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Comment Terence C. Burnham

Introduction: Consilience and Economics

> He who understands baboon would do more towards metaphysics than Locke.
> —Charles Darwin (1838) *The M Notebook*

Economists should pay more attention to baboons and less to mathematics. The chapter by Danielsson, Shin, and Zigrand (hereafter, DSZ) explores "anomalous" behavior in financial markets. An anomaly is actual human behavior that differs from behavior predicted by standard neoclassical theory.

Economic efforts to reconcile neoclassical theory with anomalies involve relaxing one of more of the standard assumptions and showing that some stylized features of actual behavior are consistent with the modified assumptions. This approach is now common in many behavioral papers on topics such as other-regarding preferences (Bolton 1991) and intertemporal decisions (Laibson 1997).

E. O. Wilson advocates a radically different approach in his book *Consilience* (Wilson 1998). He has long advocated that social scientists ground their work in the natural sciences (Wilson 1978). Consilience is the "jumping

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together" of fields. In practice, Wilson's advice suggests that social scientists should leave their hermeneutic departments and work with biologists, primatologists, archeologists, neurologists, and scientists from a host of other fields.

The eventual result of a consilient approach to economic behavior will, Wilson argues, be a richer and more accurate field. The result need not be inconsistent with mathematical models, but mathematical models without natural science knowledge will remain the "limited descriptors of surface phenomena."

The rest of this comment describes the economic and consilient approaches to understanding behavioral anomalies. It then describes some pioneering work using natural science approaches to understanding risk, the anomalous behavior that is the focus of DSZ's chapter.

Two Approaches to Anomalies

Economic Approach

The anomalies literature has documented a wide variety of divergences between actual human behavior and that predicted by standard economic theory. The behavioral school has become so well-known that citations are not required; most practitioners know to look at the work of Daniel Kahneman, Amos Tversky, and Richard Thaler.

The early phase of the behavioral approach focused on documenting failures of the standard model. These are labeled "anomalies" in the lexicon taken from Thomas Kuhn's *The Structure of Scientific Revolutions.*

A second phase of the behavioral approach attempts to build models of the anomalous behavior. These models tend to relax a small number of assumptions in the standard framework and end up with a model that mimics the most significant stylized facts in actual human behavior.

Consider, for example, behavior in the "ultimatum" game (Guth, Schmittberger, and Schwarze 1982). In the ultimatum game, one person proposes a division of a fixed amount of money. The second person faces an ultimatum; either accept their proposed share or receive nothing. Standard economic theory predicts that people will accept all positive amounts of money, even offers that are low or a small percentage of the total. Actual people, however, tend to reject small offers, choosing to leave with nothing instead of something.

How do we reconcile ultimatum game rejections with a theory that predicts no rejections? The answer, contained in many behavioral economic papers, is to retain all of the standard assumptions of economics except one. Rather than assume that people only care about themselves, these behavioral papers argue that ultimatum game rejections are the product of rational maximization of "other-regarding" preferences.

These other-regarding preference structures, when made sufficiently complex, can be made consistent with some significant percentage of the experimental results. It is not clear, however, that any of these other-regarding preference structures extends our understanding of the phenomena beyond the evidence.

DSZ's chapter follows exactly this formula. The anomaly, discovered again in the financial crises of 2008, is that people's willingness to bear risk goes down as asset markets decline. This produces the paradoxical result that investors loved owning equities when the Dow Jones Industrial Average was at 14,000, they became scared when the Dow hit 10,000, and sold in a panic at Dow 6,500. The chapter describes the puzzle: "as financial conditions worsen, the willingness of market participants to bear risk seemingly evaporates even in the absence of any further hard news, which in turn worsens financial conditions."

Using the standard view that people are rational maximizers, how can we make sense of buying stocks when the Dow is at 14,000, and selling them at less than half the price? The chapter relaxes a few assumptions, and is able to build a model that has some of the features of reality. In particular, DSZ's chapter relaxes the standard setup by allowing some traders to be forced to curtail risk because of VaR (value at risk) rules. The chapter then applies standard tools of rational expectations and fixed-point equilibrium.

