WP/04/115

IMF Working Paper

Ambiguity, Transparency, and Institutional Strength

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INTERNATIONAL MONETARY FUND

 WP/04/115

IMF Working Paper

Middle East and Central Asia Department

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July 2004

Abstract

Institutional transparency makes future contingencies more easily predictable for investors. Greater transparency can be achieved through vertical and horizontal integration of policy rules, which may result in lower Knightian uncertainty (ambiguity). In a model based on cumulative prospect theory, for a given probability and payoff structure, expected return on investment is higher in more transparent countries; therefore, those countries attract more investment and grow faster than less transparent countries. Lower transparency may result in inherently higher volatility.

JEL Classification Numbers: D70, D81, L22

Keywords: risk, Knightian uncertainty, transparency, vertical and horizontal integration, institutions

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I. Introduction

The importance of transparency in successful economies is becoming increasingly recognized in the literature and in the operational work of international organizations, including the IMF. This development is occurring in tandem with the focus on the role of institutions in promoting growth and explaining growth differentials around the world. In addition to the more familiar factors, transparency and "good" institutions are now among the generally accepted fundamentals that promote investment and growth.[2]

Based on the history of successful institution-building in the wealthy industrial countries, definitions of good institutional attributes focus on the following fundamental functions (North and Weingast, 1989; North, 1991). Good institutions (1) provide an incentive structure that promotes investment; (2) lower the transactions costs of exchange; and (3) reduce uncertainty. The third function can be broadened to include reducing volatility by imposing credible and predictable restraints on agents in power positions (politicians, bureaucracy) (Acemoğlu and others, 2003).

This paper's focus is on the institutional function of reducing uncertainty and volatility. In reference to uncertainty, North (1991) makes it clear that the type of uncertainty in focus is not simple risky situations in which probability distribution of possible payoffs to an economic enterprise (prospect) is precisely known. North's reference is to Knightian uncertainty. In real life, possible payoffs to an investment and the associated probabilities cannot be known with precision. There is Knightian uncertainty, or *ambiguity*, as distinct from measurable risk.[3] Institutions are social mechanisms that make outcomes more easily predictable and good institutions increase accuracy in prediction. Institutions (e.g., insurance markets) facilitate the conversion of uncertainty into quantifiable risk. Thus, uncertainty becomes "priceable"—uncertainty is reduced and transactions costs (e.g., insurance costs and interest rates) decline, which promotes investment and growth. Institutions are longer lived than individuals and provide impersonal safeguards to ensure time-consistent treatment of investment decisions and contractual commitments made in the past. In other words, institutions reduce uncertainty over time.

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[2] The more familiar factors constitute the basis of the original Washington Consensus; they include fiscal discipline, tax reform, financial liberalization, a unified and competitive exchange rate, openness, trade liberalization, privatization, deregulation, and secure property rights. Dani Rodrik (2003) includes corporate governance and anti-corruption in the "augmented" Washington Consensus. In a similar vein, Gerard Roland's (2000) juxtaposition of the Washington Consensus to the evolutionary-institutionalist perspective highlights the role of uncertainty (*versus* sure efficiency gains) and institutional capacity (*versus* spontaneous market development) in sustainable reform implementation (see Table 13.1, p. 330).

[3] In this paper, I will refer to Knightian uncertainty (ambiguity) as *uncertainty* and to simple risk as *risk*.

Frank Knight (1921, 2002), who lent his name to distinguishing uncertainty from risk, was the first contemporary economist to address systematically and substantively the impact of uncertainty on entrepreneurship, investment, and social progress. Knight also examined "structures and methods for meeting uncertainty." Those methods can be summarized as increasing scientific knowledge and accumulation of data, along with consolidation and specialization through large-scale organization of economic activity. Consolidation of economic activity in large corporations, in which hierarchical control on production decisions can be exercised more efficiently, reduces uncertainty and transforms it into measurable risk. Similarly, uncertainty is consolidated and its costs diversified though integrated and specialized markets and business organizations (e.g., insurance and banking); thus, decision makers "shift" uncertainty by transferring it to specialists. Central to the process of reducing uncertainty is private property and contractual freedom, which improve the prospects for control of resources (wealth) over time. Of course, consolidation, specialization, and systemic control of economic decisions and resources are the main underlying characteristics that define robust market institutions. Knight's main thesis is that such market institutions emerge primarily to deal with uncertainty.[4]

The intuitive link between good institutions and less uncertainty (and "bad" institutions and more uncertainty) is rapidly making inroads in the economic literature, particularly in the course of attempts to explain growth differentials among countries.[5] Recent economic literature refers to the basic institutional function of lowering uncertainty in the Knightian sense as *transparency*. However, an apparent gap remains between Knight's contribution, made over eighty years ago, and the current research in explaining how institutions lower uncertainty and, therefore, are instrumental in explaining growth differentials among countries.

The fundamentals of decision making under uncertainty have been subject to academic debate, ever since the Leonard Savage-John von Neumann-Oskar Morgenstern expected utility theory (EUT) gained prominence and was widely applied in economic analysis. Critiques of EUT, notably by Maurice Allais and Daniel Ellsberg (1962, 2001) and the subsequent research they spawned continue to challenge the EUT approach on a conceptual and experimental level, sometimes even questioning the fundamental-rationality hypothesis (Heiner, 1983; North, 1993; Kahneman, 1994, 2003). The bounded-rationality approach, emanating from Herbert Simon's seminal work, appears to have taken two tracks: one is the cognitive (psychological) limitations of human mind and the other is the limitations on

[4] Ronald Heiner (1983) provides a compelling argument that supports Knight's thesis. He argues that the source of predictable behavior is uncertainty; behavioral rules arise because of uncertainty in distinguishing more preferred from less preferred behavior.

[5] Acemoğlu and Zilibotti (1997) provide a formalization with linkages to growth and international capital movements. Those authors argue that lack of diversification of risks introduces a large amount of uncertainty in the growth process and slows down capital accumulation.

availability of information and technologies to process it (Knight emphasized both).[6] Availability of information and better methods of processing it reduce, but do not eliminate, uncertainty, so it is reduced to simple risk, which is the case that routinely dominates economic analysis under EUT. Complexity over space and time results in uncertainty, which persists even when we recognize and attempt to deconstruct it (Brock, 1990; Sayers, 1990).

Such critiques have fruitfully instigated the development of a new theory of decision making under uncertainty, namely the cumulative prospect theory (CPT), originally developed by Daniel Kahneman and Amos Tversky (1979, 1992), which culminated in the 2002 Nobel memorial prize in economics. Nevertheless, applications of CPT to economic theory have been scant. More broadly, as noted by David Kreps (1999) and Oliver Williamson (2000), behavior of "human actors" in uncertainty, implied by incomplete contractual situations, and the role of institutions in shaping (regulating) that behavior remains an underutilized research area.[7]

This paper attempts to incorporate the behavior of human actors into the analysis of institutions with an application of CPT. The basic premise is that human actors, bounded by the limits on their rationality and by the complexity of events they face over space and time, develop institutions to deal with uncertainty surrounding incomplete contracts. In line with the CPT approach and the supporting experimental results, human actors make *subjective* probabilistic valuations of uncertain events; thus, their investment decisions are made on a subjective basis. In line with Ellsberg's critique, human actors also have a preference for risk over uncertainty. This preference is modeled under CPT as a preference for simple prospects (lotteries) over compound prospects. Institutional strength is interpreted as vertical and horizontal integration of various decision-making bodies, because integration reduces the number of uncertain events that lead to the same payoff for a given probability structure. Integration reduces uncertainty about the range of possible policy responses to uncertain events; in this sense, integration increases policy transparency. The decision-making bodies are the public (experts), the politicians, and the agency that implements policies. Integration of various decision-making bodies (and their views) implies strengthening of the consensus

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[6] An extensive discussion of bounded rationality and institutions by the exponents of different disciplines is in the 1994 symposium volume of the *Journal of Institutional and Theoretical Economics* on "The New Institutional Economics: Bounded Rationality and Analysis of State and Society."

