Macro-Prudential Regulation and the New Road to Financial Stability

Looking Through Darwin's Glasses

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Thank you to the IMF and the Federal Reserve Bank of Chicago for inviting me to speak to you tonight.

As many of you know, the Pew Charitable Trusts devoted a great deal of effort to making sure that the recent U.S. financial reform legislation addressed the underlying causes of the recent financial crisis. However, my comments tonight are my own and do not necessarily reflect the views of Pew, its management or its Board.

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When I was at the Group of Thirty, I got to know Brian Quinn, who was Executive Director of Supervision at the Bank of England. Brian said to me once that bank failures are inevitable. That was a provocative thing to say on the face of it, because his job was to make sure that banks didn't fail. But he was acknowledging history and the universal adoption of deposit insurance. And, indeed, he conceded that one or two small failures could have a positive aspect. His staff could keep their hand in. Managing a failure could provide valuable lessons about the markets – often at a micro-level. With one or two small ones a year, his staff would be better prepared if, Heaven forbid, something more serious happened.

I think there is an additional reason why some failure is good. Evolving populations need some turnover to stay healthy. And I believe we should think about evolution when we think about financial systems and macro-prudential regulation. Macro-prudential regulation is then simply the art of constraining evolution – of allowing a complex system to evolve as freely as possible while nudging it away from any heightened risks of catastrophic collapse. Tonight, I want to take a look at financial stability through Darwin's glasses. Doing so, I believe, brings a great deal into focus.

For example, Darwin teaches us that diversity is a form of insurance. Consider what that tells us about the spread of best practice. Adopting best practices is by definition beneficial for any individual institution that does it. But if everyone tries to adopt best practices in all things, a population will lose its diversity. Carried to an extreme, herd behavior becomes more likely and, as we know in the recent crisis, that can be very destabilizing. And if diversity is lost something that might cause one individual institution to fail is increasingly likely to wipe out everyone. As counterintuitive as it might seem, the universal and strict adoption of best practice can be destabilizing for any system as a whole.

Evolutionary theory can provide insights into systemic instability – its causes, what to watch for and what to do about it. It is a big enough tent to accommodate several other theories and insights about systemic stability. And because it is comprehensive and deep, it may help us pick up signals of future instability rather than just explanations of what went wrong in the past.

Let's examine each of these assertions one at a time.

1. The Financial System is an Evolutionary System

As many of you know, evolution can be viewed as a family of algorithms for changing populations. Evolutionary algorithms:

- Work locally on individuals or families by changing them or their descendants with some unpredictability.
- History matters, in that evolution usually tinkers and only occasionally does something radical: what comes after usually resembles what went before.
- There is selection based on fitness.
- The environment changes unpredictably too. And
- The environment provides only limited resources so that competition is inevitable as successful populations grow.

There is no doubt that the financial system evolves in the colloquial sense all the time. It certainly has done so through my sixty years on this planet – pretty relentlessly too. Still, if we stop and think for a minute, we can see that the financial system also changes as an evolutionary system in the strict algorithmic sense. Change is local, usually initiated by individual institutions or small groups joining together. History does matter. There certainly is selection based on profitability -- at least when governments don't intervene. The technological, economic and social environment is always changing unpredictably. And the competition for funds, markets, talent and technology is fierce.

Now, given enough time, it is a mathematical certainty that many things happen in any evolving population of sufficient size. The list is long: diversity, complexity, speciation, cooperation, specialization, symbiosis, co-evolution and predator-prey relationships emerge. Networks of interaction and interdependency appear. Remarkably, the initial population can then spawn evolving secondary populations of networks, characteristics, processes and strategies. And I mean that strictly, not just metaphorically, in the sense that these four things -- networks, characteristics, processes and strategies – can all form populations themselves where change is

local, history matters, selection rules, the environment changes and resources are limited.

Evolutionary theory predicts all these things. So much for the canard that evolution cannot make predictions! Because it is an evolutionary system in the strict sense, we should expect to see all of these things occur in the financial system – and indeed we do. The facts confirm the theory remarkably well.

One more point. Some evolutionary systems feature intelligent populations. They *never* feature the omniscient all knowing, all anticipating intelligence of econ 101 because, for such brainiacs, there is no uncertainty and, frankly, no need to evolve. Evolving populations can only ever have limited intelligence – limited knowledge of the past and the present and limited foresight into the future. Heritable limited knowledge and foresight have interesting implications in evolutionary theory – especially when it comes to instability, to which I now turn.