Does the model work? It is consistent with some of the stylized facts that we knew before the model was written. Specifically, the authors write, "As well as the omnipresent implied volatility skew at any given moment in time, our model also predicts that implied volatilities move together in a crisis, which has indeed occurred, across securities as well as across asset classes."

Consilience Approach

E. O. Wilson suggests we look to natural science to understand human attitudes toward risk. In the natural sciences, Nobel Laureate Nikolaas Tinbergen (his brother Jan won the Nobel Prize in economics) provides a framework for examining behavior (Mayr 1961; Tinbergen 1963, 1968).

Tinbergen argues that behavior should be examined from four perspectives.

1. Ultimate cause: How does the behavior lead to increased evolutionary success? This is the domain of maximizing models in evolutionary biology.
2. Proximate cause: What machinery in the brain and body produces the behavior? Proximate explanations include hormonal influence, neuroscience work on brain function, and cognitive studies of how the brain stores and uses information.
3. Ontogeny: How does the behavior develop over the lifetime of an organism? When do children develop these traits and what influences their manifestations?

4. Phylogeny: Looking across species, what can we learn about how and why the trait developed over evolutionary time?

These are early days in consilient economics, but the number of studies is expanding rapidly. There is quite a significant field on neuroeconomics, some significant work on hormones and economic behavior, a handful of studies on nonhuman primates and economic behavior, and a few twin studies.

The next section describes four studies on risk that I label as "consilient." These are new approaches and they are not as well-developed as areas that have been under persistent study for decades.

Consilience and Risk: Pioneering Natural Science Work on Risk

Dopamine Receptor Structure and Risk Taking

Dopamine is a central reward pathway in human brains. The dopamine receptor D_4 (*DRD4*) gene is hypothesized to be involved in modulation of a variety of behaviors. Individuals vary in the genetic structure of the *DRD4* receptor. One variant, 7R+, has been shown to be associated with a "blunted" response to dopamine. Some studies argue that people with the 7R+ allele are more risk seeking because higher levels of risk are needed to generate a dopamine-based positive feeling.

One study reports that the 7R+ allele is correlated with risk-seeking behavior in an economic experiment (Dreber et al. 2009). Subjects had their *DRD4* alleles genotyped, and, for this analysis, were divided into those with 7R+ allele and those with other alleles (7R−). The subjects were asked to allocate \$250 between a safe and risky investment. The safe investment returned 100 percent of the money invested with certainty. The risky investment had two outcomes—0 or 250 percent of the money invested. Thus, the investment was risky, but had higher expected value than the safe option.

The study correlated the amount invested in the risky investment with the dopamine allele. It reports that subjects with the 7R+ allele took more risks than 7R− subjects. Specifically, the 7R+ subjects invested an average of \$175 in the risky asset versus \$136 for the 7R− subjects (p-value = 0.023).

Genes and Portfolio Choice

One study used twins to observe risky behavior in laboratory games, and concluded that risk attitudes are heritable (Cesarini et al. 2009). The partial privatization of Swedish pensions allowed examination of the genetic role in portfolio choice beyond the laboratory.

In 2001, Sweden altered its pension system to allow individuals to choose their portfolio allocation with part of their forced retirement savings (Cronqvist and Thaler 2004). The participants could choose to remain in a default allocation, or choose to allocate among approximately 500 different funds. Each of the funds was ranked for level of risk (based on the prior thirty-six months of monthly returns). The risk level was assigned to one of five categories ranging from very safe (low standard deviation of historical monthly returns) to very risky.

Twin studies separate the effects of gene and environment by comparing behavioral correlations between identical or monozygotic twins (MZ) versus fraternal or dizygotic twins (DZ). The MZ twins start with identical genetic material while DZ twins are as closely related as siblings born in separate pregnancies. Traits that are heritable will be more similar in MZ twins than in DZ twins. At an extreme, a trait like eye color will be the same in almost all monozygotic twins (not 100 percent, as mutations can occur during cell division). Nonheritable traits, such as the color of one's car, will be no more correlated between MZ twins than between DZ twins (actually, color preference might be heritable).

The study of the genetic influence on portfolio choice uses the Swedish pension reform in a classic twin study (Cesarini et al. 2010). The study uses only twins, and examines the overall risk level of the portfolio. The methodology allows an estimate of the genetic contribution to portfolio choice. The direction of the analysis is that the greater the genetic contribution, the higher the relative correlation of portfolio risk between MZ twins as compared to DZ twins.