[7] In reality, that institutional process is imperfect and suboptimal—like the way Alexander the Great unraveled the Gordian knot or the way Christopher Columbus balanced an egg on its pointy end—but nevertheless acceptable and legitimate (*satisficing*) for human actors in determining and anticipating feasible equilibria. Thomas Sargent (1993) notes that under the rational-expectations hypothesis, equilibrium solutions are reached by making the assumption that decision makers are rational, which serves to restrict the range of possible outcomes. Where such strong rationality is not a realistic conjecture (Heiner, 1983), institutions may do the same job. The knot is cut in half, the egg is broken, but the job is done to broad social satisfaction anyway.

on the policy-response rules to deal with unforeseen and unforeseeable events. Strong consensus on rules of governance is interpreted to imply greater transparency, hence strong institutions.

The first basic question the paper addresses is *how do institutions reduce uncertainty and increase transparency?* They accomplish it by excluding a wide array of possible events and outcomes through vertical and horizontal integration. Thus, the main theme of this study is that good institutions reduce uncertainty to a greater extent and more credibly than bad institutions. This hypothesis leads to the second basic question: *how can lower uncertainty (greater transparency) result in greater investment and growth?* Lower uncertainty results in a higher value for the expected rate of return on a given investment. Therefore, institutionally stronger countries attract more capital investment and grow more. Finally, the question is *does less uncertainty result in less volatility?* Volatility is the result of uncertainty about the range of possible outcomes; therefore, less uncertainty implies less volatility.[8]

The paper is planned as follows. Following this introduction, Section II presents some observations on the correspondence between institutional quality and transparency. Section III develops a model based on CPT to answer the three main questions the paper posits. Section IV concludes.

II. Institutional Quality and Transparency

A. General Observations

Institutions create the right incentive structure and reduce uncertainty through a repertory of consensual rules that govern responses to unforeseen contingencies. However, although rules can be transparent and rule responses easily predictable, rules *per se* may not necessarily provide the right incentives to promote productive economic activity and growth. For example, it is difficult to make a case that the basic rules of the institution of slavery were not transparent. In most cases, a slave was chattel—the master unambiguously reserved the right to buy and sell a slave; most predictably, a runaway slave would be severely punished, and so on. Although there was little uncertainty in the master's and the slave's mind as to the outcome of those possible events, such lack of uncertainty hardly provided any incentive to invest in the human capital and development of slaves.[9] It has been argued that a major impediment to industrialization in the Ottoman Empire was the lack of incentives to accumulate capital with the expectation of bequeathing it to one's heirs because of the

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[8] As argued later, this assertion is more generic than the standard assumptions on the characteristics of the decision maker's utility function (in that it exhibits the risk-aversion property and that it is quadratic; see Subsection III.F).

[9] See Ransom and Sutch (1978), especially Chapter 2, on the legacy of slavery and the paucity of literacy and skills among slaves before the U.S. Civil War.

transitory nature of land tenure under the Ottoman fief system.[10] The focus in this paper is not on the institutional function of providing an incentive structure that is conducive to capital accumulation and growth. Rather, the focus is on how good institutions reduce uncertainty (or increase transparency) and, given an incentive structure, how the reduction in uncertainty may affect investment decisions.

Institutions embody established rules for dealing with events that can be anticipated with varying degrees of precision and events that cannot be foreseen. In general, event probabilities and payoffs are not precisely known, that is, rules operate in ambiguous environments. Two main levels of uncertainty associated with rules may be identified. First is the uncertainty emanating from the impossibility of identifying event probabilities with precision and anticipating the full range and variety of possible events of Nature. We may refer to such uncertainty as natural uncertainty reflecting the complexity with which the world confronts us. Second is the uncertainty about the range of responses by institutional rules to uncertain events and the probabilities associated with those responses. We may refer to such uncertainty as the human-made uncertainty, which relates to the fallibilities of human actors, and their rules and institutions.

Insurance sets a familiar example. At the first level, there is natural uncertainty about the range and variety of possible events and the extent of damage events may cause (e.g., various illnesses and natural catastrophes and the extent of their severity). Natural uncertainty also reflects uncertainty about the probabilities associated with possible events (probability of a given illness or a natural disaster of a given severity).[11] So, nature presents a range of events

[10] Under the early Ottoman fief system, a fief holder was granted by the state a land tenure (*timar*) as spoils of war but the land reverted to the state upon his death, and it would then be awarded to a different fief holder for his war efforts. Arguably, the Ottoman land tenure system was weak in ensuring private property rights over time. As Bernard Lewis (1997) explains, with the decline of central power and increased need for revenue, the fiefs evolved into tax farms, which, in turn, through usurpation and abuse by the tax farmers, evolved into freeholds that were even heritable and alienable; this system became generally established through the eighteenth century. For Lewis's further comments on this process throughout the Middle East and its formative reflection on modern political institutions in that region, see Chapter 10. Richard Pipes (2000) makes similar observations on feudal Russia under the Muscovy rule (Chapter 4).

[11] Supported by actuarial data, market-generated insurance contracts may cover most eventualities. Nevertheless, there remains considerable uncertainty about some eventualities to such an extent that markets fail to provide insurance for certain types of eventualities. Notable examples are natural catastrophe insurance (e.g., earthquakes) and, more recently, terrorism insurance, which have called for government intervention to become marketable (subsidies to insurers, incentives for the insured). Lack of widespread catastrophe insurance even in developed insurance markets (e.g., the United States) may be attributed to ambiguity; see Dacy and Kunreuther (1969, Chapter 3), and Froot (1999, Introduction). Kunreuther and others (1995), Hogarth and Kunreuther (1992) present evidence that insurance premiums are

(continued…)

about which human judgments (or, expert judgments) may differ. At the second level, there is human-made uncertainty about the response specified by the rules governing an insurance contract. The fine print notwithstanding, it is possible that the buyer and seller of insurance may have different, even conflicting, interpretations of what is covered, that is, whether an insurance contract covers a certain event with a given set of characteristics, and of the extent of liability associated with an event's costs to the insured (e.g., an expensive organ transplant in the event of a severe illness). If such a case goes to court, there is further uncertainty concerning the court's decision about the insurance contract's coverage and the size of liability. So, in the absence of the artifice of complete contracts, uncertainty about the decisions of human actors adds more layers of possible events. The main focus of this study is on human-made uncertainty.

How are those two layers of uncertainty related to institutional strength? Dealing with natural uncertainty requires the development of scientific knowledge, data bases, institutions, and markets. Scientific knowledge and data accumulation, their dissemination to markets, and their systemic use in decision making improve decision makers' ability to assess contingencies. In tandem, contract law, and under that umbrella, insurance markets need to develop in order to address natural uncertainty. Indeed, these are Knight's main points. Dealing with human-made uncertainty simultaneously requires predictable rules of governance and freedom of recourse to trustworthy arbitration and adjudication. Of course, as the amalgamating backdrop, social values, ethics, customs, conventions, traditions all matter—in short, culture matters in how predictably and reliably rules will react to unforeseen events.[12]

Modern institutions, whether they have organically evolved through history or have been adopted or inherited, appear to be on the right footing as far as their intent (their incentive structure) is concerned. Contract laws aim at expeditious and fair settlement of disputes. This aim is broadly comparable across countries, regardless of their level of development. But contract law in some countries may be regarded less transparent than in others. Transparency does not only pertain to what is written in the books. It also pertains to the efficacy and reliability of adjudication and enforcement; at those levels, many events and outcomes are possible. The range and variety of possible events determine the level of uncertainty. If, in a given country, investors perceive adjudication and enforcement as ambiguous, then, for a given rate of return, investors may prefer countries with less uncertainty. In this sense, investors may prefer countries with better institutions. Alternatively, investors may seek higher rates of return in order to invest in countries with uncertain institutional settings.