2. Evolution is All About Instability

While evolution always changes a population, it doesn't always improve its fortunes. Leaving aside extinctions, which are clearly sub-optimal for those most immediately concerned, evolution is a tough pitcher that often throws a curve ball. Instability arises because of:

- Resource Constraints: When populations grow steadily for a long time, they bump up against resource constraints. If they can't then adjust to zero growth or if the resources are not renewable, they will either break into sub-populations that compete, or bump along, or just die out. The recent extinction of investment banks could be viewed that way: they had reached the limits to growth and begun to compete in ways that undermined their own resilience and reliability – sacrificing capital and liquidity for profits.

- Co-Evolution: When separate species appear and either cooperation, competition or predator-prey relationships develop between them, they start to co-evolve. What happens to one of them changes the environment of the others. There is a rich literature of mathematical analysis that goes back 100 years and agent-based simulation that goes back about twenty that tells us that co-evolution can lead to cycles that can last for a long time or create an explosion and collapse. It depends on whether there are positive feedback loops that start too quickly or last too long. Obviously, credit and leverage cycles are financial system examples that we have witnessed in their more destabilizing forms in the past three years.
- Networks of Interdependence: Two good survival strategies for species are to cooperate or to get good at preying on others. Both require networks of interdependence, which quite evidently co-evolve whether we are talking about nature or finance. Speciation or specialization begets more speciation and specialization, increasing both complexity and diversity. Network theorists and epidemiologists have a thing or two to tell us about network stability – the importance of super-spreaders and critical nodes, the dangers of concentration and about other characteristics of networks that can hamper or help contagion. Clearly systemically important financial institutions and markets – but not payments system infrastructures -- were key super-spreaders and critical nodes in 2008. Think how network mapping of credit exposures could have alerted regulators to the excesses at AIGFP.

- Limited Intelligence: Intelligence is a powerful advantage for any species. It allows a species to anticipate the responses of predator and prey. It can eliminate a lot of really bad variations via thought experiments, avoiding costly and time-consuming random variation. Lamarkian evolution can enhance Darwinian evolution in intelligent species. But, unfortunately, it can add significantly to instability because it facilitates strategies of extrapolation and imitation. These can be powerful survival tools for the below average much of the time and for everyone some of the time – the crowd can offer protection from uncertain threats. When I was a currency analyst on Wall Street, I was fascinated to

see that when times got uncertain the dispersion of forecasts from different analysts diminished. If we were likely to be wrong, we wanted to be wrong together. But extrapolation and imitation tend to produce herd behavior and homogeneity. What works for krill or starlings operating with spatial constraints as a defense against whales or eagles can make matters a lot worse with traders operating with real time information in a financial boom or bust.

- Complexity: One of the best things about evolution is that it explains complexity so satisfactorily. Complexity, however, adds to instability for those of limited intelligence. It obscures the past and the present and makes the future hard to predict. Particularly where evolution is accelerating and new complexity is popping up all over the place, it gets easier to make mistakes and extrapolation and imitation strategies become increasingly attractive. Management fashions certainly influence the senior managers of large banks who face extraordinary complexity both within and without. I don't think any market practitioner or regulator knew from stem to stern what the securitization process was becoming as it evolved.

- Self-criticality: A sixth source of instability is the tendency for evolutionary systems to be self-critical -- not in the sense that Wall Street traders might spontaneously start group therapy sessions where they can criticize themselves, but rather that evolutionary systems have a strong tendency of their own accord toward states in which they are teetering on the edge of collapse. Evolution spurs competition and drives individuals toward the edge of their abilities, exhausting their reserves and leading them to over-specialize. Across any network of interdependency, filaments of fragility of uncertain length develop and from time to time generate avalanches of failure. The sizes of these avalanches are often governed by a power law – there is a constant that dictates how, as avalanches get bigger, their frequency declines. It is not just that networks provide pathways for domino effects but, given half a chance, evolution lines up wobbly dominos.

