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**Abstract**

Political scientists have long considered ideology, partisanship, and constituency in determining how members of the United States Congress make decisions. Meanwhile, psychologists have held that personality traits play central roles in decision-making. Here, we bridge these literatures by offering a framework for modeling how personality influences legislative behavior. Drawing from experimental economics and neuropsychology, we identify core cognitive constraints for the "Big Five" personality model, parameterizing them in ways useful for crafting formal models of legislative behavior. We then show one example of the applicability of this framework by creating a formal decision-theoretic model of constituency communication.

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# Introduction

In anticipation of a forthcoming presidential bid in 2016, Senator Lindsay Graham (R–SC) dropped a bombshell on the political world and revealed that he does not use e-mail. This revelation was immediately found to be at odds with the age of mass technology in which we live. However, upon further investigation, Politico found that Senator Graham was not alone. His colleague and fellow Republican from Alabama, Senator Richard Shelby, claimed that "[t]he best thing is person-to-person like I'm talking to you. To my staff, talk to them on the phone but also notes. Hand notes. I write a lot. I've been here a while; I'm a little older than y'all." Almost immediately, Politico began referring to this cadre of apparently technophobic legislators as the "Luddite Caucus."[1]

In defense of his friend, Senator John McCain (R–AZ) revealed that, while he does not use e-mail frequently, he does use Twitter to communicate with his constituents. Senator Cory Booker (D–NJ), one of the youngest members of the Senate, concurred and added that he also uses Instagram and Facebook. Octogenarian Senator Chuck Grassley (R–IA) also uses social media quite actively. Perhaps more interesting is that his tweets include anything and everything from constituent service to congratulating local sports teams and even chronicles of his daily exploits. For example, on November 3, 2014, Senator Grassley tweeted "Windsor Heights Dairy Queen is good place for u kno what" to his followers.[2]

This variation in social media use across legislators of all ages suggests that the decision of how best to reach out to constituents is not simply explained by generational differences. Legislators' choices of how to best do so and what issues to emphasize are neatly summarized by what Fenno (1978) calls *home style*. Here, we analyze differing legislative home styles, focusing our attention on a broad question: when and why do some legislators adopt new methods of reaching out to

[1] French, Lauren. 2015. "Lindsey Graham one of several in Senate Luddite Caucus." *Politico*. March 10, 2015. http://www.politico.com/story/2015/03/lindsey-graham-email-senate-115923.html.

[2] https://twitter.com/ChuckGrassley/status/529356795924725760

constituents, and why do others never do so?

One possible way to explain the heterogeneity in behavior of members of Congress (and, more broadly, elites in general)—even among those with similar policy preferences and backgrounds—might be to focus on heterogeneity in their personalities. Indeed, there exists a long history of legislative scholarship emphasizing the role of members' personalities and other individual characteristics (*e.g*, Barber 1965, Caldeira & Patterson 1987, Dietrich et al. 2012), and personality has been proffered as one explanation for why certain members become "show horses" and other members become "work horses" (*e.g*, Matthews 1960, Payne 1980), for example.

Relatedly, personality psychologists have accumulated copious amounts of information about how stable and persistent individual differences capture myriad human behaviors, and they have developed and proposed a number of trait taxonomies in attempts to hierarchically organize them.

Importantly, they have coordinated upon a five factor structure for personality traits that has become widely—though not universally—accepted as characterizing the most important dimensions of individual difference (Eysenck 1992, John, Naumann & Soto 2008). Though they may not represent the "true" structure of personality, there is evidence these traits—Extraversion, Agreeableness, Openness [to Experience], Conscientiousness and Neuroticism (sometimes reverse-coded as Emotional Stability)—capture many important individual differences (Costa & McCrae 1992); this taxonomy also has the great strength of extensive empirical research connecting it with lower-level traits, other taxonomies, and other phenomena including leadership ability, academic and job performance, and health outcomes (Judge et al. 2002, McCrae & John 1992, Ozer & Benet-Martinez 2006). Importantly, this approach offers the promise of identifying enough fundamental individual differences to provide systematic characterizations of individuals' persistent unique qualities, while reducing them to few enough in number to be tractably translated into the language of formal modeling, thus making them more accessible to scholars of Congress (and political institutions more broadly).

