Using Neuroscience to Understand Risk: Determining the Impact of Culturally Biased Risk Perceptions on Labor Mobility

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Introduction

Labor mobility is a topic of critical importance to any labor market, but especially to those of rapidly developing nations. As nations industrialize, the difference between returns to urban labor and rural labor greatly increases, which incentivizes rural workers to migrate to urban centers where they will tend to face better employment opportunities. When rural-urban labor migration is unplanned or unexpected, urban areas experience increased rates of unemployment and underemployment[◦], as the formal labor market struggles to accommodate the influx of migrant labor[5,18,19]. It is particularly important for policymakers to understand the incentives driving the influx of rural workers to urban areas so that they can adapt policies to increase the welfare of workers during this tumultuous time. A significant influence on the decision to migrate is the subjective risk perspective of rural inhabitants. Rural inhabitants with a greater appetite for risk will migrate more readily to urban areas, than a comparable individual who is averse to risk[3]. In the minds of those who are risk averse, the large degree of uncertainty (conveyed by the high urban unemployment rate) associated with rural-urban migration tends to overshadow the expected higher payoff (increased earnings) of relocation[4,5]. The Culture Theory of Risk Perception (Culture Theory) developed by Mary Douglas provides a methodological framework by which one can analyze the effect of social structures on how individuals determine what risks they believe are worth taking. Culture

◦ Underemployment differs from unemployment, because it refers to how well the employed labor force is being utilized in terms of skills, experience, and availability to work. Underemployment refers to those who are highly skilled and working in low paying or low skill jobs, or those who are part-time workers but would prefer full-time employment.

Theory asserts that, "factors inherent to one's culture, distinct from socio-demographic characteristics, will significantly shape one's perception of risks[6]". Further work has gone on to posit that cultural risk discrepancies arise from individual biases and heuristics that are shaped by personal preferences, framed by cultural outlook. While Culture Theory provides a thought-provoking argument to explain a sizable portion of global risk discrepancies, its validity has often been challenged on the grounds of its lack of transparency, as its complexity and ambiguity have led some to discredit it[1]. Additionally much of the empirical data supporting Culture Theory is based on survey data, which critics have claimed is an unreliable measure of individual attitudes, because the questionnaire surveys used lack the contextual background to tap into the relevant dimensions of social relations[2]. The criticisms of Culture Theory could largely be avoided if one employs current neuroscience techniques to properly correlate the findings of survey data with specific brain processes associated with developing cultural values and beliefs[7]. The ability of neuroscience to elucidate the complex physiological mechanisms underlying the assertions of Culture Theory make it an ideal candidate to legitimize the findings of Culture Theory, as well as to provide an avenue for future improvements in the quantification of individual risk preferences. As rapidly industrializing nations seek to reduce unemployment and meet a growing demand for urban labor, the insights of Culture Theory, coupled with neuroscientific techniques, can provide future policymakers with actionable data to better predict and plan for regional labor migration.

Section 1: Labor Migration in Developing Nations

A man willing to work, and unable to find work, is perhaps the saddest sight that fortune's inequality exhibits under this sun.
- Thomas Carlyle

Labor Migration in Developing Nations – The Situation

Historically, developing economies throughout the world have experienced an increasing rate of rural-urban labor migration[23]. Individuals choose to migrate to urban centers when they perceive there to be a net gain in their employment situation based upon the criteria of wage, unemployment level, and transportation costs[5]. These forces dominate the migration decisions of rural inhabitants even in undeveloped and uneducated populations[22,23,26]. The inherent subjectivity of the migrants' decisions results in a disequilibrium in the labor market, because employers do not account for the perceptual biases of job seekers when they set wages, and so the wage rate will convey a different economic signal to the supply and demand of labor. The disequilibrium occurs due to rural-urban labor migration in the presence of high urban unemployment. Conventional economic theory, which predicts that full employment equilibrium will be reached through market wage and price adjustments, cannot adequately explain the rising rates of unemployment in the urban centers of economically developing regions. The lack of a conventional model primarily stems from the seemingly irrational behavior of rural migrants who will often favor moving to an urban area that is experiencing high levels unemployment, over continuing to receive positive returns for agricultural labor. This puzzling circumstance can be interpreted in light of the Harris-Todaro Model,

which establishes that rural-urban labor migration can occur in the presence of high urban unemployment as long as the wage differential between regions is sufficiently high[23]. The Harris-Todaro Model states that the decision to migrate is determined based on a comparison between the expected earnings in the urban sector and the agricultural product, therefore treating migrants as maximizers of expected utility. This case is especially relevant for developing nations, where the income of urban regions grows at a significantly higher rate than the outlying areas[22,23,25]. High levels of migration increase the labor supply so substantially that it overwhelms the urban labor market resulting in detrimental levels of unemployment and underemployment. In light of these circumstances, rapidly industrializing nations need to better plan for the migration of rural workers to the developing urban labor markets. In light of the Harris-Todaro Model, government officials have been directed towards more relevant policies to combat urban unemployment, but to achieve optimal results one must know the key determinants that shape an individual's perception of expected utility, so that they can be properly incentivized. While the Harris-Todaro Model provides insight into the general workings of the migration decision, for a proper and adequate policy response to labor migration, policymakers should know the underlying mechanisms that drive the rural migrants expected utility function.

