (New York, 1974)

revolution, Derman designed and implemented a programming language he named "Hierarchical Equation Solver" (HEQS). HEQS was a non-procedural language, namely, it allowed users to state what they wanted done without having to specify a procedure for accomplishing it. It was designed for businesspeople who knew enough to specify the equations they wanted to solve but lacked either the mathematical ability or time to solve them. In its final incarnation, HEQS could be fed thousands of algebraic equations (linear, nonlinear or simultaneous) and either solve them or inform the user that they had made a mistake in specifying an equation, making a solution impossible.

Derman likened these non-procedural programmes to Feynman diagrams in physics: pictorial representations of complex mathematical expressions in which space and time are discrete and exist only as points on a lattice, making the visualization of the mathematics easier. Feynman diagrams allowed workaday physicists to mindlessly compute the detailed quantum mechanical probabilities that had formerly demanded the virtuoso mathematical skills of a Julian Schwinger or a Richard Feynman. This model of the Feynman diagram would lie at the heart of his approach to financial modelling at Goldman Sachs where he would envisage models as a bridge between the complex mathematics underlying financial economics, and the needs of security traders. Again, Derman analogizes the role of the financial model builder to the practice of physicists. Modelers, he explains, are akin to "phenomenologists", or physicists who specialize in producing the practical link between principles and experiments. Phenomenologists 'create heuristic approximation to engineer the theory into a pragmatic tool…Phenomenologists deal a little more with the ripples on the surface and a little less with the laws beneath it.'[35]

This was the ethos that Derman would bring to the task of producing a more user-friendly computer interface for bond options traders—one that both simplified the calculation of the price of over-the-counter bond options and sped up interactions with clients. It would also facilitate a meeting of minds with Fischer Black, who was also trained as a physicist and was inclined to approach modeling in similar Feynmanian terms. This is clearly on display in the pair's most influential contribution (along with Richard Toy) to options theory, namely, the Black-Derman-Toy (BDT) model for bond options pricing[36]. When Derman joined Goldman

[35] Emanuel Derman, 'My Life as a Quant,' (New York, 2005), 27
[36] Fischer Black, Emanuel Derman and William Toy, 'A One-Factor Model of Interest Rates and Its Application to Treasury Bond Options,' *Financial Analysts Journal: 24-32*

Sachs in 1985, the market for over-the-counter bond options was bourgeoning. Funds that had bought bonds in the late-1980s and early-1970s when interest rates were high, saw their yields drop as interest rates began to decline in the mid-1980s. Many of these funds resorted to selling call options against the bonds they held in order to generate extra revenue. There was substantial money to be made by sell-side firms like Goldman Sachs supplying these call options. The problem was how to price them. The Black-Scholes model applied to stock options, not to bonds options. Stocks are relatively simple; they guarantee no future dividend payments and have no natural termination date, so their future prices are unconstrained. By contrast, bonds are much more intricate. Since they promise to repay their principal when they mature, their price on that date is constrained. Furthermore, because all Treasury bonds can be decomposed into a sum of more primitive zero-coupon bonds of varying maturities, they are all interrelated.

Derman et al. reasoned that if in the Black-Scholes model it is the stock prices which are assumed to diffuse like particles under Brownian motion, it is the interest rate which varies randomly and continuously in the case of bond options. However, since bonds of different maturities are related to one another, the entire yield curve needed to be modeled. Derman and his colleagues, in the spirit of Feynman, set out to visually represent a simplified version of the model in order to make the problem tractable without the need for sophisticated mathematical knowledge. They imagined a world in which markets only cared about a single factor, the short-term interest rate. This is a world, unsurprisingly give Black's involvement, just like the ideal CAPM where all investment decisions are driven by the short-term riskless rate of interest and the price of risk. They assumed that the shortest investment you could make lasted exactly one year, and was represented by the one year treasury bill interest rate. They then assumed that long-term interest rates were a reflection of the market's perception of the probable range of future one-year interest rates. Furthermore, they simplified the volatile movement of interest rates over time by assuming that at each period there is a 50% chance of the interest rate going up or down by a fixed proportion. This allowed them to construct a lattice which could aid a trader to visualize how the price of an option is determined by averaging and discounting future payouts over the interest rate distribution. The resulting Feynman diagram is reproduced below[37].