We develop a framework for incorporating personality into models of legislative behavior, within the context of tactical adoption. First, we review the literature and show how each of the Big Five traits can be connected to nonideological preferences and beliefs identified by experimental economists and variations in brain structure identified by neuropsychologists, demonstrating that formal parameters empirically supported by personality measures may plausibly influence decisions made by legislators and that they can be incorporated into models of institutions.[3] We then develop a formal decision-theoretic model of tactical adoption when tactical quality is uncertain and personality plays a role. We refer to these decisions to adopt tactics without high confidence *tentative decisions*. We apply our model of personality-influenced tentative decisions to the decision to adopt a new form of communication technology that allows Congressional personality to play important roles. We then discuss potential avenues for future research.

## The Big Five and Modeling Individual Differences

Our goal is to demonstrate the relevance of personality measures in examining decision-making in Congress specifically, and institutions more generally. We draw from the experimental economics and neuropsychology literatures to obtain parameters correlated with the Big Five that are important to political decision-making and can be translated into terms scholars can incorporate into formal models of institutions. However, doing so first requires us to characterize the traits as single—mathematically modelable—concepts.[4] Psychologists and economists have begun to do this:

> "[P]ersonality traits impose constraints on agent choice behavior. More fundamen-

[3]Other work (Gallagher & Allen 2014, Hall 2015) examines the importance of Big Five traits in institutions, but relies on traits themselves as opposed to representing modelable parameters.

[4]Before proceeding, however, it should be noted that the process of incorporating personality traits into formal models of political institutions requires that each trait be translated into one or more modelable parameters, which itself requires us to make a number of simplifying assumptions about the nature of each trait in order to state them in modelable terms. We do not argue that the parameters we choose are the traits themselves; instead, we argue that these parameters are our best approximations of the traits in terms of the variables used in models of institutions.

tally, conventional economic preference parameters can be interpreted as consequences of these constraints. For example, high rates of measured time preference may be produced by the inability of agents to delay gratification, interpreted as a constraint, or by the inability of agents to imagine the future." Borghans et al. (2008, p. 977)

Additionally, neuropsychology has made significant strides in characterizing differences in neurochemistry, brain region volume, and resting state brain activity associated with the Big Five (Adelstein et al. 2011, DeYoung et al. 2010, Wacker, Chavanon & Stemmler 2006). Accordingly, we identify core cognitive constraints captured through the Big Five factors by focusing on the biological differences in brain functioning that neuropsychology has associated with each trait. Once we characterize each trait in terms of a core cognitive constraint, we express those core cognitive constraints in terms of modeling parameters. These constraints influence behavior in systematic ways that may be mathematically modeled, but are dependent on the contexts of the models themselves. As we are interested in modeling personality in ways useful for the study of Congress, we will describe a simple framework of legislative utility and identify useful approximations of each core cognitive constraint's influence. The resulting framework will direct the incorporation of each trait's core cognitive constraint into formal models of institutions. As we discuss later, we believe constituency communication is an ideal tactic to examine, because of the roles played by multiple personality traits and the relative ease of modeling.

## Openness to Experience

Openness to Experience is associated with desires to explore and imagine new situations and ideas, as well as an appreciation for aesthetic beauty, intellectual pursuits, tastes for novel experiences, and tendencies for creativity and imagination (Borgatta 1964, Tupes & Christal 1992).[5] This trait has found applications among political scientists, with a positive association between Openness to

[5]The trait is alternatively called Intellect in other frameworks (Saucier & Goldberg 1996).

Experience and ideological liberalism (Alford & Hibbing 2007, Barbaranelli et al. 2007); similarly, more Open individuals are less likely to hold racial prejudice, authoritatian beliefs, homophobic attitudes, or stigmatize people with AIDS (Cullen, Wright & Alessandri 2002, Duriez & Soenens 2006, Flynn 2005, McCrae et al. 2007, Stenner 2005).

Additionally, it is associated with several related cognitive functions, such as reduced latent inhibition—that is, blocking irrelevant stimuli from consciousness (Peterson & Carson 2000)—as well as resting state functional connectivity (RSFC) activity with areas of the prefrontal cortex (PFC) associated with working memory (DeYoung et al. 2009, Sutin et al. 2009). More Open individuals have increased RSFC in parts of the brain associated with imagination, as well as pattern recognition and apophenia, the detection of patterns in meaningless data (Adelstein et al. 2011). Increased dopaminergic activity in Open individuals in the PFC reduces latent inhibition and maintains working memory, and further increases motivation for intellectual exploration (DeYoung et al. 2011). Increased intellectual exploration along with greater perception and working memory all serve to combine in powerful ways to both drive and equip Open individuals for cognitive exploration. Therefore, Openness to Experience's core cognitive constraint is a *compulsion to gather and process information*.