Labor Migration in Developing Nations – The Problems

Issues arising from rural-urban labor migration have long plagued many industrializing nations. High levels of urban unemployment and underemployment

are symptoms of many industrializing nations such as China, Brazil and India[18,19,25], and are the result of individuals' distorted perceptions of rural-urban income differentials[26,19]. In China there are many well-documented problems resulting in societal harm that have arisen from the employment situation in its urban centers. China is currently experiencing a huge floating population of rural-urban migrants due to its rapidly developing economy[25], which is an indicator of both social and labor distress, as it has been shown to result in increased unemployment, overcrowding, criminal activity, and pressure on social safety nets[25]. The volume of Chinese internal migration has expanded steadily since the 1980s[25], and according to recent estimates the size of the floating population exceeds 13 million in the Guangdong Proving (near Hong Kong) and over 4 million in the city of Shanghai[22]. These migrants are often treated as second-class citizens as, government officials in China are far more concerned with finding jobs for the urban residents who are unemployed over migrants seeking work[22]. In China rural migrants also face the issues of a lack of access to education, health services and social security[25]. As rural-urban labor migration continues, competition for formal labor market opportunities becomes incredibly fierce and many migrant workers are driven into unregulated, informal labor markets. The widespread presence of informal labor markets indicates a state of underemployment. A study conducted in India in the late 1970s concluded that underemployment is a more serious problem than typical unemployment and that over 20% of the rural migrant population experiences underemployment[18]. In May 2010 there was streak of migrant worker suicides at the infamous Foxconn factory in China due to stresses related to insufficient wages

resulting in 12 deaths over a 5-month period[25]. As China continues to privatize once state owned enterprises, many urban residents will be laid off which will intensify labor market competition and ultimately leave the floating population with fewer formal employment opportunities[22], which will only exacerbate the many problems caused by unsatisfactory labor opportunities. On a larger scale, research has shown that underemployment is strongly correlated to an increased incidence of depression[32], and an increased rate of juvenile and young adult arrests in the region where it occurs[31]. These many social issues occur in addition to the more obvious negative economic implications of a high unemployment rate. Unemployment and underemployment levels have a profound influence on the well-being of societies and must be addressed by officials with a great deal of concern and care.

Labor Migration in Developing Nations – The Present and Future of Policy

Current policies regarding labor migration are often ill suited to properly curb the decisions of rural laborers, as officials do not fully understand what motivates their determination of risks. Recent Chinese thought is that policymakers must encourage investment and resources to be directed to rural areas in order to decrease rural-urban migration[22]. Historically this approach has achieved puzzling results. In the early 1980s the Chinese implemented major agricultural reforms, which officials presumed would decrease rural-urban migration due to the increased return to agricultural labor. Counter-intuitively this policy resulted in an increased level of rural-urban labor migration. Although these reforms led to an increase in the average income of rural households, the dominating effect of the reform was to

decrease the marginal contribution of individuals to household income, which incentivized many to migrate to urban areas[5]. As the opportunity cost of leaving rural labor markets decreased, individuals became more willing to tolerate the risk associated with seeking employment in urban environments. Clearly there is a disconnect between the intentions of policymakers and the interpretations of individuals, and until there is a sufficient model of the mechanisms driving individual choice, the implementation of policies to combat labor mobility will be exceedingly difficult and unreliable. In general, economists have proposed a dual policy approach to improve welfare, which consists of both a wage-subsidy and a migration-restriction. Such a policy could help recalibrate both the level of urban employment and the distribution of labor between the rural and urban sectors. The subsidy will boost employment, and the migration restriction will disable the increased wages from inducing labor migration that leads to unemployment[23]. In subsequent research it has been found that the aforementioned welfare goals can be met without migration restrictions via alternative taxes or subsidies[21]. While these policies are attractive in the simplicity of their solution and its implementation, they are far from ideal as they result in great inequity. In order to achieve their goals, these policies limit the freedoms and economic opportunities of rural laborers in order to counteract their distorted perceptions of the gains associated with migration. These policies disincentivize labor migration by punishing individuals who choose to migrate. Ideally the level of punishment will be determined so that only those who should rationally migrate have an incentive to do so. This approach unfairly worsens the economic circumstances of all those who should rationally

migrate, as they must bear the burden of the punishment that exists because of the irrational behavior of others. For optimal policy, officials must understand that psychological framing effects can result in a reinterpretation of policies, which distorts their true value based on individual attitudes or perceptions. Framing effects can lead individuals to misinterpret the risks associated with a particular policy, resulting in a seemingly irrational migration choice from the viewpoint of policymakers. Individuals tend to be risk seeking when facing gains and risk averse when facing losses[20], which in this specific case indicates that labor migrants tend to be overly optimistic about the chances of getting a higher paying job in the city in spite of high urban unemployment statistics. Although they prove difficult to accurately model, framing effects must be addressed due to their profound implication on policy outcomes[8]. Policymakers must be aware of the scope of effects that their decisions have on labor mobility, in order to appropriately plan for the subsequent redistribution of labor. Even with appropriate policies in mind the efficiencies of those policies are largely dependent on how they are calibrated to the perceptions of migrants. Developing nations must find better mechanisms to anticipate labor migrations before they are able to make satisfactory policy decisions, which both minimize the social distress of the unemployed and underemployed workers, as well as capitalize on the economic gains to be had from the massive influx of low wage labor to the booming urban environments.

Section 2: Cultural Influences on Risk Perception

What you see and hear depends a good deal on where you are standing; it also depends on what sort of person you are.
- C.S. Lewis, *The Magician's Nephew*

Cultural Influences on Risk Perception – Background

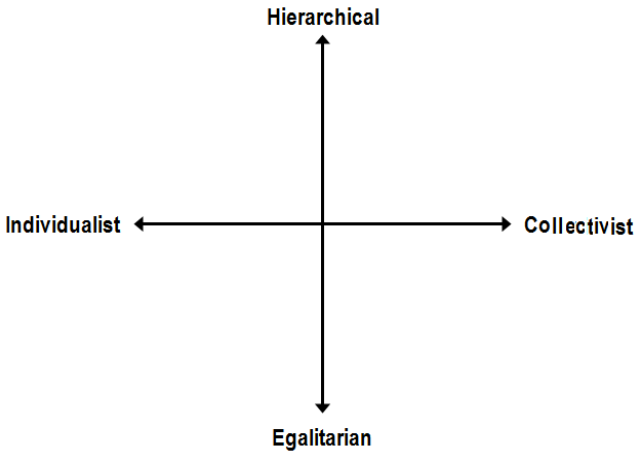
While the individuals that make up a migrant population of a nation are diverse in many ways, they do necessarily share one common trait, culture. Traditional risk theory would ignore this fact, because it is grounded in the belief that risk perceptions are driven by a simple cost benefit analysis[47]. Traditional risk theory is often insufficient in explaining real world behavior, which has led many to look to more complex models of human choice to interpret behavior. The Culture Theory of Risk Perception proposes a model to explain how one's culture can shape the way one interprets risk. It states that culture, defined as the institutions surrounding a society, is a lens through which risks are interpreted and thus culture is a salient factor in an individual's choice behavior under uncertainty. Culture theory asserts that individuals within a society adopt a perception of risk that serves to reinforce their society's institutional framework against alternative structures[52]. Global risk discrepancies will therefore arise due to cultural disparity among nations. Culture Theory categorizes societies along the axes of group (the extent to which individual choice is subject to group determination) and grid (the degree to which an individual's life is circumscribed by externally imposed controls), which when weighted with multiple variables dependent on individual perceptions, produce a quantitative model that can evaluate decision making under uncertain circumstances. The group-grid typology places societies into one of four general

types, which are defined in Table 1 and depicted graphical in Figure 1[6].