[37] Derman, *My Life as a Quant*, 158; The visual representation as a lattice is based on John Cox, Stephen Ross and Mark Rubinstein's binomial options-pricing model. See John C. Cox, Stephen A. Ross and Mark Rubinstein, 'Option Pricing: A simplified approach,' *Journal of Financial Economics* 7/3: 229 – 263. For an

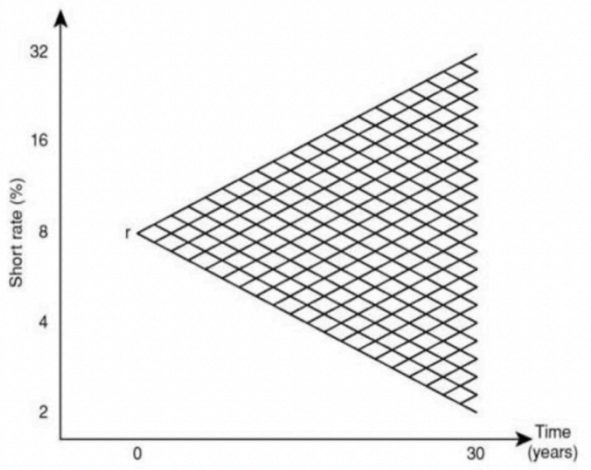

Figure 1. A schematic representation of a multiperiod short-rate tree in the Black-Derman-Toy model with equal periods extending for many years

The BDT model was not very accurate at estimating bond prices and traders balked at its extremely strong assumptions. However, its real value, like Feynman diagrams in physics, lay in helping its practitioners visualize complex phenomena. In BDT's case, it gave traders an intuitive grasp of the term structure of practically any interest-bearing security. The model was not an accurate depiction of the real world, but armed with it, and combining it with both their sector specific expertise and the requirements of their clients, traders were able to get a better grip on the problem of pricing custom options. Derman was beginning to appreciate Black's idea that options pricing models could be powerful tools in the hands of "information traders". However, it was Derman, rather than Black, who would actually build these tools in the course of the derivatives revolution during the 1990s.

Derman replaced Black as the head of the Quantitative Strategies Group in 1989, just as 'the Soviet Union had collapsed, the end of history was ostensibly upon us, and global capitalism was rampant.' In the context of early globalization, investors wanted to dip their toes in foreign markets while hedging against currency and other risks. The proliferation of so-called "exotic options" were the result. These were tailored instruments which ostensibly gave customers exactly the risk profile they desired. Derman and his group busied themselves with developing bespoke computer interfaces both to price these options and to manage the risk

overview of this model, see Mackenzie, *An Engine, Not a Camera*, 285 – 288. The analogy with Feynman diagrams, as well as the epistemological features this implies, is made by Derman.

associated to monitor Goldman's trading positions. They also reported for both traders and clients describing the underlying options pricing models in plain language and with the aid of visual representations. Such was the demand for exotic options that Dermans group grew to 30 people, with approximately three software engineers for every modeler. We can see in the passage below Derman in effect describing how the proliferation of options motivated arbitrage and squeezed profit margins over time,

> The development of new options structures resembled an arms race. Any firm that created something popular with clients had a few months to press their advantage before another firm copied them. It took that long to reverse-engineer a product, add a few wrinkles, develop a risk management strategy, put in place the legal and technical infrastructure, and then market it[38].

We can see Derman appreciating the role of information traders, but what about the noise traders? In December 1990, Goldman Sachs head options trader in Tokyo showed Derman the computer screen used to watch the prices of options on the Nikkei 225 index. He drew attention to a peculiar asymmetry in Nikkei options prices. The price of out-of-the-money puts were unexpectedly larger than that of other options. This price asymmetry came to be referred to as "the smile" or "the skew". In the course of the 1990s, the smile, initially a peculiarity of equity options, began to appear in other markets in slightly different forms. The smile showed that as the price of the security underlying an option moves further in or out of the money (i.e. moves further away from the strike price—the price at which the options contract allows its holder to buy or sell the underlying security at a specified date), its volatility increases far more than the Black-Scholes model predicted. Given that in the Black-Scholes equation the value of an option is measured by its volatility, with the price of the option increasing as the volatility of the underlying security increases, the presence of the smile in real world markets implied that certain options were being systematically underpriced. Derman reasoned that the smile was likely a legacy of the 1987 Black Monday stock market crash. Investors feared another unforeseen instantaneous large jump in the markets and were thus willing to pay up for protection. One of the cheapest forms of "insurance" available were low strike price options on stock market indices. In effect,