## Conscientiousness

People who are more Conscientious have been described as being hard-working, responsibile, and prudent (VandenBos 2007), and tend to be more driven, goal-oriented, uptight, better-organized, and have more willpower (Ozer & Benet-Martinez 2006). Given its association with duty, order, and discipline, Conscientiousness has had clear hypothesized relationships with temperamental and ideological conservatism (Mondak et al. 2010), and investigation has found evidence in favor of an association with ideological conservatism (Stenner 2005). One might also think the link with duty might drive Conscientious individuals to be more civically engaged, though findings here are mixed (Bekkers 2005, Gerber et al. 2011).

Physiologically, Conscientiousness is correlated with the volume of the middle frontal gyrus in the left lateral PFC, a portion of the brain "involved in maintaining working memory and the execution of planned action" (DeYoung et al. 2010, p. 826) and linked with abilities to plan and follow complex rules (Miller & Cohen 2001). Examination of RSFC revealed an association between Conscientiousness and parts of the brain associated with planning for the future (Adelstein et al. 2011). Overall, Conscientiousness has strong links with parts of the brain associated with self-control, planning, and execution of planned action. This evidence suggests the core cognitive constraint of Conscientiousness is an increased *capacity to realize planned future outcomes*.

## Extraversion

Extraversion is associated with activity of many kinds, as Extraverts are more sociable, talkative, assertive, and energetic; the trait is also associated with positive outlooks on life. That it has been easy to find connections between political activity and Extraversion is thus unsurprising; for example, Extraverts are more likely to become active contributors to voluntary associations (Bekkers 2005). Additionally, political psychologists have found evidence that voters evaluate leaders at least partially on the basis of their Extraversion, as they show preferences for more sociable individuals (Caprara et al. 2006). Though some studies suggest Extraversion is associated with conservatism, the results are not robust (Barbaranelli et al. 2007, Riemann et al. 1993).

Psychologically, one major theory argues Extraverts have more dopamine terminals than introverts, and a prevailing theory suggests these terminals support coding stimuli in terms of reward, which drives behavior to approach stimuli as sources of potential reward (Depue & Collins 1999, Fischer, Wik & Fredrikson 1997). Additionally, Extraversion has been associated with the size of the medial orbitofrontal cortex, which codes the reward value of stimuli, sensitivity to reward, and the extinction of fear responses (Adelstein et al. 2011, DeYoung et al. 2010); relatedly, Extraverts have lower threshholds of reward needed to take given actions, broader abilities to find rewards for stimuli, and easier conditioning to associated stimuli with reward (Depue

& Fu 2013). Therefore, through dopaminergic activity and the orbitofrontal cortex, Extraversion's core cognitive constraint is *sensitivity to and fixation on prospective reward*.

## Agreeableness

Agreeableness is described as linked with altruism (DeYoung et al. 2010) and tendencies to trust others, cooperate, and act unselfishly (John, Robins & Pervin 2008, VandenBos 2007). Generally, it is associated with pro-social attitudes and other-minded thinking, suggesting many applications in political behavior; to wit, Agreeableness is associated with a stronger psychological sense of community, which can serve as a basis for political trust and economic liberalism (Gerber et al. 2011, Lounsbury, Loveland & Gibson 2003). Agreeableness can be conceptually connected to tolerance, which is supported by findings that it is negatively associated with racial prejudice, negative attitudes about diversity, and stigmatizing people with AIDS (Duriez & Soenens 2006, McCrae et al. 2007, Strauss, Connerley & Ammermann 2003). In line with Agreeable individuals' inclinations to be concerned about others, the trait is associated with distaste for political discourse and political competitiveness (Hibbing & Theiss-Morse 2002). Voters also seem to value Agreeableness in their elected officials (Caprara et al. 2006).

Agreeableness has been found to be positively associated with the volume of the posterior cingulate cortex, an area of the brain involved in the process of understanding other individuals' beliefs (DeYoung et al. 2010, Saxe & Powell 2006). Additionally, the ability to understand others' beliefs is part of the theory of mind capability thought to be essential in the ability to act altruistically (de Waal 2008). The larger posterior singulate cortex has been associated with empathy, and Agreeable individuals have higher measured resting state activity in the posterior cingulate cortex as well (Adelstein et al. 2011). As Agreeable individuals have increased capacities to interpret the beliefs and motivations of others and experience empathy, Agreeableness' core cognitive constraint appears to be a *capacity for altruism*.