Generally, the degree of uncertainty about rule responses to unforeseen and unforeseeable contingencies is a primary determining factor in economic decisions. Such uncertainty varies

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significantly higher when there is uncertainty about event probabilities and about the magnitude of the associated losses.

[12] Mariano Grondona (2000) provides a broad review of various cultural influences on economic development.

among industries and countries (at least as indicated by country risk assessments and transparency indexes). If uncertainty is a factor in the lack of development of some types of insurance, it is plausible that uncertainty may also be a factor in the lack of development in some countries.

Lack of transparency also reflects inadequate dissemination of information that is available to some economic agents (e.g., to the government, the ruling elites) and inadequate reliability of the rules that govern responses to unforeseen events. Inadequate reliability of rules implies a weaker consensus on rules and opens possibilities for bending rules. This implies the possibility of a greater range of events and outcomes, which signals greater institutional uncertainty or less transparency. Such lack of transparency amounts to institutional weakness. Examples are many and perhaps all-too-familiar, and they cut across every aspect of economic and social interaction. To name a few: (1) inadequate data collection and dissemination systems that plague many developing countries (macroeconomic data essential for policy formulation; demographic data essential for deciding on budgetary allocations to health and education; absence of an adequate cadastre essential for better enforcement of property rights); such weaknesses result in more subjective and conflicting guess work by decision makers; (2) deliberate obfuscation of information or disinformation (size of the budget deficit; expenditure allocation to various budgetary line items; demographic data for preparing accurate election rolls); (3) prevalence of unpredictable and informal ways of bending the rules to affect outcomes (political dependency of courts; bribery and corruption; ascription-based as opposed to achievement-based upward social mobility; personal political influence in obtaining lucrative contracts; election fixing; *coups d'état*). Such weak institutional environments are more uncertain in the sense that the range of possible events and outcomes is increased. This makes decision outcomes less predictable relative to strong institutional environments where the range of possible outcomes is more restricted.

B. Ambiguity in a Policy Setting: An Example

Consensus through vertical and horizontal integration

How does uncertainty emerge in a policy setting? This model argues that uncertainty increases as the number of events leading to an outcome is increased. Let us consider the impact on investment returns of possible good and bad shocks on the economy and the possible policy responses to such shocks. For example, in the event of a bad shock, the policymakers might be tempted to increase taxes in order to meet their budgetary requirements. If a consensus on the general and specific rules of response to shocks does not exist, or, if the enforcement of the rules is weak, then the number of possible events leading to the same outcome is increased.[13]

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[13] We can easily extend the monetary and fiscal policy analogy to other policies, economic or political. How do the policymaking institutions respond to a constitutional crisis (e.g., executive corruption)? How do institutions respond to a threat of war (e.g., a terrorist attack)? How well are the institutional responses formulated and coordinated within a constitutional consensus? How strong is the constitutional consensus?

Facing the possibility of shocks, the public's evaluation of the policy response first involves assessing the likelihood and magnitude of shocks. We can look at this assessment process by decision makers as the first layer of uncertainty (*Event 1*). Public evaluation of uncertainty can be diverse, reflecting, for example, a lack of consensus among economic experts on whether the economy is going into recession, how deep the recession might be, how long it might last, and whether the *status quo* policies might be sustainable in the process. Such uncertainty may be interpreted to emanate from a degree of institutional weakness because the experts (public) are in disagreement as to the likelihood and magnitude of shocks and what the policy-making institutions' response to shocks will be. Of course, diverging expert opinions can be viewed as the embodiment of fractious public opinions, the opinions of different interest groups that stand to gain more or less, or, the views of different political parties that represent them.

Another layer of uncertainty is due to the politicians' decisions and the likelihood that they will want to respond to a shock (*Event 2*). If the politicians decide to respond, then the executing agency's acquiescence is also required, which may or may not agree with (or may or may not have the capacity to implement) the politicians' decision (*Event 3*).[14]

The strength of the institutional framework may be evaluated as follows. First, a strong framework would achieve a degree of *vertical integration* through a consensus on decision-making hierarchy. For example, the politicians and their agency reach an agreement on a policy response rule and a policy tsar is appointed who represents the consensus between the politicians' and their agency. Then, *Events 2* and *3* are combined into one, *Event V*, and the number of events leading to the same outcome is reduced.

However, even after vertical integration, the experts might still be in disagreement about the policy rule, perhaps because the consensus between the policymakers is weak, or, the policy tsar's decisions might tilt to one political faction or another. A consensus might be achieved among experts (or, the various human actors who represent varying views and interests) through the *horizontal integration* of the divergent views on what the policy response rule should be.[15] Then, *Event 1* and *Event V* (the combination of *Events 2* and *3*) are combined into a single random event, *Event VH*. A single event now represents a consensus among experts, politicians, and the agency on what the likelihood and magnitude of shocks will be and which policy rule will be followed leading to the same outcome.

[14] For example, in the military, decisions (orders) follow a strictly established chain of command. The Joint Chiefs of Staff might give an order with a certain probability; the order is disseminated through n ranks, that is, n events need to occur for the order to be carried out. Within the military hierarchy, the n events are *nonevents* in the sense that hierarchy ensures that n events are *vertically integrated* into a single event. Thus, a strong hierarchy typically indicates a strong military institution.

[15] For example, the Chiefs of Staff resolve their differences and agree on which events constitute a threat of war, which call for a coordinated armed response and the associated probabilities.

Of course, in reality, uncertainty is not reduced to simple risk. Even in the presence of strong institutions, a degree of uncertainty always remains. However, with strong institutions—strong in the sense that they are vertically and horizontally integrated— uncertainty is less than it is with weak institutions. Events continue to exhibit varying degrees of uncertainty; the question is whether the institutions are strong enough to deal with them. Presence of consensual rules of response to such events—or, consensual rules on formulating response rules to uncertain events—reduces uncertainty.

The foregoing example can also be considered in a dynamic setting, with events occurring over time. In a dynamic context, the uncertainty about events is compounded. This is because, at the point in time when the decision maker is making a decision, he/she faces future possibilities, some of which are predictable, some less predictable and some entirely unknowable. Strong institutions reduce dynamic uncertainty because of their permanence; institutions are longer-lived than individuals.

Limits on benefits from integration and other issues

The present analysis does not address the undesirable consequences of horizontal and vertical integration in ambiguous, second-best environments. In the economic arena, the desirable extent of integration has been subject to the close scrutiny of antitrust legislation. Some political systems that achieved very effective degrees of horizontal and vertical integration were one-party dictatorships. The economic and political failure of such systems is testament to the virtues of the fundamental democratic principle of separation of powers. Evidently, integration can be excessive and start breeding its own disincentives and uncertainties by creating an opaque and entrenched elite with monopoly powers and unaccountable ways of deciding on various policies. Such entrenched elites are not confined to the pages of history of totalitarianism. Given the opportunity, they tend to surface not only in bureaucracies, governments, and parliaments, but also in corporate board rooms at a great cost to shareholders who are left in the dark.[16]

Two other relevant issues that arise in the present context are: (i) how integration is achieved (or, how a consensus is reached); and, (ii) the time consistency of integrated policy rules in an environment of Knightian uncertainty. As discussed in the introduction, both issues have been addressed by Knight in a general context, and by Heiner (1983) and North and Weingast (1989), and others in behavioral and historical contexts. Of course, specific modeling of those issues under Knightian uncertainty remains a challenge; that is left for future research. Thus, this paper's focus is on how integration of policy rules might make policies more transparent—greater transparency that may be achieved through integration is interpreted as greater institutional strength.

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[16] The model presented below may also be useful in addressing the impact of such uncertainties on investor decisions to explain some market phenomena that remain puzzling under the expected utility paradigm (equity premium puzzle, home equity bias).