[38] Derman, *My Life as a Quant*, 223

investors were loading up on these options as an insurance policy against a potential crash of the Nikkei, thus pushing up their prices.

Derman attempted to adapt the Black-Scholes model to take account of this discrepancy. Traders' intuitions were based on Black-Scholes, and so any attempt to shift their behaviour towards new market realities would have to involve simple rules of thumb that would nudge the Black-Scholes model in the right direction. He took the same approach that he had taken with Black when they developed the BDT model. He started by decomposing the overall pattern of volatility observed in the smile into shorter term units or "local volatilities". These could then be represented in a simple binomial tree—a "Feynman diagram"—that could be used by traders to intuit how volatility differs at different strike prices. An example of such a tree and the corresponding complex observed data it is derived from is reproduced in Figure 2[39].

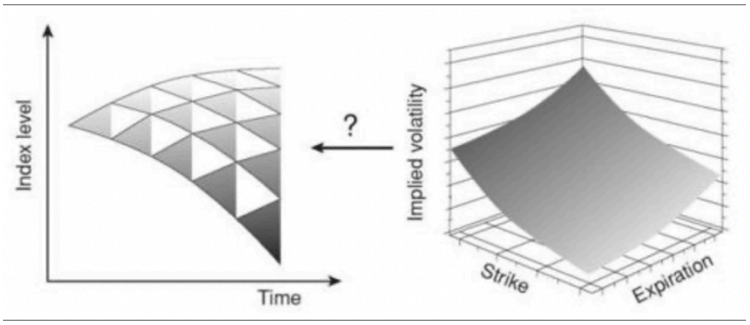

Figure 2. At left, an implied binomial tree of future index moves. Each future percentage move has a local volatility that rises as the index falls

While Derman's new model, and models like it, captured the new market conditions well for a while, he soon discovered that it was not a model that could replace the Black-Scholes model, with its more simplistic assumptions about volatility, for good. Over time, "smiles" even began to emerge in options priced with the revised models, as the observed pattern between option price and volatility diverged from that predicted by the model. For Derman,

[39] Derman, *My Life as a Quant*, 234

two essential lessons emerged from the attempt to model the smile: one about the nature of financial models, and the other about the nature of financial markets.

Firstly, financial modelling is not the same as modelling in physics. There are no Grand Unified Theories, as attempting to model the smile revealed. The predictions of quantum electrodynamics are accurate to one part in 100 billion. No financial model could dream of achieving this stunning accuracy. For Derman, this is to be expected given that, 'In physics you're playing against God, and He doesn't change his laws very often,' while 'in finance, you're playing against God's creatures, agents who value assets based on their ephemeral opinions.' [40]Financial models, then, are not analogous to theories in physics. Instead, they're much closer to the thought experiments of physicists—Schrödinger's famous cat, or Einstein imagining what he'd see sitting on the edge of a moving light beam. They are 'mental stress tests', where a simplified world is imagined in which one attempts to force one's conceptual picture of the world into contradiction. On this account, financial models are not meant to be accurate descriptions of the actual financial and human world, but a 'collection of parallel thought universes you can explore' from which a more nuanced and complex understanding of financial phenomena can be explored. This places certain ethical obligations on financial modelers to be explicit about the model's assumptions, as well as its limitations. These ethical obligations, as Derman sees them, are summed up well by "The Modelers' Hippocratic Oath", which he coauthored with Paul Wilmott in the aftermath of the Great Recession of 2008:

> I will remember that I didn't make the world, and it doesn't satisfy my equations.
> Though I will use the models I or others create to boldly estimate value, I will always look over my shoulder and never forget that the model is not the world
> I will not be overly impressed by mathematics. I will never sacrifice reality for elegance without explaining to its end users why I have done so.
> I will not give the people who use my models false comfort about their accuracy.
> I will make the assumptions and oversights explicit to all who use them.