Table 1. *Grid-group labels*

Source	Definition by 'grid' and 'group' axes: Low grid, low group	High grid, low group	High grid, high group	Low grid, high group
Douglas (1982)	Individualism	Atomised subordination	Ascribed hierarchy	Factionalism
Douglas (1992)	Markets	Isolates	Hierarchies	Sects
Rayner (1992)	Competitive individualists/ markets	Stratified individuals	Complex groups/ hierarchies	Egalitarian groups/ collectives
Jordan & O'Riordan (1997)	Individualists	Fatalists	Hierarchists	Egalitarians
Coyle (1994)	Libertarianism	Despotism	Hierarchy	Egalitarianism
Ellis & Thompson (1997)	Individualism	Fatalism	Hierarchy	Egalitarianism

Figure 1. Group-Grid Axis



There is a bounded distinction between types among societies, which is due to the fact that individuals tend to associate societal harms with conduct that transgresses societal norms. Such a tendency promotes specific social structure by stigmatizing

and punishing subversive behavior[11]. Therefore according to Culture Theory, riskiness is a relative term evaluated in the context of specific societal practices that frame individual decision-making[48]. Culture Theory's unique methodology allows for analysis of the impact of cultural identity on individual risk perception. Empirical research has established that Culture Theory is capable of measuring worldviews at the societal level, as well as correlating cultural risk biases with specific types of risk, which demonstrates that cultures have unique risk appetites[12]. While the findings of Culture Theoretical research have come to fascinating conclusions about the role of culture in risk perception, it also has generated many questions and criticisms. Work in the field of Culture Theory has shown that culture engenders risk bias, but it has little to say about the mechanisms through which individuals develop such biases. For an explanation of how cultural risk biases arise one must turn to a complimentary theory of risk. The Psychometric Theory views risk perceptions as a result of the internal distortion of rational decision-making by heuristics and biases that are intrinsic to an individual's cognitive processing[49]. In the psychometric framework, individuals do not fully explore the information concerning decision alternatives and thus revert to what they remember as opposed to all available information[50]. Research in psychometrics has proven that risk perception is highly dependent on intuition, experiential thinking, and emotions, but psychometric researchers have made no attempt to analyze their findings beyond the level of individual characteristics, and consequently ignore the role of social organization in influencing risk perception. Mary Douglas, the mother of Culture Theory, has criticized the Psychometric Paradigm for depoliticizing risk, yet the

psychometric paradigm can be understood as the mechanisms which underlie risk attitudes reflecting individual commitments to competing cultural structures thus reinforcing Culture Theory on a deeper and more significant level. Mary Douglas has emphasized that, "if we were invited to make a coalition between group-grid theory and psychometrics, it would be like going to heaven.[130]" The application of PT to CT can be seen as "a strategy for exploiting the full richness of Douglas and Wildavsky's thoughts on risk perception"[52]. More recent thinking has led to a new understanding dubbed the Cultural Cognition of Risk, which asserts that the dynamics of the Psychometric Theory are the mechanisms that underlie Culture Theory's findings[10]. To develop a complete understanding of cultural risk we must turn to a methodology, which can reliably and effectively interpret the mechanisms of individual cognitive heuristics and biases so they can be applied to a group-grid typology.

Cultural Influences on Risk Perception – Evidence

There is a large body of empirical evidence that supports the use of a group-grid typology to analyze risk preferences. In France, a large study found that personal risk is significantly correlated with at least one cultural bias for 18 of 20 risk issues tested. This study went on to confirm that cultural bias provides added explanatory power compared to standard socio-demographic variables[13]. Further research has gone on to show that risks associated with nanotechnology development are linked to one's cultural outlook. Those individuals with hierarchical and individualistic worldviews perceived the technology as significantly more beneficial than those

with egalitarian and community oriented worldviews[36], showing clear preference among distinct groups within the group-grid typology. There is also evidence that has shown that culture biases choices that classical economics would deem irrational. Through the 19th century in southern Illinois, towns inhabited by German-Catholic settlers substantially differed in terms of land ownership, farming practices, and choice of crops, from towns inhabited by descendants of Yankee settlers, despite similar environmental conditions. The Yankees treated farming as a business and thus were more profitable, while the German-Catholics viewed the farm as a family institution and consequently were reluctant to sell their land and tended to grow more labor intensive crops so that they could employ their children[44]. Even in the presence of consistently lower returns, the German-Catholic settlers did not change their behavior, because they interpreted the risks associated with economic gain differently. In light of the German-Catholics' collectivist views, their decisions to maintain their land and employ their children can be seen as rational, because they enhance the economic prosperity of the collective (in this case the family). Additional research into the distinction between collectivists and individualists found that there was a significant difference in the way that American and Chinese individuals perceived and responded to risks, which was dependent on their cultural location on the individualism-collectivism spectrum[41]. While the Americans were oriented towards individualistic decision-making, the choices of the Chinese were consistent with a collectivist world-view. Choice behavior in culturally diverse populations have been studied extensively by Heinrich et al., who used an

ultimatum game bargaining model† to illustrate the economic decisions of different cultures. In an initial study a significant difference was found between the choices that Americans and Peruvians made, dependent on risk[43]. In a more comprehensive study, Henrich et al. found significant differences in the level of offer between Americans, Indonesians, Israelis, and two distinct cultural populations of Peru, the Machiguenga and the Mapuche (mean offers of 48%, 50%, 36%, 34% and 26% respectively). In confirmation of the cultural impact on results, it was proven that individual differences in economic and demographic variables accounted for little of the variance among cultural groups[46]. Heinrich's data was supported by ethnographic and cultural data that confirmed a link between differences in cultural practices and their respective risk preference differentials. A recent study in 2012 using a Culture Theoretical framework from Yale Law School, which consisted of an 1800 person global survey, found that "cultural worldviews better predicted perceptions of various risks than did any other individual characteric"[51].