Against this background, the question is, how do decision makers react to Knightian uncertainty in making economic decisions? This calls for a model of decision-making in uncertainty in order to explain how greater institutional uncertainty may result in lower investment and growth.

III. The Model

The model is based on a simple pure-gain compound lottery. Uzi Segal (1987) argues that Ellsberg-type ambiguous lotteries can be viewed as two-stage or multi-stage compound lotteries. Under certain conditions on the probability weighting function of the decision maker, compound lotteries *cannot* be reduced to simple lotteries as under EUT, that is, the *reduction of compound lotteries axiom* of EUT is violated. In this model, I evaluate uncertainty on the same premise and use the properties of the empirically supported CPT probability weighting function. The focus is on a pure-gain prospect for simplicity but this comes at the cost of some loss of generality. However, the focus on pure-gain prospects is general enough to make the main point of this study.[17]

A. Cumulative Prospect Theory (CPT) Approach

CPT valuation of a pure-gain prospect

The CPT valuation of a prospect that involves only gains, G_i, is as follows. Rank G_i as $0 < G_1 < G_2 < \ldots < G_n$ and let p_i be the given probabilities associated with each G_i. Then, the CPT valuation of this prospect is

$$V = \Pi_1 U(G_1) + \Pi_2 U(G_2) + \ldots + \Pi_n U(G_n);$$

$$\begin{aligned} \Pi_1 &= w(p_1 + p_2 + \ldots + p_n) - w(p_2 + p_3 + \ldots + p_n), \\ \Pi_2 &= w(p_2 + p_3 + \ldots + p_n) - w(p_3 + p_4 + .. + p_n), \\ &. \\ &. \\ \Pi_{n-1} &= w(p_{n-1} + p_n) - w(p_n), \\ \Pi_n &= w(p_n), \end{aligned} \qquad (1)$$

where $w(.)$ is the probability weighting function and $U(.)$ is the utility function, $U' > 0,$ and $U(0) = 0$, as in CPT; $U(.)$ obeys the usual risk-aversion property, $U'' < 0$.

[17] The more general case of mixed prospects (which involve both gains and losses) might be useful for modeling limits on benefits from integration, disincentives to innovation in hierarchies, time consistency of hierarchical compacts and integrated policy rules.

Lower subadditivity condition

The function *w(.)* exhibits the subadditivity properties of subjective probability weighting. The subadditivity property in focus here is the *lower subadditivity condition* (*LSA*), which can be expressed as

$$\begin{gathered} w(p_1 + p_2) \le w(p_1) + w(p_2) \\ \textit{subject to} \\ p_1 + p_2 \le 1 - \varepsilon, \end{gathered} \tag{2}$$

where ε is a small number. This condition indicates that when the probability total is increased from p_1 to p_1+p_2 (when a possible event becomes more probable); the increment is weighted less, provided that the increment does not result in certainty (i.e., $p_1+p_2 \le 1 - \varepsilon$).

Compound event-splitting effect

It can further be shown that a subadditive probability weighting function indicates that

$$\begin{gathered} w(p_1)w(p_2)\cdots w(p_n) < w(p_1 p_2 \cdots p_n) \\ \textit{for all } p_1 p_2 \cdots p_n \ne 0,1. \end{gathered} \tag{3}$$

The foregoing argument is the compound lottery version of the *event-splitting effect*.[18]

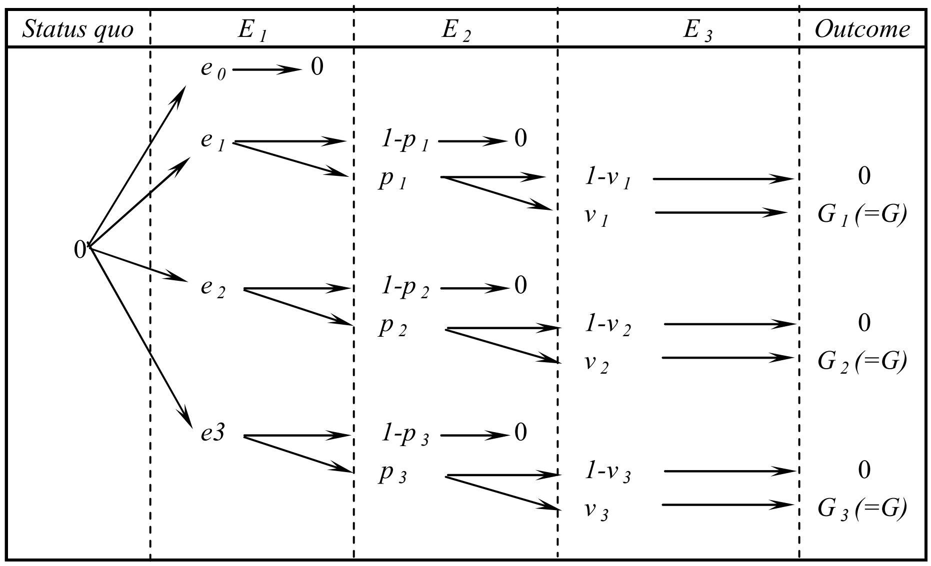
B. Compound Prospect Evaluated

Consider the compound prospect in Figure 1. For example, such a prospect may represent an investor's evaluation of country risk in the process of deciding whether he should invest in that country or in another. The first event, E_1, represents the stage at which opinions are formed about the possible states of the economy; there are four experts, e_0, e_1, e_2, and e_3, whose views about E_1 are divergent. The first expert believes nothing will happen and the

[18] According to *LSA*, a split prospect that pays $X > 0$ such that $EV(S) = [w(p_1)+w(p_2)]X$ is preferred to one that pays the same prize but is juxtaposed as a combined event such that $EV(C) = w(p_1+p_2)X$, that is, $EV(S) \ge EV(C)$. This is the event-splitting effect. For a discussion and experimental results, see Starmer and Sugden (1993) and Humphrey (1995). The theorem in equation (3) is the compound lottery version of the event-splitting effect. It means that a single-event (simple) lottery that pays *X* is preferred to one that involves *n* events with the equivalent compound probability, that is, $w(p_1p_2...p_n)X \ge w(p_1)w(p_2)...w(p_n)X$. For a proof and discussion of the theorem in equation (3), see the Appendix.

status quo (indexed at zero) will be maintained with probability e_0.[19] The other experts predict that a shock will occur with diverging probabilities e_1, e_2, and e_3 and have differing opinions about the possible policy responses. As for the possible reaction of the politicians to shocks (or, the second event, E_2), each expert predicts that the politicians will react with probabilities p_1, p_2, and p_3, respectively. As for the reaction of the agency (or, the third event, E_3), they also have diverging opinions, and they predict that the agency will implement the politicians' decision with probabilities v_1, v_2, and v_3, respectively. Furthermore, the experts disagree about the magnitude of the returns to investment and predict G_1, G_2, and G_3, respectively.[20]

Figure 1. A Compound Lottery as the Source of Uncertainty



The CPT valuation of the compound prospect in Figure 1 (along Segal's lines) is as follows. The decision maker first evaluates E_3 and values and compares the final payoffs, G_1, G_2, G_3 as in

$$V_{11} = w(v_1)U(G_1); V_{12} = w(v_2)U(G_2); V_{13} = w(v_3)U(G_3). \quad (4)$$

[19] Here, e_0 can be interpreted as a small probability event, corresponding to ε that applies for *LSA* in (2) to hold.

[20] For brevity, the model is omitting some possible sub-lotteries in Figure 1. For example, the credibility of expert opinions and the likelihood of shocks on the economy are subsumed into a single stage in the form of the probabilities, e_i. The reason why we might assume $G_i = G$, $i = 1, 2, 3$, in Figure 1 will be explained below.