3. Implications for Macro-Prudential Strategy

I could go on, but I think I have made my point. Evolution suggests plenty of things for macro-prudential regulators to monitor for early signs of instability:

- Homogeneity – of organizational structures, practices, and strategies;
- Co-evolution -- of processes, practices, institutions, markets, strategies, products and services;
- Concentration – a form of unstable interdependence;
- Declining robustness and resilience (or declining "wellness," one might say) – meaning declining excess capacity, increasing leverage, declining capital or liquidity;
- Positive feedback mechanisms – and things that encourage positive feedback such as information asymmetries and misaligned incentives (including moral hazard);
- Complexity, opacity and speed of change – including complexity of networks and organizational structure, incomprehensibility of new instruments and trading strategies, and rapid growth in activity and profits, which can be symptoms of something going wrong as often as something going right;
- Turnover – which should be neither too low nor too high but just right;
- Interconnectedness – which can create super-spreaders and critical nodes, and new pathways for other kinds of instability; and
- Multiple small causes – that are associated with impending avalanches of self-criticality.

Some of these can be measured and tracked by traditional types of economic indices and surveys. We will have to draw on experience in management, marketing (believe it or not) and the sciences to measure and monitor such things as homogeneity, process evolution, complexity and opacity.

What can evolution tell us about policy levers? First of all, tread very carefully. The possibilities for undesirable side-effects not only are legion but forever changing. Secondly, there is no substitute for knowing the details, where the devil resides. Macro-prudential regulation can't

work without top quality micro-prudential regulatory input.

Beyond that, there are some familiar ideas to consider such as discouraging concentration, aligning incentives, raising capital and liquidity requirements, lowering permitted leverage and loan-to-value ratios, counteracting protracted positive feedback loops in the credit and liquidity cycles, increasing transparency and making sure that institutions of all sizes can be broken up or allowed to disappear when they fail.

Then there are some less familiar ones such as encouraging (and certainly not inhibiting) diversity; avoiding threshold effects that can precipitate rapid positive feedback in micro-prudential and market regulations; monitoring the co-evolution of markets, products and processes along with institutions; and looking for circumstances in which many small things may be going wrong together - -lengthening those filaments of instability associated with self-critical systems.

Evolution offers some important general advantages. First, it gives us a more balanced theory of micro-prudential regulation and market discipline. Both are capable of adding to stability by raising wellness. But both are also capable of creating positive feedback loops, instilling complacency and increasing homogeneity.

Second, evolution is a forward-looking context for other theories and insights. Agent-based modeling (ABM), complex adaptive systems (CAS) analysis and network analysis all clearly apply to evolutionary systems. CoVaR and credit exposure mapping address network instability by charting the relationships between the size of links and vulnerability – how close and how wobbly the dominoes are.

Finally, evolution may offers us some comfort that we will be ready to fight the next war rather than the last one. Only “some comfort” because we are creatures of limited intelligence and, while we may be looking at the right thing when we study evolution, critical details are bound to

elude us from time to time.

I can't really demonstrate it in an after dinner speech but there is one more thing that gives me faith in evolution as an exciting approach for the task at hand. It is that the mathematics for all of this is ripe. I have developed from my own study and from several discussions with the Board of Mathematical Studies at the National Academies of Science in Washington DC and with the Committee to Establish a National Institute of Finance – the grass roots effort behind the legislation creating the Office of Financial Research under Dodd-Frank. The expansion of IT systems capability and improvements in modeling strategies of the last 20 years are there to be used. New data is needed, but that's fine. Evolutionary theory gives us some solid clues about what we should collect and help us avoid collecting useless data.

4. Conclusions

I am reminded of an old friend of mine who was a civil engineer. In the late 1960s, he supervised the construction of the M4, the motorway that runs West from London across the Cotswolds past Bristol and Bath into South Wales. I was studying mathematics at Cambridge at the time and one day when he came to pick me up at my college for a lift to London, he told me all about a new piece of software his firm had developed. He was very excited because it allowed him to try out different routes and then to "drive" along them to see how the lay of the land changed. Over the succeeding months, he and his colleagues worked out a route of gentle turns, elegant bridges and lovely vistas. The result is arguably the most beautiful motorway in England.

Macro-prudential regulators are also trying to look across the landscape and try out different routes. They are not building a motorway but rather shepherding an independent minded flock through trees. In the past, they focused on the trees ahead and the individual sheep. They rarely looked at the woods or the flock as a whole. If they did look up, the view across the hills and valleys was blurred in the extreme.

In the future, we need to study the lay of the land and nudge the evolving financial system away from cliffs and precipices. We need to ensure the co-evolving populations of which the system is made up are strong enough to run the occasional rapids and weather the occasional storm. There is no doubt that it will be difficult to see the landscape ahead but we should of course try to look. I think Darwin's glasses may help. I hope, by now, that you do too.

Thank you.