Many researchers have already begun to show the utility of applying Culture Theory to existing economic anomalies. A once perplexing issue, the white-male effect* has recently found an explanation stemming from Culture Theory. Kahan et. al found that the primary source of racial and gender bias in risk perception arose from a

† The ultimatum game is a game in which two players interact to decide how to divide a sum of money that is given to them. The first player proposes how to divide the sum between the two players and the second player can either accept or reject this proposal. If the second player rejects, neither player receives anything. If the second play accepts, the money is split according to the proposal. The game is played only once so that reciprocation is not an issue.[46]

* The white-male effect is a well documented pattern of white men fearing various risks less than women and minorities.

state of motivated cognition that promoted the protection of the cultural identity of individuals, as the white male bias conformed with their adherence to hierarchical and individualistic worldviews which engender risk seeking behavior. The impact of culture on the results is profound as, "the cultural effects on risk perception were large relative to that of other individual characteristics that might be thought to bear on risk perception, such as religion or political party affiliation"[34]. Culture Theory has also been crucial to understanding international discrepancies in preference for foreign direct investment. These discrepancies have been previously unexplained by classical economics, but when cultural trust levels are incorporated into a choice model of foreign direct investment this previously puzzling situation is explained[33]. This finding is confirmed by the results of Camerer et al. which suggest that "people have simply adopted rules of behavior that they think apply to themselves and others, regardless of the situation"[45]. This statement implies that while the choices of individuals may appear irrational to classical economists, they are completely rational in the context of one's cultural beliefs. As a consequence of these findings, it is clear that economics can only stand to benefit from finding a reliable and accurate way to incorporate culture into their models of decision-making under risk.

Cultural Influences on Risk Perception – Criticisms

Economists are reluctant to include culture as determinant of economic outcomes because, "it is so broad and the channels through which it can enter economic discourse so ubiquitous and vague that it is difficult to design testable, refutable

hypotheses"[39]. Economists have a valid point that Culture Theory alone may not provide a complete picture of international risk discrepancies. Many have criticized that Culture Theory makes no claim of understanding the nature of individual free will[8]. Additional criticism of culture theory arises from the fact that its typology is static and therefore cannot illustrate the process of change[9]. While these criticisms raise valid and significant points, they do not discredit the fundamentals of Culture Theory, but rather they identify areas for improvement to better validate the findings of empirically modeled societal risk perceptions. In improving the methodologies of Culture Theory, one should seek out a framework that is transparent and reliable. Many critics have taken issue with Culture Theory's inherent opaqueness and frequent use of survey data[1], the latter of which has led some critics to argue that its results are often statistically significant, but not substantially significant[38]. The psychometric paradigm establishes the mechanisms by which group-grid typology influences individual risk perception[10], as it focuses on the roles of affect, emotion, and stigma in influencing risk perception. The results of Psychometric research are often criticized because analysis relies on mean scores rather than raw data, so explanatory power is easily achieved[38]. A coalition between the two ideologies, much in the manner described by the Cultural Cognition of Risk Theory, would create an improved methodology[12]. Psychometric thought can provide significant benefits to Culture Theory, because it is able to make claims as to the nature of the cognition of risks, and through its mechanistic interpretation of decision-making, it may reveal how risk perceptions adapt and change over time. Yet, in order for such a coalition to be of much use there needs to exist a

methodology that is transparent, reliable, and reveals the inner workings of human choice behavior in a highly quantifiable manner. Scientific disciplines are well suited to take on these tasks, which would allow for a comprehensive interpretation of cultural risk biases.

Section 3: The Neuroscience of Decision-Making

Science is nothing but developed perception, interpreted intent, common sense rounded out and minutely articulated.
- George Santayana

The Neuroscience of Decision-Making – Background and Usefulness

Traditionally the examination of the complex inner workings of the human mind has been restricted to analysis of overt behavior, this is especially the case in the field of economics, yet the burgeoning field of neuroeconomics aims to understand the neural basis of individual choice behavior. The power of analyzing decisions in a neuroeconomic framework is revealed in the following statement, "Decisions, the ultimate expressions of will, can be dissociated from the actions through which they are commonly manifest, and owe their true existence to processes hidden within the recesses of the brain[53]." Due to technical restrictions traditional economic methodology has been forced to interpret behavior based on observations of choice, which has prevented the identification and quantification of the true determinants of decision-making.

Promising work done by neuroscientists has begun to determine exactly how the human brain makes choices. Various studies have confirmed the role of the neurotransmitter dopamine's role in processing the motivational aspect of reward. Current theory is that dopamine neurons provide a signal, through their firing rates, that indicates a disparity between expectation and reward. These error signals play an instrumental role in learning. Their function however is adaptive, as recent work

has shown dopamine responses to be strongly modulated by contextual information pertaining to the evolution of reward probability[54]. These results were discovered in animals and confirmed in humans with fMRI[55] and further research has gone on to show that areas of prefrontal and parietal association cortices display modulated activity due to the expectation or delivery of reward and indicate a basis for maintaining a representation of value over time[56]. These findings clearly illustrate that neuroscience has already made solid progress in identifying brain regions associated with an internal representation of expected value. Expected value is not the only determinant of choice and researchers, identifying a population of neurons labeled 'mirror neurons', have found a neural basis for interpersonal affect's role in choice behavior. Mirror neurons are neurons who are active when a subject performs an action as well as when the subject observes another subject performing the action[60]. The function of mirror neurons is based on an internal representation of an action rather than the physical action itself. Though mirror neurons were originally discovered in primates, recent work using transcranial magnetic stimulation (TMS) has confirmed the existence of a functionally similar population of neurons in human subjects as well[61]. Additionally the function of mirror neurons has been extended to emotional responses and pain responses[62,63]. Together this research indicates that sympathy and empathy are pervasive components of human behavior. Much in the way that midbrain dopaminergic neurons enable humans to learn about rewards, the population of mirror neurons enables humans to learn about the emotional states of others around us in a self-centric frame of reference.