Without loss of generality, let us assume that $V_{11} < V_{12} < V_{13}$. Then, the certainty equivalents can be calculated as $C_{1i}=U^{-}[w(v_i)U(G_i)]$, $i = 1, 2, 3$, with $C_{11} < C_{12} < C_{13}$, which correspond to p_1, p_2, p_3 in E_2. Then, E_2 is evaluated as

$$V_{21} = w(p_1)w(v_1)U(G_1); V_{22} = w(p_2)w(v_2)U(G_2); V_{23} = w(p_3)w(v_3)U(G_3). \quad (5)$$

Similarly, it is possible to find the certainty equivalents for V_{2i} (values corresponding to e_i) and rank them; suppose we have $V_{21} < V_{22} < V_{23}$ so that $C_{21} < C_{22} < C_{23}$. Then, the prospect including E_1 is evaluated as

$$\begin{aligned} V^C = {} & [w(e_1+e_2+e_3) - w(e_2+e_3)]w(p_1)w(v_1)U(G_1) \\ & +[w(e_2+e_3) - w(e_3)]w(p_2)w(v_2)U(G_2) \\ & +w(e_3)w(p_3)w(v_3)U(G_3), \end{aligned} \quad (6)$$

where V^C stands for the value of the compound prospect in Figure 1.

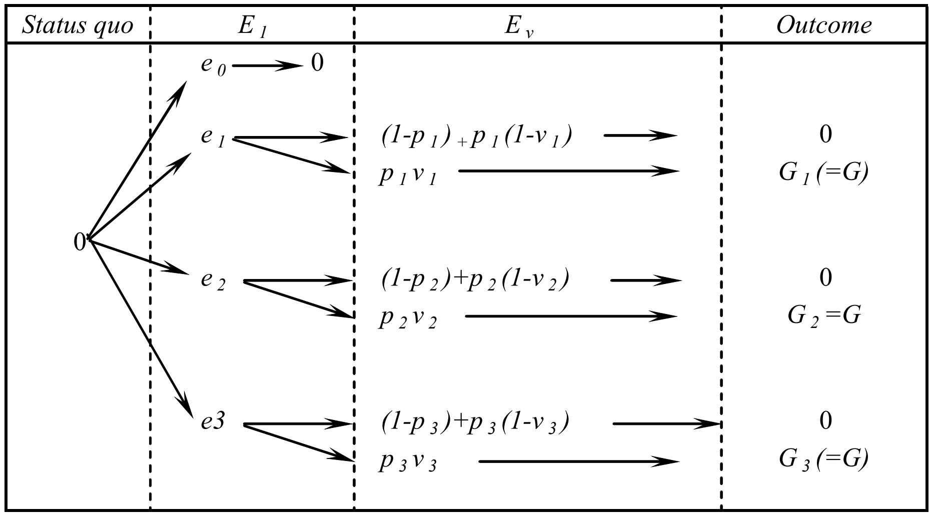
C. Vertically Integrated Prospect Evaluated

This prospect is shown in Figure 2. Vertical integration indicates that the politicians and their agency reached a consensus, and E_2 and E_3 are now reduced to a single event, E_V. Following the same steps used in the evaluation of the compound prospect, we can show that the value of the vertically integrated prospect is

$$\begin{aligned} V^{VI} = {} & [w(e_1+e_2+e_3) - w(e_2+e_3)]w(p_1v_1)U(G_1) \\ & +[w(e_2+e_3) - w(e_3)]w(p_2v_2)U(G_2) \\ & +w(e_3)w(p_3v_3)U(G_3). \end{aligned} \quad (7)$$

The theorem in (3) indicates that $V^C < V^{VI}$ because the respective coefficients of $U(G_i)$ in V^C are less than the corresponding coefficients in V^{VI} because $w(p_i)w(v_i) < w(p_iv_i)$, $i = 1, 2, 3$.

Figure 2. Reduced Compound Lottery with Less Uncertainty (Vertical Integration)



Interpretation

This result can be interpreted as follows. Suppose one is faced with a three-step lottery. You draw balls from an urn that contains balls of four different colors. Let e_i represent the number of *i*-colored balls in the urn, Σe_i being the (normalized) total number of balls in the urn. If you draw a ball colored e_0, the lottery is terminated; if you draw a ball colored e_i, you proceed to draw from a second urn that contains x balls, of which $p_i x$ are colored blue; if you draw a blue ball, you proceed to draw from an urn that contains y balls, of which $v_i y$ are colored red; if you draw a red ball you win the prize $\$G_i$. Alternatively, one can face a two-step lottery with the same probabilities and prizes, which can be easily traced from Figure 2. The result $V^C < V^{VI}$ means that bettors would prefer the two-step lottery to the three-step lottery. The interpretation is that the vertically integrated lottery exhibits less uncertainty than the compound lottery.

We can relate this result to Ellsberg's *two-color* problem easily. Suppose "Urn E_3" in Figure 1 contains 100 red and blue balls with an unknown composition. There are 101 experts, p_i, $i = 1, 2, ..., 101$, who predict that "Urn E_3" contains v_i red balls, with v_i ranging from zero to unity. Further assume that $G_i = G$, or, that each expert predicts the same prize. Now consider "Urn E_v" in Figure 2. "Urn E_v" contains 100 balls also, of which exactly $\Sigma p_i v_i$ are red. Let $\Sigma p_i v_i = ½$. You win $\$G$ if you draw red. Which urn would you draw from, E_3 or E_v? Experimental results confirm most bettors prefer E_v to E_3. Decision makers prefer risk to uncertainty.

Of course, in reality, compound prospects are more complicated than Ellsberg's two-color problem and they are never as well-defined as those shown in Figures 1 and 2, even in a static sense. There are many unknowns and unknowables about probabilities and payoffs. In a dynamic setting, unknowns and unknowables increase in number, creating greater uncertainty. The result that follows from (6) and (7) is a simple axiomatization of the preference for risk over uncertainty under CPT (or, of the preference for less uncertainty over more uncertainty). The basic intuition is that a vertically integrated institutional setting might be viewed as less uncertain (less ambiguous) than an unintegrated setting. In that sense, the vertically integrated institutional setting might be considered more transparent and, therefore, stronger than the unintegrated setting.

D. Further Vertical Integration

In Figure 2, further vertical integration can be interpreted as the merger of expert opinions with the integrated policy rules agreed upon between politicians and their agency. For example, the decision maker might be facing an investment decision in a country where four political parties are competing in an election and each political party presents a unified policy rule, with the prospect of capturing the majority of parliamentary seats and making political appointments to the agency that will implement the rule. Let us designate the further vertically integrated system as $\pi_1 = e_1p_1v_1$, $\pi_2 = e_2p_2v_2$, $\pi_3 = e_3p_3v_3$. Assuming that the ranking of payoffs is $G_1 < G_2 < G_3$, the value of the further vertically integrated prospect, V^{FVI}, is

$$\begin{aligned} V^{FVI} &= [w(\pi_1+\pi_2+\pi_3) - w(\pi_2+\pi_3)]U(G_1) \\ &+[w(\pi_2+\pi_3) - w(\pi_3)]U(G_2) \\ &+w(\pi_3)U(G_3). \end{aligned} \qquad (8)$$

The conditions in (2) and (3) indicate that $V^{VI} < V^{FVI}$. The more vertically integrated prospect dominates the less vertically integrated one.[21]

E. Vertically and Horizontally Integrated Prospect Evaluated

Partial horizontal integration

Institutional strength may be further increased through horizontal integration. Let us first look at the case in which there is only partial horizontal integration. Suppose the views of two vertically integrated political parties ($\pi_1 = e_1p_1v_1$ and $\pi_2 = e_2p_2v_2$) converge after vertical integration is achieved. This indicates that the two parties also agree that the outcome (payoff) will be G. However, the third party's views ($\pi_3 = e_3p_3v_3$) continue to diverge from the consensus established between the parties π_1 and π_2. Without loss of generality, assume that $G < G_3$. Then, the value of the partially horizontally integrated prospect is

$$V^{PHI} = [w(\pi_1+\pi_2+\pi_3) - w(\pi_3)]U(G) + w(\pi_3)U(G_3). \qquad (9)$$

---

[21] The condition in (2) indicates that in (7), we have $w(e_1+e_2+e_3)-w(e_2+e_3) \leq w(e_1)$, and, in (8) we have $w(e_1p_1v_1+e_2p_2v_2+e_3p_3v_3) - w(e_2p_2v_2+e_3p_3v_3) \leq w(e_1p_1v_1)$. Therefore, by substitution we have $w(e_1)w(p_2v_2) \leq w(e_1p_1v_1)$, which follows from (3).