## Neuroticism/Emotional Stability

Neuroticism is associated with high levels of anxiety, depression, impulsiveness and vulnerability to stress; related traits include external locus of control, high irritability and a sense of vulnerability to external conditions (John, Robins & Pervin 2008). Neurotics tend to have low self-esteem and are unstable, withdrawn, easily angered, and difficult to motivate. However, unlike other Big Five traits, there are fewer clear connections between Neuroticism and various political phenomena. One possible connection is an association between Neuroticism and ideological severity, as individuals who are less well adjusted (as Neurotics tend to be) should be more easily drawn into fanatical positions (Soldz & Vaillant 1999). However, other research has found strong and consistent relationships between Neuroticism and ideological liberalism (Gerber et al. 2010, Gerber et al. 2011, Mondak 2010). Additionally, Neurotics may have less stable political attitudes and more uncertainty about the attitudes they do have (Mondak et al. 2010). Psychologists have argued Neurotics experience variability and "mental noise" in their cognitive operations, and this may cause additional uncertainty and instability in their responses (Robinson & Tamir 2005).

More Neurotic individuals have been found to have larger mid-cingulate gyri, a region of the brain associated with the detection of error and pain (DeYoung et al. 2010); larger mid-cingulate gyri may be associated with higher sensitivities to possibilities of error and punishment (Eisenberger & Lieberman 2004). A broader theory of Extraversion and Neuroticism has argued that Neuroticism is a biochemically induced counterpoint to Extraversion, and as Extraversion is associated with a fixation on reward, Neuroticism is associated with a fixation on punishment (DeYoung & Gray 2009, Gray & McNaughton 2003). In the lab, Neurotics are prone to behavioral inhibition through passive avoidance and freezing, presumably due to their fixation on threat and punishment (DeYoung & Gray 2009). If Neurotics are preoccupied with error and threat, absent some shock, the best way to avoid punishment and stress would be to withdraw and maintain the status quo. Whether it is through sensitivity to error, stress avoidance, or a tendency to negative self-evaluation and rumination, Neuroticism's core cognitive constraint is a *sensitivity to and fixation on prospective punishment*.[6]

## A Framework for Political Choice

We now outline a framework incorporating personality into models of institutions. Given our focus on the United States Congress, the most useful ways to consider the choices made by legislators must emerge from the literature. Thus, we start with a very basic general model of legislative utility that considers the utility of legislators in terms of that derived from policy, from holding office (including both reelection and influence within Congress), and leisure; this model itself has been modified in various ways over the past half-century (Calvert 1985, Fenno 1973, Mayhew 1974). Every action legislators may take has policy and office utility implications, and after transformation through the weights they place on each source of utility, legislators compare the utilities of possible actions to determine the optimal course of action. Importantly, this model can be extended by incorporating the cognitive constraints we use to characterize each trait.

The utility gained from winning future office incorporates any policy utility that may be obtained by holding it (Mayhew 1974). Conscientiousness' core cognitive constraint is a capacity to realize planned future outcomes, and less Conscientious individuals should derive lower levels of utility from future policy gains they can neither imagine nor obtain through planned actions. This arises as a smaller discount factor for future utilities, be they from office, policy, or other sources. This modeling decision is supported by attempts to link personality with measures of time preference. Experimentally, higher scores on Conscientiousness are associated with lower discounting of future payoffs; indeed, "conscientiousness is particularly implicated in the ability to make sacrifices now for rewards later" (Daly, Harmon & Delaney 2009, p. 3).[7] Therefore, we expand our model to include motivation to hold office, enact policy, leisure, and time preferences.

[6] Also see Klingler, Hollibaugh & Ramey (2015).

[7] But see Dohmen et al. (2010).

A second necessary component is utility gained from the well-being of others. Agreeableness is strongly associated with the capacity for empathy and development of theory of mind that enables individuals to understand the incentives of others and act altruistically (de Waal 2008, Adelstein et al. 2011). Since Agreeableness is a top-level trait, we must consider the impact of every action on the well-being of others. This has support in models of legislative utility that put weight on selfless statemanship, as well as the idea of the "welfare of the nation" apart from policy and office goals (Cavanagh 1982, Uslaner 1996). More Agreeable individuals with higher capacities for empathy and understanding others are capable of deriving more utility from others. Therefore, we expand our consideration of utility to include motivation to hold office, enact policy, leisure, and act according to the norms of selfless statesmanship, all subject to future discounting.