[40] Derman, *My Life as a Quant*, 266

> I understand that my work may have enormous effects on society and the economy, many beyond my apprehension[41].

If the epistemological limits of models place clear ethical demands on the way their developers market them, then what about the ethical obligations of the ultimate end user? When used honestly, Derman believed that models aided what Black termed "information traders". They allowed traders to reason about the potential sources of risk and return and adapt their strategies accordingly. However, as the derivatives revolution gained momentum, both Black and Derman began to worry that the use of derivatives could also be used as alibis to amplify noise trading. For instance, in his post-mortem of the 1987 financial crash, Black argued that the increased purchase of portfolio insurance in the run up to the crash holds the key to understanding what went wrong. In the ideal CAPM world, Black explains that investors do not change their risk preferences with movements in the level of the market. As we saw in the example earlier, a change in the level of the market leads to each household adjusting their holding of equity and cash so that they keep they maintain the proportions between the two consistent with their appetite for risk. Black argues that in real markets, we might find that some investors increase their appetite for risk with a rise in the market level, that is, the increase in their wealth may give them more confidence or make them greedier.

He calls these traders "flexible traders". If we add to the mix their ability to purchase portfolio insurance against a potential drop in the market, they might be even more inclined to increase their risk exposure. When a market consists of such "flexible traders", upswings in the market result in a flurry of speculative activity, increasing the overall volatility of the market. However, relying on models that haven't taken into account the additional volatility introduced by these "flexible traders", other market actors systematically underestimate the level of risk in markets and the degree to which prices and expected returns deviate from their real value. In effect, the presence of "flexible traders" introduces noise in the market that other investors then trade on. A crash occurs when the majority of investors realise their mistake by adjusting their calculation of estimated returns, leading prices to hurtle downwards. While for some financial crashes are evidence of imperfect markets, or price rigidities or externalities, for Black they are merely abrupt adjustments to equilibrium. In Black's account of the crash, it is not so much the derivatives that drove speculation, rather it

[41] Derman and Wilmott quoted in Derman, *Models. Behaving. Badly*, 198

was the propensity for certain investors to speculate that drove speculation. 'Most of the risks we worry about are man-made,' Black explains, 'The simplest way to deal with these risks, if we decide we don't want them, is not to hedge them, but to avoid creating them in the first place. If we decide we do want them, then financial institutions can spread them around, using diversification, syndications, derivatives, and all the other tools in our bag of tricks.'[42]

Derman seems to have had the same worry about "noise trading" distorting market actors' ability to make accurate estimations of value and volatility. In fact, he attempted to model the effects of noisy trades in the wake of the dot-com crash[43]. He argued that in most contexts investors are fairly indifferent to the frequency at which a stock trades when estimating expected risk and return. However, in highly speculative and rapidly developing sectors—like the internet, communications and biotechnology sectors—where relevant news arrives frequently, expectation can suddenly soar and investors may have very short-time horizons. In such markets the frequency at which a stock is traded, which Derman calls its "temperature", may influence investor behaviour. One day speculative traders who specialize in these sorts of markets may make one-off short-term profits in excess of the return expected by the broader market. This may induce more conventional investors, trading according to a more conventional time scale to buy the stock in anticipation of earning the same excess return. Such traders, according to Derman, 'are responding to temperature as though it were risk'[44]. He constructs a simple model of the interaction of the short-term temperature-sensitive investors and the conventional long-term investors and shows that it is characterized by stock prices with super-exponential growth, offering a potential econometric marker of speculative bubbles. Furthermore, he conjectures that such speculative contagion might account for some part of the volatility smile.