How does V^{PHI} in (9) compare to V^{FVI} in (8)? The main point is that (9) dominates (8) provided that the switch from the prospect in (8) to the prospect in (9) is *mean-preserving*, which means that G is chosen such that

$$\begin{gathered} G = \left(\frac{\alpha_1}{\alpha}\right) G_1 + \left(\frac{\alpha_2}{\alpha}\right) G_2; \\ \alpha = w(\pi_1 + \pi_2 + \pi_3) - w(\pi_3) = \alpha_1 + \alpha_2; \\ \alpha_1 = w(\pi_1 + \pi_2 + \pi_3) - w(\pi_2 + \pi_3); \\ \alpha_2 = w(\pi_2 + \pi_3) - w(\pi_3). \end{gathered} \tag{10}$$

Using (10), the comparison of V^{PHI} and V^{FVI} shows that $V^{PHI} \geq V^{FVI}$ because

$$U\left(\frac{\alpha_1}{\alpha} G_1 + \frac{\alpha_2}{\alpha} G_2\right) \geq \left(\frac{\alpha_1}{\alpha}\right) U(G_1) + \left(\frac{\alpha_2}{\alpha}\right) U(G_2). \tag{11}$$

This result follows from the risk aversion property that the utility of the expected value of a prospect is greater than its expected utility.

Thus, a vertically and partially horizontally integrated prospect dominates the prospect that is only vertically integrated.

Full horizontal integration

Finally, all vertically integrated parties (π_1, π_2, π_3) may become horizontally integrated, and present the unified view of the random policy response rule. The value of the horizontally and vertically integrated prospect is

$$V^{VH} = w(\pi_1 + \pi_2 + \pi_3) U(\hat{G}), \tag{12}$$

where $\hat{G}$ is the mean-preserving value during the switch from the prospect in (9) to the prospect in (12). Therefore, $\hat{G}$ needs to be chosen as

$$\begin{gathered} \hat{G} = \left(\frac{\beta - \beta_1}{\beta}\right) G + \left(\frac{\beta_1}{\beta}\right) G_3; \\ \beta = w(\pi_1 + \pi_2 + \pi_3) > \beta_1 = w(\pi_3). \end{gathered} \tag{13}$$

Substituting $\hat{G}$, β and β_1 into (9) and (12), we can show that $V^{VH} > V^{PHI}$ because

$$U(\hat{G}) > \left(\frac{\beta-\beta_1}{\beta}\right)U(G) + \left(\frac{\beta_1}{\beta}\right)U(G_3). \qquad (14)$$

This result also follows from the risk aversion property that leads to the result in (11). Therefore, the vertically and fully horizontally integrated prospect dominates the vertically and partially horizontally integrated prospect. The interpretation is that the vertically and horizontally integrated prospect represents the institutionally strongest environment because it is the least uncertain. In the present model, with vertical and horizontal integration, uncertainty is reduced to simple risk.

F. Variability

The foregoing analysis implies that, as the compound prospect is simplified according to CPT, the end result is comparing prospects that are subjectively evaluated as $\{\rho_0, 0; \rho_1, G_1; \ldots; \rho_n G_n\}$ where ρ_i is the subjectively derived probability associated with the payoff, G_i. In order to make the simplest case for why variability (as measured by the variance) with more uncertainty is higher than it is with less uncertainty, let us assume that $G_i = G$. Then, prospects of varying uncertainty can be expressed as $\{\rho_0, 0; \rho, G\}$. The foregoing analysis indicates that the less uncertain (the more integrated) a prospect is, the higher the value of ρ, and, conversely. The expected value and variance of the prospect $\{\rho_0, 0; \rho, G\}$ are, respectively:

$$\mu = \rho G; \sigma^2 = \rho_0(\rho G)^2 + \rho(G - \rho G)^2. \qquad (15)$$

The simplest evaluation of variability is through considering a compound prospect that involves two events; when the first event occurs, the probability of moving to the second event is p_1 (with 1-p_1, the prospect is terminated); when the second event occurs, the probability of winning G^A is p_2 (with 1-p_2, the payoff is zero). Along the same lines as above, we can show that the CPT valuation of this prospect is $V^A = w(p_1)w(p_2)U(G^A)$. We compare this compound prospect to a simple prospect (single event) that pays G^U with probability p_1p_2; the value of the reduced prospect is $V^U = w(p_1p_2)U(G^U)$. Along the lines of (1), we can easily show that, for prospect A, $\rho_0 = 1\text{-}w(p_1)w(p_2)$, and, for prospect U, $\rho_0 = 1\text{-}w(p_1p_2)$.

The foregoing analysis indicates that, if $G^A = G^U$, then $V^A < V^U$, therefore, for $V^A = V^U$, the value of G^A must be[22]

[22] In (16), $G^A > G^U$ because, with $\theta > 1$, the inequality implies $\theta U(G^U) > U(G^U)$. Since a lower subjective probability applies to G^A than to G^U, with risk aversion, G^A needs to be greater than G^U in order to yield the same level of expected utility.

$$G^A = U^{-}[\theta U(G^U)] > G^U;$$
$$\theta = \frac{w(p_1 p_2)}{w(p_1)w(p_2)} > 1. \qquad (16)$$

Substituting G^A in (16) into (15) and letting $G^U = G$, we can find the means and variances of the two prospects as

$$\mu^A = w(p_1)w(p_2)U^{-}[\theta U(G)];$$
$$\sigma_A^2 = [1 - w(p_1)w(p_1)]w(p_1)w(p_2)\left(U^{-}[\theta U(G)]\right)^2; \qquad (17)$$
$$\mu^U = w(p_1 p_2)G;$$
$$\sigma_U^2 = [1 - w(p_1 p_2)]w(p_1 p_2)G^2.$$

By (16) and (17), with $\theta > 1$, we have $\mu^A > \mu^U$ because $U^{-}[\theta U(G)] > \theta G$.[23] For the same probabilities, p_1 and p_2, the compound prospect needs to pay a higher return for $V^A = V^U$. Similarly, comparing the variances in (17) we can further show that $\sigma^2_A > \sigma^2_U$.[24] This is a familiar result: for a higher expected value, the risk-averse decision maker is willing to accept greater variance.

As Rothschild and Stiglitz (1970, 1971) emphasize, risk aversion is *not* sufficient for this familiar result to hold under EUT; in addition to risk aversion, if the utility function is also quadratic, then the comparison of prospects based on the mean-variance approach is valid under EUT. Notice, however, that here we have reached this familiar result with only the risk aversion assumption, without relying on the additional assumption that the utility function is quadratic; in this sense, the familiar result is *more generic* in this model than it is under EUT.[25] Since the focus here is not the second-order properties of the utility function in

[23] Applying $U(.)$ on $U^{-}[\theta U(G)] > \theta G$, we have $\theta U(G) > U(\theta G)$. If $G = 0$, the two means are equal to zero; as G is increased, the increase in $\theta U(G)$ is always greater than the increase in $U(\theta G)$ because risk-aversion ($U'' < 0$) implies $\theta U'(G) > U'(\theta G)$ for all $\theta > 1$ and $G > 0$. Notice that, if θ were *less than unity*, the inequality $\theta U(G) > U(\theta G)$ would be reversed because, with risk aversion, expected utility is less than the utility of expected value. However, we have $\theta > 1$, therefore, the inequality holds and, hence, $\mu^A > \mu^U$.