The core cognitive constraint of Openness to Experience—a compulsion to gather and process information—has both direct and indirect effects on behavior. Foremost, any action that provides information, experience, or learning to legislators will likely provide additional utility to more Open members.[8] A second implication is more useful for modeling the utility of political elites, as situations with multiple possible outcomes require individuals to devote cognitive resources to the imagination (and retention) of alternative scenarios—such as policy outcomes—and Open individuals pay fewer costs for the collection and retention of this information. Thus, Openness is associated with higher utilities for convex combinations of outcomes, and reduced risk aversion by implication (Borghans et al. 2008, Pratt 1964). Therefore, after considering Openness, we can model legislative utilities as being affected by four motivations (policy, office, leisure, and statesmanship) and the utilities themselves may be transformed by time or risk preferences.

Extraversion has neurological connections with sensitivity to reward and fixation on positive incentives (Derryberry & Reed 1994, DeYoung 2014), resulting in a direct parameterization as higher weights being placed on potential rewards when calculating expected utilities. Modeling utilities relative to the status quo has limited usefulness in game theory. However, this implies

[8] In some situations, a source of utility linked to information consumption may be useful.

that Extraverts will persistently overestimate the successes they expect in contests, offering a more useful alternative application of the parameter as a subjective resource in contest success functions. Therefore, after accounting for Extraversion, legislator utilities are derived from policy, office, leisure, and statesmanship motivations, and these utilities may be altered by biased expectations of success, as well as preferences over risk and time.

The sensitivity to punishment underlying Neuroticism implies a direct parameterization of the trait as the assignment of greater weight to potential losses, and this is supported by Neuroticism's association with sensitivity to error (DeYoung et al. 2010). Again, modeling relative utilities is not often useful, but an alternative application of the parameterization is available. Greater weights placed on potential losses from action implies preference for a 'safe' status quo to avoid making error; this is supported by the finding that Neurotic individuals experience indecision and "freezing" behavior when forced to decide between conflicting goals (DeYoung & Gray 2009, Gray & McNaughton 2003).[9] This "freezing" effect can be modeled with an inhibition parameter in the utility function for legislative actions that represent decisions not to decide, such as voting present, or not taking action, such as missing votes or not introducing legislation.[10] Therefore, after accounting for Neuroticism, utilities in our framework are derived from policy, office, leisure, and statesmanship motivations, and these utility sources may be altered by biased expectations of success and failure, as well as preferences over risk and time.

All core cognitive constraints, as well as the associated parameters, are summarized in Table 1.

This modeling framework allows us to incorporate the traits within the five factor model into models legislative decision-making. In the next section, we incorporate four out of the five traits, Openness to Experience, Conscientiousness, Extraversion, and Emotional Stability, into a

[9]This assumes no exogenous punishment from indecision, which would drive Neurotic individuals to act to *avoid* punishment. As long as such a punishment may be avoided, more Neurotic individuals would prefer to be indecisive and avoid any punishment rather than take action and face potential punishment from an exaggerated probability of being wrong.

[10]This inhibition parameter's influence on the utility of indecision and inaction is diminished and may even be negative if there is a punishment for inactivity.

Table 1: Big Five Traits as Core Cognitive Constraints and Parameters

| Trait | Cognitive Constraint | Parameter |
|---|---|---|
| Openness to Experience | Compulsion to gather and process information | Risk Preferences |
| Conscientiousness | Capacity to realize planned future outcomes | Time preferences |
| Extraversion | Sensitivity to and fixation on prospective reward | Weighted relative gains |
| Agreeableness | Capacity for altruism | Utility from well-being of others |
| Neuroticism | Sensitivity to and fixation on prospective punishment | Weighted relative losses |

decision-theoretic model of technology adoption when the quality of the technology is uncertain. We use communications technology, specifically Twitter, as the motivating case.