There are already precise models of multiple mechanism neural functionality that depict the relative influences of emotion and reason on choice[65,66]. Economic theory only focuses on high cognitive processing in humans, the rules by which humans consciously evaluate decisions. Such thought is inherently flawed by a misunderstanding of neural development. Emotions govern instinctive behavior and logic governs rationale behavior, but observed behavior is a compromise between the two. Choice theory must incorporate the aspects of both conscious and subconscious mechanisms, as they are both present throughout an individual's decision-making process. Reason is often at odds with reflexive behavior[67] and to properly determine behavioral outcomes one must acknowledge these parallel determinants of choice. These powerful insights into the mechanisms driving behavior illustrate the utility of a neuroscientific analysis of decision-making under risk.

A criticism of neuroeconomics is that it cannot disprove economic theories. While this is true, as the traditional economic stance, that rationality is not assumed but is rather a maintained hypothesis, prevents it from being disproved by neuroscientific findings, it is no indication that neuroscience is of little use to economics. Economists reject the proposition of neuroeconomics by constraining the views of their field to a narrow and specific rhetoric that refuses cooperation with novel scientific inquiry into the basis of rationality. Economists seem to consciously ignore the proposition that neuroscience may provide specificity (and thus better results) to what they deem as the "broad and flexible methodology" of current economic

thought. Economists state that numerous techniques exist to account for instability in utility models such as assuming that preferences depend on an exogenous state variable, the information of opponents, consumption history, and the learning of a parameter over time. All of the aforementioned techniques require assumptions of the mechanisms driving utility, so it is perplexing that economists would prematurely reject a discipline that may provide a more comprehensive interpretation of what determines utility. Currently economists use revealed preference to infer the mechanisms that underlie choice, but such reverse logic is susceptible to overlooking silent or subtle determinants of choice[96]. Neuroscience is poised to challenge current thought on what constitutes rational behavior. As thought on the nature of rationality evolves, so too must the methodology of economics. It would be illogical to treat rationality as a maintained hypothesis, if neuroscience were to create a reliable model of the specific mechanisms determining rationality. Advances in the neuroscientific analysis of choice behavior stand to revolutionize the field of decision sciences by deepening the understanding of what drives behavior at the cellular and molecular level.

The Neuroscience of Decision-Making – Findings Relevant to Risk

Choices are made based on preference, but the determination of preferences is no simple matter. When there is risk associated with a choice, preferences become weighted by a component of subjective risk, which strongly biases choice and these biases vary across individuals[59]. Neuroscience is well suited to analyze this variance in risk bias, because specific neural systems contribute to biased, risk sensitive

decision-making[59]. Current research has confirmed the intuition that neuroscientific analysis will be able to discern how the brain perceives risks, moving one step closer to a complete picture of human choice behavior.

It is clear that risk and preference are inseparable concepts, even at the functional level of the brain. Risk is coded in the same area that generates reward prediction errors but it is coded on a different timescale[98]. Understanding the relationship between risk and preference will provide better interpretations of complex theories of human choice, such as Prospect Theory. A key component of Prospect Theory is loss aversion, which is characterized by the fact that most people will reject a gamble until the size of potential gain becomes approximately twice as large as the size of the potential loss. This odd phenomenon is potentially being resolved by work that demonstrates that predictions errors encoding gains and losses occur in distinct regions of the ventral striatum[59], meaning that there are likely two separate mechanisms for determining choice based on frame of reference. Additionally the anterior cingulate cortex, orbito-frontal cortex, and insula respond to both risk, and monetary gains and losses, so while distinct mechanisms may be present, their function is clearly not localized to one specific brain region. Other studies have shown that lesions of the nucleus accumbens enhance risk aversion in rats[57], and that humans with ventro-medial cortex lesions that impair the ability to mark memories of past feelings of gain or loss do not show anticipatory emotional reactions to the potential consequences of their choices[121], both of which further emphasize that choice behavior is a product of interaction among a diverse array of

functional areas across the brain. This body of evidence does not yet provide a complete picture for the neural basis of loss aversion, yet it points to a more comprehensive explanation of Prospect Theory. Through current neuroscientific research we can surmise that choice based on risk is evaluated by different neurological mechanisms depending on the perspective of the subject. This promising work will potentially provide a comprehensive theory of how reference frames can influence the manner in which the brain evaluates risky decisions.

Reference frames are not simply limited to when an individual faces a gain or a loss. The fairness of a deal, or the affective response to a decision, can also have significant implications on how the brain processes risk. In a study using ultimatum game bargaining models, players tend to make fair offers to one another, and small offers tend to be rejected. These findings conflict with game theory predictions that players should make small offers and reject nothing. Autistic adults are more likely than normal adults to offer nothing to the other player and this may arise from their incapability of understanding other players' beliefs, which results in them behaving in an ideal state of self-interest much as game theory would predict[68]. fMRI imaging of players shows that unfair offers, relative to fair offers, elicit greater activation in the insular cortex, which is an area associated with feelings of disgust, and in the anterior cingulate cortex, which is an area active in difficult reasoning requiring cognitive control. Players with more insular cortical activity are more likely to reject unfair offers. This is an excellent example of how complex decisions are made, which involve parallel processes that essentially boil down to an internal battle

between reason and affect[69]. Affect often overrules logical reasoning in everyday life. A colloquial example of such illogical behavior is that individuals tend to fear terrorism more than the consumption red meat. While consuming red meat is more likely to cause death, the visceral response to terrorism overrides an individuals' objectivity in decision making[70]. The competition of affect versus reasoning often results in illogical behavior and this point is further illustrated by the impact of insular activity on behavior. Activity in the right insula is negatively correlated with risky decisions after a negative outcome, and its increased activity is associated with participants subsequently switching from a risky to a safe option[97]. This finding coupled with the results of the ultimatum game illustrate that activity in the insula leaves individuals subject to making choices based on passions. Economics currently has no way to account for such passions, and this surely results in heightened variance in their models of behavior under risk.