[24] $\sigma^2_A > \sigma^2_U$ requires that $U^{-}[\theta U(G)] > \gamma\theta G$, $\gamma = [(1-w(p1p2)/(1-w(p1)w(p2)] < 1$. Applying $U(.)$ on the foregoing inequality, we have $\theta U(G) > U(\gamma\theta G)$, which holds because $\gamma < 1$ and we have already shown that $\theta U(G) > U(\theta G)$; hence $\sigma^2_A > \sigma^2_U$.

[25] We can show that the basic result that follows from (17) holds with risk neutrality also, that is, if $\mu^A = \mu^U$, then $\sigma^2_A > \sigma^2_U$.

particular, for simplicity, we may further assume that the utility function is quadratic. The main focus here is the question why an investor, comparing the risky and uncertain prospects, requires a higher return, and, why this inherently results in higher variability for the uncertain prospect. Since the probability valuation is subjective, the valuation of the means and variances is also subjective. The results imply that the decision maker is viewing the uncertain prospect as *inherently riskier* than the risky prospect. Faced with two prospects, one involving two events (uncertain) and one involving a single event (risky) with the same probability structure, the decision maker requires a higher return on the uncertain prospect and he subjectively views the uncertain prospect as riskier. For example, the uncertain prospect might characterize an investment in an institutionally weaker country and the risky prospect might characterize an investment in an institutionally stronger country. The investor, by requiring a higher return in the weaker country, is also subjectively evaluating the return in the weaker country as more variable.

The empirically relevant question that follows is, how would such decision making by investors manifest itself in the *observed* relative volatility of returns in the stronger and weaker country?

In the absence of a formal model of investment, an answer can be given along the lines of the following reasoning. Investors will exploit gains from international capital movements; they will exit the low-expected-return country in favor of the high-expected-return country. With a sufficient degree of openness, returns to investment in the two countries will co-vary. Suppose shocks occur on the value of G in a random fashion and we observe the different values of G over t periods as $G_t = G + u_t$, where u_t is the random shock.[26] Then, if the shock on G is negative in a given period ($G_t < G$) in the strong country, investors are willing to accept a lower return in the weak country; and conversely, if the shock on G is positive ($G_t > G$). In this model, the expected return in the weaker country is higher than the expected return in the stronger country and the returns co-vary in the two countries *vis*. the shocks on G. But the expected return in the weaker country is more variable than the return in the stronger country because the investors inherently require a greater adjustment in the expected rate of return in the weaker country than in the stronger country. Investors value claims on profits on the basis of expected returns. For example, if G declines in the strong country, the

[26] The distribution of the shocks G could be further modeled and incorporated into the model (e.g., as in Figure 1). This would not change the results that follow from (16) and (17). In present context, assuming that G is subject to random shocks is the equivalent of the common assumption that residual errors are identically independently distributed with a zero mean and a given finite variance. Presumably, this assumption reflects the extent of the decision maker's ability to deconstruct uncertainty. So, the random process in the institutionally strong country can be described as $G^U{}_t = G + u_t$, where u_t can be interpreted as natural uncertainty specific to the institutionally strong country, which the decision maker cannot deconstruct further. For simplicity, let us assume that u_t is the only source of natural uncertainty for both countries, that is, the institutionally weaker country faces no country-specific natural uncertainty. Then, by (16), $G^A{}_t = U^{-}[\theta U(G^U{}_t)]$, which captures both natural and human-made uncertainty in the institutionally weak country.

investors are willing to accept a lower return in the weak country; they move their capital to the weak country and the value of claims on profits declines in the weak country also; but the decline in the value of claims in the weak country is larger than the decline in the value in the strong country.[27] Therefore, the observer would observe *t* data points (returns), which would show a higher mean but more variable return in the weaker country than in the stronger country. Thus, institutional weakness may explain the empirically supported observation that economic variables in weaker countries tend to be more volatile.

The foregoing results indicate that it is not sufficient to argue that investment is simply riskier (returns are more variable) in less developed countries. This argument is typically made according to the mean-variance analysis on the basis of observed data. But we also need to explain why investment is perceived to be inherently riskier in less developed countries. The present analysis puts such perceptions in an analytical context determined by the investors' subjective perceptions (evaluations) of prospects in institutionally weaker and stronger countries. Furthermore, the present analysis indicates that such subjective perceptions can inherently result in higher variability in institutionally weaker countries. After all, variability in markets is primarily the result of human actors' comparative subjective decisions (reactions) to natural and human-made uncertainties in a given institutional setting.

G. Implications for Investor Choice

The main implication of the model is that, faced with the same payoffs and probabilities by assumption, an investor expects to earn a higher profit, if he invests in an institutionally stronger country than in an institutionally weaker country. Alternatively, for the same probability structure, the investor requires a higher payoff to invest in the institutionally weaker country (or, the investor requires better odds for winning for the same payoff). The dynamic implication of the model is that less uncertainty extends the time horizon of investment, a point emphasized by Knight also. With less institutional strength, uncertainty over time is greater, therefore, potentially very productive investment prospects to which returns will be realized in the future might not be undertaken.

The relative institutional strength of more developed countries serves as an important benchmark for investors and provides a context for a comparative evaluation of investment prospects in less developed countries. More capital investment flows to institutionally stronger, transparent countries, interest rates are lower, growth is higher, and so on. Indeed, institutions might rule in cross-country growth (development) comparisons because better institutions imply a less ambiguous investment environment according to the present analysis (Rodrik, Subramanian, and Trebbi, 2002). The present analysis also shows that it is not sufficient to argue that investment is simply riskier in less developed countries. We need to

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[27] In (17), by comparing the two means, we have $U^{-}(\theta U(G)) > \theta G$. Notice that the term θG is a linear function of G, when G changes by one unit, it rises by θ. But risk aversion implies that the term $U^{-}(\theta U(G))$ is an increasing function of G, which is steeper than θG, for all $\theta > 1$, $G > 0$. Therefore, $d\mu^{A}/dG > d\mu^{U}/dG$.

explain why investment is (subjectively) perceived by investors as inherently riskier in less developed countries, as long as we cannot argue that risk assessment by investors is exhaustive to the extent that decision makers somehow sort out all available information and figure out future contingencies, building them into their investment decisions. In reality, such an exhaustive risk assessment is not possible. A degree of Knightian uncertainty remains. However, stronger institutions serve to reduce Knightian uncertainty and make risks more easily predictable.

Arguably, in less developed countries with a lower capital stock, investment is more productive than in more developed countries with a greater capital stock because of diminishing returns. The neoclassical logic is that investment seeks the highest returns in the world markets and, in the long run, less developed countries should attract more capital than more developed countries and, therefore, grow more and catch up. However, this "catch-up" hypothesis has been invalidated in many instances. The present analysis indicates that in most cases, catch-up did not happen because of the persistence of institutional weaknesses in less developed countries.[28]

IV. CONCLUSIONS

This paper has argued that vertical and horizontal integration increases institutional strength because integration reduces the number of events leading to the same outcome, given the same probability structure. The reduction in the number of events indicates a smaller range of possible policy reactions to unforeseen events and a greater consensus on policy reactions. The process through which such consensus emerges amounts to institution building, and greater consensus implies stronger institutions. Consensus achieved through integration of policy decisions reduces uncertainty and increases transparency. Under the CPT model, the reduction of compound lotteries axiom does not hold. Therefore, different levels of integration produce different expected values for the same payoffs and probabilities. This argument relates to Ellsberg's critique: decision makers prefer risk to uncertainty. Lower uncertainty results in higher expected profit. Thus, reflecting institutional weakness, uncertainty can help explain why investors prefer institutionally stronger, more developed countries to institutionally weaker, less developed countries. Institutional strength expands the time horizon of investment decisions. This explanation amounts to more than the standard risk analysis because it also reflects the implications of human actors' subjective evaluations of risk on risk. Furthermore, the analysis explains why human actors' profitability comparisons between institutionally strong and weak countries might make the observed economic aggregates in weaker countries inherently more variable. This sheds light on the greater economic (and perhaps social and political) volatility observed in institutionally weaker countries. The model also unifies Uzi Segal's approach to modeling uncertainty and

[28] The reasons for the persistence of institutional weaknesses are beyond the scope of this study. However, the CPT approach and Knightian uncertainty might have a bearing on this persistence. CPT argues that losses are valued more than gains by investors, which might result in *status quo bias*, and this bias might be stronger in uncertainty.

the conditions that apply to the CPT subjective probability weighting function (the lower subadditivity condition and the compound event-splitting effect).