The paper reports significantly higher correlations for MZ twins than for DZ twins: "In women, the correlations are 0.27 and 0.16. In men, they are 0.29 and 0.13." The authors state that 30 percent of the variation of portfolio risk is explained by shared genes and environment. The exact proportion that is genetic is not identifiable, as it is possible that MZ twins have a more common environment than DZ twins. Parents may treat MZ twins more similarly than DZ twins, and they may be part of the reason that MZ twins' portfolios are more correlated. That said, it is also possible that parents treat MZ twins more similarly because MZ twins are more alike genetically.

Testosterone and Risk Taking

Testosterone is associated with a variety of behaviors in men and males of a wide variety of species (Wingfield et al. 1990). In men, high testosterone is correlated with dominance-seeking behavior (Mazur and Booth 1998). When dominance is mediated by aggression, testosterone also appears to facilitate this process. A meta-analysis summarizing the results of forty-five human studies found a consistent, positive relationship between aggression and testosterone (Book, Starzyk, and Quinsey 2001). Testosterone is hypothesized to mediate status and hierarchy in an adaptive manner (Mazur 1973, 1983, 1985; Kemper 1990). Testosterone modulates a variety of behaviors that are risky.

Subjects in a study of testosterone and risk taking (Apicella et al. 2008) had their testosterone levels assayed using saliva samples. They participated in the same experimental assessment of risk as the study of the *DRD4* allele. Specifically, they allocated $250 between a safe asset and a risky asset. The study reports that a one standard deviation increase in testosterone is associated with 12 percent higher contribution ($30) to the risky asset.

Nonhuman Apes and Risk Taking

Chimpanzees (*Pan troglodytes*) and bonobos (*Pan paniscus*) are the closest living relatives to humans. In the wild, chimpanzees depend on riskier food sources than do bonobos. The authors of a study of the phylogeny of risk attitudes hypothesize that if risk preferences are shaped by the environment over evolutionary time periods then chimpanzees should exhibit riskier behavior than bonobos (Heilbronner et al. 2008).

Chimpanzees and bonobos made a risky choice in a laboratory setting. The animals selected one of two upside-down bowls. The safe bowl always contained four grape pieces. The risky bowl contained either one grape piece or seven with equal chance. (Note that the risky option had the same expected value as the safe option.) Chimpanzees selected the risky option 64 percent of the time, versus 28 percent for the bonobos ($p = 0.003$). Thus the hypothesis that chimpanzees are built to be more risk seeking than bonobos is consistent with the findings.

Concluding Comments

The chapter by DSZ begins with a puzzle about human nature. When asset markets decline, people seek safety and sell their risky assets. What have we learned about risk from the four studies just described?

In summary, the studies suggest that biology and evolution play a role in our risky behaviors. Chimpanzees and bonobos in the wild live in different environments, and these environments are hypothesized to connect to their risk attitudes in experiments. If the "natural" environment shaped bonobo and chimpanzee risk preferences, then we might learn a lot about human risk preferences by learning more about humans "in the wild." Some important scholars argue that the wild environment for humans ended 10,000 years ago with the invention of agriculture (Tooby and Cosmides 1990; Cosmides and Tooby 1994). If we are, as these scholars argue, "Pleistocene hunter-gatherers," then economists will have to learn from archeologists and anthropologists.

Our shared human environment might explain average levels of risk taking but what about variation between people? The early twin studies suggest that different genes in different people influence behavior. Our genes may have profound influences on our choices, ranging from laboratory gambles to asset allocation. If this is true, economists have much to learn from geneticists and evolutionary biologists.

How do genes alter risky choices? We have two studies that suggest roles for dopamine and testosterone. Those with particular brain structures, particularly the 7R+ allele of dopamine, may be more risk seeking. In addition, those with high testosterone may be more likely to take risky economic decisions. If these are important for a wide range of economic behaviors, the lesson is that economists should learn from the related natural science fields.

The consilient approach to economic behavior is a growing part of the literature. For it to become more fully integrated, scholars in both social and natural sciences will have to spend more time together, and learn from each other.

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