For both Black and Derman, the moral of the story is right there in the CAPM model: don't expect to earn greater returns if you are not simultaneously prepared to accept greater risk. Speculators like the flexible traders or those enticed by high temperature stocks might benefit in the short-term by trading in noise, but they will suffer the consequences when information traders catch up with them and prices are readjusted. Is there any role for the state in this world where the level of risk neatly corresponds to the level of return or pain. Fischer Black

[42] Fischer Black, 'Hedging, Speculating, and Systematic Risk' *The Journal of Derivatives* 2/4 (1995), 6 – 8 at 7
[43] Emanuel Derman, 'The perception of time, risk and return during periods of speculation,' *Quantitative Finance* 2 (2002), 282 – 296
[44] Derman, 'The perception of time, risk and return during periods of speculation', 294

was adamant that there was none: 'I don't see that the private market, in creating this wonderful array of derivatives, is creating any systemic risk. However, there is somebody around creating systemic risk: the government…Perhaps the biggest systemic risks that the government creates…come from its debt guarantees.'[45] For Black, as always viewing the world through the lens of CAPM, government debt guarantees distort the risk/reward calculus. In effect, they encourage investors to believe that they can enjoy a particular return without being exposed to the corresponding risk, and this creates noise which moves markets out of equilibrium. The end result can only be an abrupt readjustment.

In the aftermath of the Great Recession, Derman expressed similar worries about the state intervention in times of financial crisis,

> I am deeply disillusioned by the West's response to the recent financial crisis. Though change doesn't treat everyone fairly, what makes the intrinsic brutalities of capitalism tolerable is the principle that links risk and return: if you want to have a shot at the upside, you must be willing to suffer the down. In the past few years that principle has been violated. When Wall Street and the U.S. economy were threatened, the ethical principles of capitalism took a backseat. After the bailout of the financial sector, after the provision of cheap government loans to banks at taxpayers' expense, and after the banks' rapid rebound from taxpayer life support to record profits and bonuses, I am ashamed of the hypocrisies of the system[46]

He expands on his reasoning by invoking an unlikely theorist of derivatives, Baruch Spinoza. In part 3 of the *Ethics* Spinoza tried to do for human emotions what Euclid did for geometry. Geometric primitives include points and lines. For Spinoza, the primitive sensations are pain, pleasure, and desire. On the basis of these primitive sensations, Spinoza enumerates various "derivative emotions". Derman explains that, 'Just as the value of a stock option depends on the underlying stock price, so the more complex human emotions depend, via one or more degrees of separation, on the three underlying primitive sensations.'[47] So, for Spinoza, if pleasure is the transition of a person from a less to a greater perfection, then love is derivative

[45] Fischer Black, 'Hedging, Speculation, and Systemic Risk,' 7 – 8
[46] Emanuel Derman, *Models. Behaving. Badly* (New York, 2011)
[47] Derman, *Models. Behaving. Badly*, 82

of pleasure because it is pleasure associated with an external object—it is an emotion one step removed from simple pleasure. Hate by contrast is pain associated with an external object, and so on. There are some emotions which are derivatives of multiple underliers: envy is pain at another's pleasure. Derman likens these kinds of derivative emotions to 'convertible bonds, modern-day corporate securities that have both debt and equity characteristics.'[48] Ideal financial instruments, for Derman, are the kind that combine all three of Spinoza's primitive emotions.

This is simply CAPM brought to bear on seventeenth century philosophy. Financial instruments embody a specific desire (optimal allocation of one's wealth) which is itself based on an expectation of a balance between pleasure (return) and pain (risk). What about the most basic financial instrument, money? According to Derman "genuine money" is indeed a derivative of all of Spinoza's primitive emotions. It is 'crystallized work, and work is pain in the service of the desire to survive. Genuine money is also security, the expectation of future pleasure and freedom from pain.'[49] But we don't have "genuine money" in our contemporary economy, Derman explains. We have fiat money which, 'unlike genuine money, incorporates only pleasure and desire. Without work, it lacks the connection to pain that gives it value and respect. By virtue of this lack, it induces contempt.'[50] Elaborating on this account of money in an opinion piece in the Guardian, Derman laments that, 'Money is insubstantial now. It used to be a solid thing – coins or paper. To create it you had to dig, smelt and cast, or at least print. You had to store it in a vault.'[51]