The Neuroscience of Decision-Making – Techniques and Limitations

Research in neuroscience has come to astonishing conclusions, but it has led many to wonder if those conclusions are reliable and justifiable. Current techniques used to conduct neuroscience research do suffer from many limitations. Due to ethical and safety concerns, much of the most specific research on decision-making is confined to animal models. With animals, invasive techniques such as single cell recording can be used, which enable researchers to propose models for human choice behavior. In order to confirm these models there are many techniques available to neuroscientists to determine the functional role of many different regions of the human brain. Currently brain imaging is the most widely used

technique to determine the functional role of brain regions, with the most common imaging technique being fMRI. Additional widely utilized tools available to neuroscientists include TMS, MEG, EEG, and analysis of the galvanic skin response to stimuli[64,75,76,79]. There are also promising roles for the use of lesion studies and genetic correlations in future behavioral research in humans[77].

While the capabilities of neuroscientific inquiry provide an exciting alternative to the traditional economics of choice behavior, they do have many limitations. fMRI is the most widely used technique to evaluate the neural correlates of choice behavior. Imaging using fMRI has demonstrated that there is a prediction error signal in the human brain that is consistent with models posited by reinforcement learning[81], as well as the presence of utility driven value signals during human choice that are consistent with decision theory models[82,83,84]. fMRI also has the capacity to determine whether there are separate mechanisms required to process reward under risk versus uncertainty[88,89], and between immediate versus delayed rewards[90,91]. Besides differentiating neural mechanisms of choice, fMRI has been shown to identify different mechanisms of decision-making across individuals[92], which could improve econometric predictions of choice[93]. The most promising of all results though is that neural activity as imaged by fMRI can predict individual behavior outside of the scanner[95]. Unfortunately the fMRI is not a perfect measure of neural activity. fMRI is not able to provide information about neurodynamics at a fast time scale or distinguish between bottom-up versus top-down signaling, therefore its findings primarily limit investigators to identify regions of interest for

further analysis and very general mechanistic understandings of behavior. Measuring neural activity at the timescale in which cognition occurs can be achieved using MEG, which has high temporal resolution (<1ms). It is currently difficult to spatially localize the source of neural activity using MEG but there is great potential to solve this problem in the future using dense electrode nets and newer statistical methods which are currently in development[75,76]. Neural substrates of behavior can be identified through changes in behavioral patterns in their absence. This type of investigation can occur through lesions studies[77], or by the temporary disruption of the activity of a specific region of the brain using TMS[78,79], in combination with imaging analysis of the brain. Lesion studies are fortunately hard to come by as they require a natural insult to the nervous system, and TMS is currently limited to affecting the dorsal cortical surface[79]. While there is not likely to be a breakthrough in the prevalence of lesion studies, there is research in progress to develop better magnets allowing for TMS to reach deeper tissues of the brain[80]. Genetics provides an interesting approach to the study of behavior. Genetic polymorphisms can be analyzed to see if they have an impact on behavior. Genetic chips and genome wide association studies allow for the analysis of hundreds of polymorphisms at a time[77]. Hurdles to overcome with genetic studies is the influence of the environment on genetics, as well as the issue that most behaviors depend on many genes and thus a single polymorphism will likely have a diffuse and insignificant effect on behavior[77]. In sum these techniques are very promising, and their limitations seem not to be an indicator of an inherent flaw in neuroscientific inquiry into human behavior, but

rather a signal of the enormous potential that has yet to be realized through this methodology.

There is a bright future for research seeking a neural interpretation of behavior. Novel techniques have been proposed such as optical imaging[126], voltage imaging[127], arrays of nanoprobe sensors[129], and DNA polymerases[122], which have the potential to enable researchers to reconstruct activity patterns across brain regions at the level of single cells[122]. While these new techniques are not yet suited to analyze the entirety of the brain in an animal model, recent developments in optical hardware, nanotechnology[128], and computational approaches indicate that these challenges will likely be overcome with future technical advances[123]. With adequate funding it is reasonable to assume that within 15 years scientists will have succeeded in reconstructing the neuronal activity of the neocortex of an awake mouse and begin work on primates[122]. Additionally there is potential for engineered cells to safely determine human brain activity via wireless electronics[122]. Such advances will require a concerted effort focused on enhancing the tools available to neuroscientists. The American government has begun a project called "Brain Research through Advancing Innovative Neurotechnologies" (BRAIN) with the aim of developing greater technical capabilities to be able to create a brain activity map in the foreseeable future. BRAIN has developed a substantial infrastructure and will receive as much as $3 billion over the next 10 years from the US government[124]. A similar project occurring in Europe, called the Human Brain Project, seeks to use a supercomputer to create a computational simulation of the brain using current

knowledge of the human mind. The Human Brain Project will receive $1.3 billion in funding over the next 10 years in equal parts from philanthropists and the European Union[125]. The enormous infusion of resources towards projects working to reconstruct patterns of neural activity will foster advances in our understanding of human decision-making. If a complete activity map of the human brain were created, neuroeconomic researchers could use a multi-method approach to make behavior a dependent variable[77] and subsequently uncover the cellular basis of risk perception.

Section 4: Towards a Unified Theory of Cultural Risk Perception: Implications for Labor Mobility Policy

All civilization in a sense exists only in the mind. Gunpowder, textile arts, machinery, laws, telephones are not themselves transmitted from man to man or from generation to generation, at least not permanently. It is the perception, the knowledge and understanding of them, their ideas in the Platonic sense, that are passed along. Everything social can have existence only through mentality.

- Alfred L. Kroeber, *The Superorganic*

Towards a Unified Theory of Cultural Risk Perception: Implications for Labor Mobility Policy – Applying Neuroscience to Culture Theory

A unified theory of cultural risk would explain how culture shapes the heuristics and biases that influence decision making under risk. It is clear that neuroscience can provide valuable insights into the inner workings of human choice behavior, but current research indicates that it has the additional capacity to analyze these behavioral mechanisms in the context of Culture Theory's group-grid typology. Through such analysis, work in the field of neuroscience can establish a model for the impact of cultural framing effects on behavior under risk.