The results of the model find empirical support in the work by Rodrik, Subramanian, and Trebbi (2002), who argue that institutions' influence on growth and development has been more significant than geography and trade. More germane to the focus of this paper, Gelos and Wei (2002) find that transparency (as measured by certain indexes) has a significant impact on international portfolio investment, with less transparent countries attracting less investment. Similarly, Glennerster and Shin (2003) present evidence that adoption of some transparency reforms has resulted in a decline in sovereign spreads in some countries.

Further interesting approaches that support the connection among uncertainty, transparency, and institutional strength studied in this paper come from the insurance literature. Of course, insurance market development is a fundamental part of financial sector development in general. The size and depth of insurance markets and insurance coverage might be indicative of (that is, inversely related to) the level of uncertainty an investor might face in a given country. Outreville (1990) presents evidence on the relationship among insurance market development, financial sector development, and growth. Similarly, Ward and Zurbruegg (2000) present evidence that, in some OECD countries, insurance market development has resulted in economic growth.

For simplicity and better focus, this model has relied solely on the subjective evaluation by human actors of a given probability and payoff structure, juxtaposed in more or less ambiguous institutional settings. The model has not addressed other economic incentives (mainly emanating from transactions costs) that may motivate vertical and horizontal integration. Although there is a wide body of literature on those issues, including game-theoretic models, those models have been criticized because they do not adequately incorporate subjective evaluations by human actors with bounded rationality.[29] Kreps (1999) provides an excellent critique of such approaches, which centers on their heavy (often unrealistic) informational requirements on future contingencies.[30] Incorporating explicit

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[29] A seminal contribution on vertical and horizontal integration is Grossman and Hart (1986). Similar motivations for integration have also been discussed by Arrow (1975) and Tirole (1986).

[30] "*Returning to the real world where future contingencies are vague at best, we are unable to specify explicitly what will be the path of play. Hence, we are in a world where the parties must anticipate not only what will happen over time, as (unforeseeable!) contingencies arise, but they must do this foreseeing in a situation where a continua of specifications can give an equilibrium arrangement. Equilibrium analysis presumes, rather incredibly, that (i) they all do all this foreseeing and (ii) their prediction(s) coincide and turn out to be factually correct.*" (Kreps, 1999, p. 135, emphasis in the original).

transactions costs into this model might present interesting avenues for future research, especially in formulating and implementing more credible and effective economic policies.[31]

[31] For example, the present analysis implies that consensual policy rules (e.g., inflation targeting) are less ambiguous, hence they may be more effective policy tools than discretionary policies. For a transactions costs approach to (imperfect) economic policy making, see Dixit (1996).

TECHNICAL APPENDIX

PROOF OF THE THEOREM IN EQUATION (3)

Theorem

If the subjective probability weighting function of the decision maker obeys the subadditivity conditions, then $w(p_1)\cdot w(p_2)\cdots w(p_n) < w(p_1\cdot p_2\cdots p_n)$ *for all* $p_1\cdot p_2\cdots p_n \neq 0,1.$

Proof

First evaluate the simple case of $w(p_1)w(p_2) < w(p_1p_2)$; $p_1p_2 \neq 0, 1$. Let $p_1p_2 = q$; the Taylor series expansion of $w(p_1)$ and $w(p_2)$ around q yields:

$$w(p_1) = w(q) + p_1(1-p_2)\left(\left.\frac{dw(p_1)}{dp_1}\right|_q\right) + \omega_1;$$

$$w(p_2) = w(q) + p_2(1-p_1)\left(\left.\frac{dw(p_2)}{dp_2}\right|_q\right) + \omega_2; \qquad (178)$$

where ω_1 and ω_2 are the residuals. Notice that $\left.\frac{dw(p_1)}{dp_1}\right|_q = \left.\frac{dw(p_2)}{dp_2}\right|_q = \psi > 0.$ After dropping the residuals and making use of ψ, take the product of $w(p_1)$ and $w(p_2)$ to obtain

$$w(p_1)w(p_2) \approx (w(q))^2 + \phi;$$

$$\phi = \psi w(q)[p_1(1-p_2) + p_2(1-p_1)] + p_1p_2(1-p_1)(1-p_2)\psi^2. \qquad (19)$$

Subtracting the term in (19) from $w(p_1p_2) = w(q)$ yields

$$w(p_1p_2) - w(p_1)w(p_2) \approx w(q) - (w(q))^2 - \phi, \qquad (180)$$

which implies that $w(p_1p_2)-w(p_1)w(p_2) > 0$ if $w(q)(1-w(q)) - \phi > 0$. But $w(q)(1-w(q))$ is positive for all $q = p_1p_2$, $p_1p_2 \neq 0, 1$ and the value of ϕ is small.
Therefore, $w(p_1p_2) - w(p_1)w(p_2) > 0$.

The foregoing proof can be generalized to n probabilities $p_1, p_2, ..., p_n$. Let $p_1p_2...p_n = q$ so that $w(q) = w(p_1p_2...p_n)$. Expanding $w(p_1), w(p_2), ..., w(p_n)$ around q yields

$$
\begin{aligned}
w(p_1) &= w(q) + p_1(1 - p_2 p_3 \cdots p_n)\psi + \omega_1; \\
w(p_2) &= w(q) + p_2(1 - p_1 p_3 \cdots p_n)\psi + \omega_2; \\
&. \\
&. \\
w(p_n) &= w(q) + p_n(1 - p_1 p_2 \cdots p_{n-1})\psi + \omega_n;
\end{aligned}
\tag{21}
$$

where

$$
\left.\frac{dw(p_1)}{dp_1}\right|_q = \left.\frac{dw(p_2)}{dp_2}\right|_q = ... = \left.\frac{dw(p_n)}{dp_n}\right|_q = \psi.
$$

Taking the product of $w(p_1), w(p_2), ..., w(p_n)$ after dropping the residuals, ω_i , we find

$$
w(p_1)w(p_2)\cdots w(p_n) \approx (w(q))^n + \phi', \tag{22}
$$

where ϕ' is a cross-multiplication term similar to ϕ in (20). The term in (22) implies that, for $w(p_1p_2 ... p_n) - w(p_1)w(p_2)...w(p_n) > 0$, it is necessary that $w(q)(1-(w(q))^{n-1}) - \phi' > 0$, where the first term is positive for all $q \neq 0, 1$ and the value of ϕ' is small. Therefore, $w(p_1p_2 ... p_n) - w(p_1)w(p_2)...w(p_n) > 0$.

The foregoing proof can be interpreted as follows. First notice that, with two probabilities, $q = p_1p_2 < p_1 \leq p_2$ implies that $w(q) < w(p_1) \leq w(p_2)$. The subadditivity property of the CPT probability weighting function indicates that the smaller probability, q, has a greater impact on probability weighting due to *diminishing sensitivity* of the probability weighting function. This is because q turns impossibility to possibility but the greater probabilities, $p_1 = q + z_1$ and $p_2 = q + z_2$ make an event more possible, therefore, they have a smaller impact on probability weighting.

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