At first glance this reads like the ravings of a conventional goldbug. That is, until you look closer and notice CAPM. What Derman means by fiat currency here is clearly the proliferation of privately issued credit money. Its "debasement" is not the old spectre of an increase in the price level. Rather, it is the spectre of the noise induced by investors who behave like there are only upsides to their risky investments. Derman is not concerned about the quantity of money in circulation. If there is a role for government regulation for him, it is not about managing the money supply, but about managing market liquidity. 'Liquidity,' he explains, 'is not an unmitigated good…illiquidity makes people pause and think about the

[48] Ibid, 83
[49] Ibid, 88. Derman
[50] Ibid.
[51] Emanuel Derman, 'Why financial heists are getting bigger and we put less value in money,' *Guardian* (29 Jun 2014). https://www.theguardian.com/money/2014/jun/29/money-robbery-respect-banks-financial-crime

long run.'[52] While central bank intervention to add liquidity to a particular market or act as a "dealer of last resort" during a crash is an unacceptable reward for speculation, he seems more comfortable with the reverse[53]. Namely, the government intervening to limit liquidity, or add a degree of friction into particular markets. To use his phrasing, such government intervention reduces the "temperature" of trading, thereby reducing the noise in a particular market.

The history of economic thought is a perennial debate about intervention versus laissez-faire. There is undoubtedly a family resemblance between Black's and Derman's critiques of government intervention and those of monetarists. However, theirs are also decidedly post-monetarist perspectives[54]. Post-war monetarism, like post-war Keynesianism, was reacting to a world of industrial oligopoly and powerful labour unions, a world in which the Federal reserve had more or less total control over the money supply, and in which the U.S. government was the key bond issuer. This world was thoroughly changed by the recovery of private capital market after the war. Economic thought, in turn, transformed as a result. Black and Derman reflect this transformation of laissez-faire thinking in this context. On the other hand, Minskyan central bankers who advocate government injections of liquidity into the capital markets in times of crisis, on the premise that liquidity is inherently scarce and credit inherently destabilizing in a free market, represent the transformation of interventionist thinking. The "money wars" of the post-Bretton Woods period thus hearkens back to older pre-war debates dating back to the nineteenth century debates on whether a lender of last resort should provide liquidity to forestall panic[55]. So while Stefan Eich is right to narrate the history of political thought's relationship to the question of money as one of periodic

---

[52] Emanuel Derman, 'Tobin or not Tobin? Too much friction may be bad, but a little friction is often a good thing.' (blog) https://emanuelderman.com/tobin-or-not-tobin/

[53] For academic developments of this interventionist perspective see Morgan Ricks, John Crawford and Lev Menand, 'A Public Option for Bank Account (or Central Banking for All),' Vanderbilt Law Research Paper 18 – 33 (2018); UC Hastings Research Paper No. 287; Katharina Pistor, 'A Legal Theory of Finance,' *Journal of Comparative Economic* (2013) *s* 41/2: 315 – 330; Perry Mehrling, 'Three Principles for Market-Based Credit Regualtion,' *American Economic Review* 102/3: 107 – 112

[54] See Perry Mehrling, 'Minsky and Modern Finance: The case of Long Term Captial Management,' *The Journal of Portfolio Management* 26/2 (2000): 81 – 88

[55] Thomas M. Humphrey, 'Lender of last resort: the concept in history,' in Forrest Capie and Geoffrey E. Wood, eds., *The Lender of Last Resort* (London, 2006): 287 – 302; MD Bordo, 'The lender of last resort: alternative views and historical experience,' in in Forrest Capie and Geoffrey E. Wood, eds., *The Lender of Last Resort* (London, 2006): 303 – 320; Michael D. Bordo and David C. Wheelock, 'The promise nd performance of the Federal Reserve as lender of last resort, 1914 – 1933.' No. w16763. National Bureau of Economic Research. 2011; Denis Patrick O'Brien, 'The lender-of-last-resort concept in Britain,' *History of Political Economy* 35/1 (2003): 1 – 19; Vincent Bignon, Marc Flandreau and Stefano Ugolini, 'Bagehot for beginners: the making of lender-of-last-resort operation in the mid-nineteenth century.' *The Economic History Review* 65/2 (2012): 580 – 608

de-politicization and re-politicization, I think he is wrong to lay the blame at Hayek's door for the depoliticization of money post-Bretton Woods[56]. The far more powerful source of depoliticization has come from the revived capital markets, exemplified in the thought of the physicist bankers Fischer Black and Emanuel Derman at Goldman Sachs. Unlike Hayek, they don't believe in efficient markets. Nor are they as squeamish about modelling the economy. Viewing the things through the prism of CAPM, however, their ideal world is one without money.