Analyzing neural activity across a range of cultural values provides new insights into the mechanisms by which culture frames risk. Social status hierarchy is a fundamental principle of social organization across a range of species from ants to primates[99,100] and thus it is likely that hierarchical social structures among humans have arisen from adaptive mechanisms in the brain[101]. To confirm this assumption a study was conducted of naval reserve officer midshipmen who were familiar with names, insignia, uniforms and salutes for various naval ranks. They were shown various images of Arabic numerals, status insignias, faces of officers, and Toyota

cars (to examine social status inference from familiar cultural objects). fMRI imaging confirmed that neurological processing of social status hierarchy and numerical comparisons are associated with activation in distinct and overlapping regions of the inferior parietal cortex. Additionally in bilateral intraparietal sulci there was a 'distance' effect, which resulted in heightened activation when stimluli were closer to each other in hierarchical rank[102]. These findings indicate that individuals evaluate hierarchical social rank using similar neural substrates that underlie one's ability to rank numbers[◦]. Through this type of research there is the possibility not only to identify the neurological regions where cultural processing occurs, but also to reveal cultures links to more basic and better understood neural constructs.

While the Navy provides a natural experiment for testing culture, because the midshipmen are predisposed to a hierarchical environment, researches are also able to induce a cultural outlook on subjects. In a study of the impact of individualism versus collectivism, participants were culturally primed using the pronoun circling task[†].[107] The priming revealed very high accuracy for individualistic (92.6%) and

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◦ A potentially useful follow-up study could reassess the results using subjects who were identified as egalitarians and were taught the rank and symbol hierarchy. If egalitarians showed similar brain activation, it would indicate that they possess hierarchical processing, but that this hierarchical signal is being overridden by some other and likely egalitarian neural construct. Such research could reveal parallel and competing brain processes that determine one's ultimate social outlook.

† The pronoun circling task entails participants reading a brief paragraph about a trip to a city after which they are instructed to circle the 19 pronouns in the text. In the independence priming condition, the pronouns represented the individual self (e.g., "I," "me," "mine"), while in the collectivist priming condition the pronouns represented the relational self (i.e., "we," "our," "us"). This task has been shown to

collectivist (95%) scores, indicating that the subjects had indeed adopted an acute awareness of a specific cultural mindset. Subjects were shown stimuli that were either self-relevant, father-relevant, or of unfamiliar persons. fMRI imaging showed that activity in DMPFC was significantly greater in individualistic subjects compared to collectivists when comparing self-relevant and father-relevant stimuli. The activity difference appears to be due to a distance effect, because individualists view themselves relatively independent from their fathers, which requires more processing to distinguish, than collectivists who simply see themselves and their fathers as a singular collective entity[108]. In a similar study researchers were able to associate activity in the MPFC when subjects viewed general-descriptors and activity in the PCC when subjects viewed self-descriptors[114]. The activity in the MPFC and PCC were correlated to individualist and collectivist priming respectively, and these regions have been previously shown to direct attention towards evaluation of information about one's self[112]. Because collectivists are prone to describe themselves contextually, whereas individualists usually describe themselves generally, these findings may reveal distinct roles for the MPFC and PCC in the process of self-evaluation and subsequently the parallel neural mechanisms that individuals with different cultural outlooks employ to frame their views[113].

Cultural values can also transform the way individuals interact with those it identifies as group members. Empathetic responses differ for in-group members relative to mankind in general. African-American and Caucasian subjects were

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elicit values and attitudes congruent with the primed way of thinking about one's self[131].

shown images of both in-group (same race) and out-group (different race) members in pain, and to gauge empathy, they were asked to rate how much time and money they would be willing to offer the person in pain. Imaging results revealed that empathetic responses to in-group members elicited activation in the medial prefrontal cortex that was not observed when out-group members were viewed by the subjects. Furthermore the level of activity in the MPFC predicted the level of empathetic and altruistic response from the subject to in-group members[119]. The localization of this activity demonstrates that group membership is a cognitive function, and is likely derived from the concept of reciprocal altruism whereby individuals are more likely to help someone if they expect the favor to be returned. In this study in-group preference was only observed in African-American subjects, but African-Americans reported significantly greater identification with their social group relative to whites, which is consistent with prior studies that show that racial minorities have greater ease in identifying with their social group than racial majorities[118]. This study therefore reveals a neural region, whose activity can predict altruistic responses selectively for in-group members, as long as the group is strongly identified with by the subject. This theory of group behavior has been extended to cultural groups that lie on the group-grid typology. In a similar study, those identifying with hierarchical beliefs (as indicated by the social dominance orientation scale[109]) significantly differed from those with egalitarian beliefs (as indicated by the interpersonal reactivity index[110]) in their empathetic responses to perceived pain in others. Subjects with hierarchical views displayed less activity in the left anterior insula and anterior cingulate cortices, which are associated with the

ability to feel concern for the emotional salience of others[111]. This evidence provides a cultural perspective on previous work using an ultimatum game model (see section 3b), which together indicate that dissociation from the emotional condition of others has a cultural component and is derived from a cognitive suppression of affective activity. Research on empathetic response provides evidence for a cognitive theory of culture, whereby culture engenders distinct cognitive processes that influence or overtake our affective responses to choice, resulting in unique culture-specific behaviors.