Conclusion

In this paper I have examined a set of thinkers, and several sites of intellectual production that are largely neglected by the dominant historiography of neoliberal thought. While economists and sociologists have increasingly come to emphasize the role of ideas originating from the financial sector in shaping economic policy and regulation, historians of political thought and political theorists have been slow to engage with them[57]. Understanding how these individuals view the world involves understanding their models, not only the assumptions that underlie them, but the challenge in communicating their properties to their eventual users, their attempts to manage how they get used, and the broader technical infrastructure and regulatory frameworks in which they get embedded. In this regard, we still have much to learn from our colleagues in science and technology studies and the history and philosophy of science who have long studied the interplay between philosophical thought and technologies and devices[58].

Fundamentally, the ambition that underlies this paper is to begin to rethink the global networks that were at the core the market revolution. Derman's first boss at Goldman Sachs, the head of the Financial Strategies Group Stanley Diller, had a reputation for hiring foreign born mathematicians and physicists in the 1980s—patronizingly referred to as "Diller's Dillies" in a Forbes magazine profile of the new "rocket scientists" on Wall Street[59]. At the height of Derman's tenure as the head of Quantitative Strategies Group, only about 20% of

[56] Stefan Eich, *The Currency of Politics* (Princeton, 2022), 177 – 206
[57] Greta Krippner, *Capitalizing on Crisis: The Political Origins of the Rise of Finance* (Harvard, 2012); Daniela Gabor, 'The Wall Street Consensus,' *Development and Change* 52/3 (2021): 429 – 459
[58] Steven Shapin and Simon Schaffer, *Leviathan and the air-pump* (Princeton, 1985); Donald Mackenzie, *An Engine not a Camera*; Mary S. Morgan, *The World in the Model. How Economists Work and Think* (Cambridge, 2012); Lorraine Daston, *Rules: A Short History of What We Live By* (Princeton, 2022); Keith Breckenridge, *Biometric State* (Cambridge, 2014)
[59] Ben Weberman, 'Diller's Dillies,' *Forbes* (Sep 25 1984), 82

his team were American born[60]. This is not a story centred on academics and their allied think tanks. A large portion of the intellectual firepower behind the rise of finance was a product of post-war developmentalism. Practically every country with ambitious programmes to develop the technical and engineering expertise in the post-war period would be represented in the "quants" departments of the major Wall Street investment banks in the 1990s. These programmes involved choices about who would be the beneficiaries of this upskilling. These choices are most starkly on display in Apartheid South Africa where clear racially defined beneficiaries are defined, but they are present wherever the development of a technocratic elite is actively fostered[61]. Given the context of the Cold War, there is naturally a geopolitical dimension to this story, as many countries explicitly relied on American universities to develop these skills[62]. Emerging market economic crises in the 1980s and 1990s, and the end of the Cold War all led to further brain drains into the US[63].

The winding down of government spending in scientific research in the aftermath of the Vietnam War led not only to a migration of scientists and engineers into Wall Street. It also saw the Democratic Party trying to mobilize unemployed scientists and engineers as a political bloc[64]. The Democrats saw themselves increasingly bound to the interests of the emerging tech sector and to a vision of the economy centred on high-wage, high-skill, knowledge-based growth[65]. In the case of the former, Democratic lawmakers and the Clinton administration would work hard in the 1990s fostering an environment in which venture capital could emerge as a viable alternative to government funding for tech ventures, and delivering tax breaks and relaxing regulation to foster a new ecosystem of high-tech start-ups. It is within this new configuration and politicisation between the old Cold War triple helix of