The existence of culture-specific behaviors has been observed in the risk preference of distinct populations. Americans and Brazilians displayed significantly different risk preferences as determined by a study using the Iowa Gambling Task[†]. Americans performed 34% better on the task than Brazilians, indicating that Brazilians suffered from a bias towards impatience, while Americans were better able to gauge the long-term benefits of their choices[120]. Investigators noted many sources of bias in this study, including that Brazilians were unpaid while Americans were both paid and more familiar with the testing facility, which could have resulted in higher engagement for the American subjects while performing the task. Work in

[†] The Iowa Gambling Task is a game where participants are presented with 4 virtual decks of cards on a computer screen. They are told that each time they choose a card they will win some game money. Every so often, however, choosing a card causes them to lose some money. The goal of the game is to win as much money as possible. Every card drawn will earn the participant a reward. Occasionally, a card will also have a penalty. The decks differ from each other by the number of trials over which the losses are distributed. Thus, some decks are "bad decks," and other decks are "good decks," because some will offer greater short-term gains yet losses in the long run while others will lead to more modest short-term gains that are sustained in the long run.

genetics has also identified culturally linked polymorphisms that are predictive of decision making under risk. The presence of the s/s allele of the 5-HTTLPR gene resulted in subjects taking on 28% less risk than those carrying the s/l or l/l alleles[116], while the presence of the 7-repeat allele of the DRD4 gene was correlated with subjects taking on 25% more risk in investments[115].. The prevalence of the s/s and 7-repeat alleles has been strongly correlated to collectivist social structures at both the national (R=.85 p<.02) and cultural regional (R=.67 p<.03) levels as indicated by Hofstede[117]. These studies indicate that there may be a genetic predisposition to unique cultural risk behavior, yet there is not sufficient to reveal a causal relationship[97]. The potential implications of work in genetics merits further investigation, but future studies will need to use larger samples, as well as identify causal mechanisms by which genetic polymorphisms influence culture-specific behavior. Though scientific data linking culture to risk behavior is sparse, the promising results of the few studies that have been done should leave neuroeconomists optimistic about the potential impact that their contributions will have on economic choice theory.

Towards a Unified Theory of Cultural Risk Perception: Implications for Labor Mobility Policy – Potential to Address Labor Mobility Issues in Developing Nations: Benefits and Implications

Culture Theory provides policymakers with an opportunity to adapt foreign labor migration policies to suit the unique needs of their home nation. Because rural workers' evaluation of risk plays such a significant role in their decision to migrate, an accurate model of risk discrepancies among nations would be an invaluable tool

to assess the state of labor mobility in a region. With such a model, successful economic labor policies could be better implemented throughout the world, engendering increased development of the global economy, as well as greater stability and prosperity for industrializing nations and especially their migrant laborers.

Cultural risk biases have the ability to redefine the impact of policy decisions. In the 1980s Chinese officials were puzzled with the effects of policies that raised the return to agricultural labor. They had envisioned a decrease in rural-urban labor migration based on the decreased relative return to urban labor, but instead migration to urban centers actually increased. A powerful explanation for this pattern of behavior has its roots in culture. The intuition that a greater return to rural labor would decrease rural-urban labor migration comes from an individualistic mindset. Traditional economic theory has long favored an individualistic outlook on choice behavior, because its predictions are based on individual rational decision making. It has been documented though that East Asian populations tend to be of a more collective mindset than generally individualist Westerners[105]. This cultural distinction has been affirmed by work in neuroscience showing that young Americans have considerably greater volume in fronto-parietal regions that are associated with self-projection of future events than young East Asians[104]. This study indicates that the functional unit of economic choice is not oneself in East Asia but rather a larger collective group[106], and this mindset has resulted in physiological differences between populations. When it is understood

that East Asians think collectively, it is entirely rational that an increase in rural wages, would lead individuals to migrate, because it has effectively decreased their marginal contribution to their family's earnings. When the rural wage increased, it decreased the risk to a family of having an individual move to an urban center in search of higher wages. Had Chinese officials better understood how culture can frame risks it may have avoided the disastrous results of its policies in the 1980s.

While culture's impact on behavior is clear, there has yet to be a methodology that is reliable and accurate enough to incorporate cultural outlook into economic modeling. Neuroscientific research has already been established as a tool for cross-cultural risk analysis, but it is only with great technical advances that neuroscience will be able to provide extremely accurate models of human decision-making. In the meantime neuroscience has laid the groundwork for exploration into specific neural substrates that underlie choice behavior under risk. As neuroscientists come closer to identifying specific mechanisms in the brain for evaluating choices through a cultural lens, it seems reasonable to assume that technical advances over the next 20 years will allow for the quantification of risk discrepancies based on cultural differences. With an empirical model of cultural risk bias, policy-makers will be able to more accurately shape labor migration policies based on the cultural outlook of its laborers. Tailoring policy to better influence the minds of rural workers will indisputably increase the effectiveness of the policy, lowering urban unemployment and underemployment and increasing the social welfare and productivity of citizens in general.

Conclusion

Risk is a key component of choice and so a careful examination of the determinants of risk will yield better insights into human choice behavior. Risk is not a simple concept though, as it is a construct that derives its value from the perspective of the decision-maker. Individuals must choose which risks are worth taking, and such choices will differ due to biases that are unique to individuals. A primary source of such biases is cultural outlook. The social structures surrounding a population serve to frame its decisions in a manner consistent with promoting its unique set of cultural values. Through a more comprehensive understanding of the mechanisms by which culture asserts its influence on choice, it is possible to develop a framework of cultural risk discrepancies that will better predict choice behavior. Economists have long avoided the notion that preferences could be driven by social interactions, but this is primarily due to a lack of reliable information on how social structures interact with economic variables. Neuroscience has already begun to deepen our knowledge of the way culture shapes the way our brain interprets choices, and is poised to greatly expand upon its findings in the near future. With advances in neuroscientific technologies, the cultural determinants of risk can be justified and quantified, enabling economists to incorporate the influence of social organization into choice theory. A refined model of choice behavior will redefine economic thought, as its most basic tenants will be reassessed in light of a new interpretation of human behavior. A choice theory that accounts for cultural risk biases will be more accurate and subsequently improve the efficacy of policy

decisions, which can benefit both social welfare and productivity. Though there is great value in developing a substantiated theory of cultural risk preferences, it should be noted that there are significant ethical considerations associated with such an endeavor. Culture is an ideology and can only refer to an individual's perspective on how social interactions should optimally occur. By definition an individual's cultural ideology derives its meaning from the societal infrastructure surrounding an individual, although with the ever increasing use of social technologies (such as Facebook and Twitter) such infrastructure is not necessary limited to a spatially defined area. In order to uphold the integrity of their work researchers must begin to control for the influence of these virtual social platforms to avoid the stereotyping of geographically distinct populations. With such considerations in mind, the future of decision theory is bright, as we come ever closer to realizing the benefits of a complete description of cultural risk perception.

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