---

[60] Personal communication with the author
[61] Ajantha Subramanian, *The Caste of Merit* (Harvard, 2019)
[62] Ross Bassett, *The Technological Indian* (Harvard, 2016), Stuart W. Leslie and Robet Kargon, 'Exporting MIT: Science, technology, and nation-building in India and Iran,' *Osiris* 21/1 (2006): 110 – 130; Ali Erken, *America and the Making of Modern Turkey* (New York, 2018); Honhong Tinn, *Island Tinkerers: Innovation and Transformation in the Making of Taiwan's Computing Industry* (Cambridge MA, 2025)
[63] Ina Ganguli, 'Scientific brain drain and human capital formation after the end of the Soviet Union,' *International Migration* 52/5 (2014): 95 – 110; Mohammad A. Chaichan, 'A new phase of globalization and brain drain: Migration of educated and skilled Iranians to the United States,' *International Journal of Social Economics* 39/1-2 (2012): 18- 38; AnnaLee, 'Silicon Valley's new immigrant high-growth entrepreneurs,' *Economic development quarterly*
[64] Lily Geismer, *Don't Blame Us: Suburban Liberal and the Transformation of the Democratic Party* (Princton, 2015), Susannah Glickman, 'Scientists, Engineers, and the End of the Vietnam War,' *Science History Institute* https://www.sciencehistory.org/collections/blog/scientists-engineers-and-the-end-of-the-vietnam-war/
[65] Nick O'Donovan, *Pursuing the Knowledge Economy. A Sympathetic History of High-Skill, High-Wage Hubris* (Cambridge, 2022)

defense, academia and industry that we should seek to understand the ideas that shape the worldview of highly skilled immigrants in both finance and the tech industry in the 1990s.

Just as it would produce a seriously distorting picture of Emanuel Derman's thought to centre the influence of Spinoza over that of CAPM and Fischer Black, so I think it's a trap to try to understand the PayPal mafia through their readings of Carl Schmitt, or a tweet of a Milton Friedman quote. The place to start, is probably the University of Illinois in Urbana-Champaign in the 1990s from which the majority of PayPal's engineers—mostly immigrants from the former Soviet bloc—were drawn. The University was home to the National Center for Supercomputing Applications (NCSA) which had grown out of a series of programs, beginning in 1949, to design and build large computers for the U.S. Department of Defense and its research wing, the Advanced Research Projects Agency (ARPA). In the 1990s, however, it was the centre of a perfect storm of technical innovations in public key cryptography and the libertarian cypherpunk culture associated with it, a newfound potential to repurpose public research for private gain (exemplified by the success of Marc Andreesen's Netscape web browser), and a regulatory environment supportive of high tech start-ups. It is thinking about how to leverage network effects for maximum profit, both within the tech start-ups themselves and within academia, that produces the cutthroat, brash business culture which abhors regulation and embraces monopoly[66]. It is the transformation of American society in the 1980s and 1990s which is the decisive context for shaping both the South African emigres in finance and in the tech industry. It would be a mistake to read too much into their formative years in South Africa.

This is not to say their impressions of South Africa are entirely inconsequential. Throughout his writing, Derman evokes his formative years in South Africa, lending unexpected poignancy to his descriptions of the trials and tribulations of a Goldman Sachs quant. His recollections of attending the trial of the anti-Apartheid Adrian Leftwich, for instance, suggests that there is perhaps more to his epistemological caution than the fear of speculative bubbles. Leftwich had been an acquaintance of Derman while they were both students at UCT. Leftwich had been the charismatic leader of the National Union of South African Students before joining the African Resistance Movement and engaging in acts of sabotage against strategic infrastructure in 1963. He had been a principled activist whose courageous

[66] The key academic text on the economics of network effects is Carl Shapiro and Hal R. Varian, *Information Rules. A Strategic Guide to the Network Economy* (Boston, 1999)

stance against Apartheid Derman had admired. However, once arrested, and under threat of torture, he collaborated with the police and state prosecutors, leading to the imprisonment of his co-conspirators. ‘You can count yourself lucky,’ writes Derman, ‘if your model of yourself survives its collision with time.’[67]

[67] Derman, *Models. Behaving. Badly,* 18