# A Model of Constituency Communication

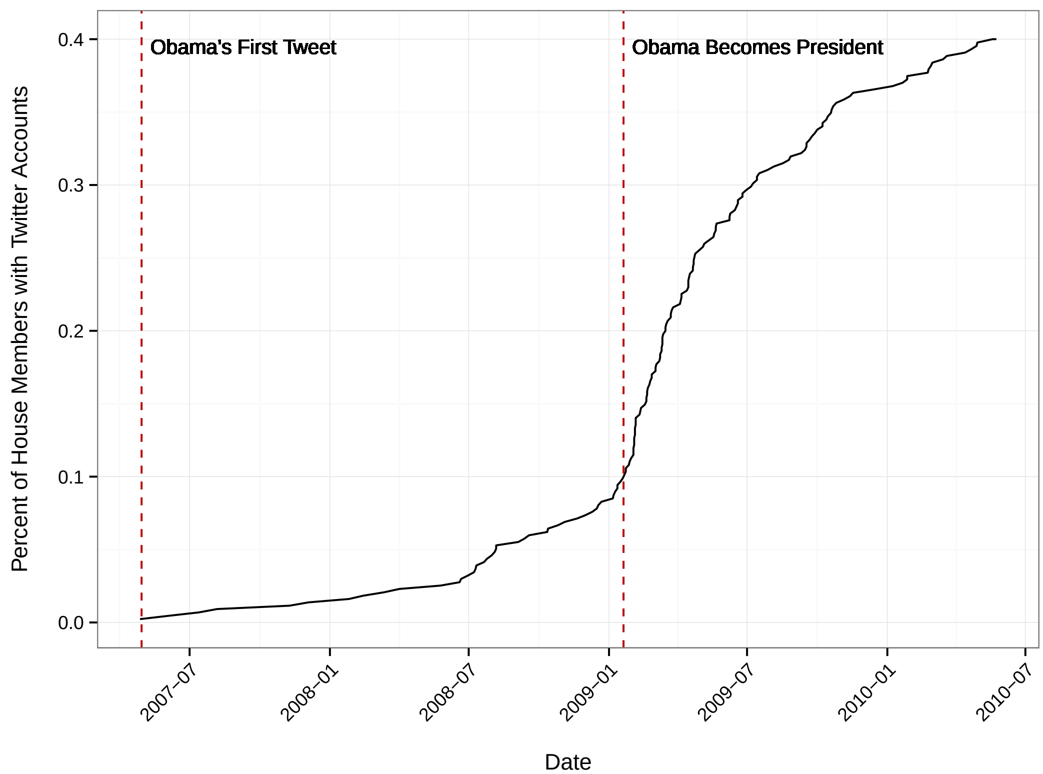
Twitter debuted in 2006 as a medium of communication whereby users can sent tweets, short messages limited to 140 characters. By 2014, the number of active American Twitter users was estimated to be around 45 million.[11] In its early days, few politicians in the United States viewed Twitter as a valuable means for connecting with their constituents. That all changed in late April of 2007, when a young Democratic Senator from Illinois, Barack Obama, registered a public Twitter account and issued his first tweet.

While Obama became quite popular and would go on to lead a successful campaign for the Democratic presidential nomination, few of his fellow legislators followed suit. Using data from Chi & Yang (2010), Figure 1 shows the percentage of members of the House of Representatives

[11] Ribiero, John. 2014. "Twitter users to grow 24.4 percent in 2014, U.S. still largest market." *PCWorld.com*. May 27, 2014. http://www.pcworld.com/article/2159420/twitter-users-to-grow-244-percent-in-2014-us-still-largest-market.html.

with active Twitter accounts during the early days of Twitter—2007–2010. While the percentage of members with accounts grew over this period, it was not until Senator Obama became President Obama in 2009 when the number of House members on Twitter rose precipitously. Though dramatic, we can see that as late as the summer of 2010, only about 40% of House members were on Twitter.

Figure 1: Twitter Adoption by House Members (2007–2010)




Why did some legislators adopt Twitter during these early days whilst others did not, and among those who did, what explains *when* they adopted it? More generally, why do legislators vary at the rates and speeds at which they adopt new technologies for constituency communication? Even the now-ubiquitious technology of email is not yet fully adopted by members of Congress, as illustrated in the beginning of this article.

To answer these questions, we can model the decisions of legislators with respect to adopting a new technology. Like investing in a start-up company, adopting a new technology requires a significant investment of time and energy. Moreover, as the technology is new, there are substantial upside and downside risks. On the upside, if the medium proves to be adopted by the public at large, the legislator will be rewarded for being "ahead of the curve." These rewards could be electoral—e.g., young and tech-savvy voters might jump on his/her electoral bandwagon—or they could come in the form of prestige from their foresight. For example, in the 2008 Presidential campaign, then-Senator Obama assembled a team of technological "wizards" to develop sophisticated models of voter turnout. While the class of traditional consultants scoffed at this decision initially, Obama's success vindicated the risks and countless politicians tried desperately to copy his approach or gain access to his data.

Of course, there are downside risks as well. If the new medium proves to be a dud, the legislator will suffer a loss in prestige. Furthermore, the time and effort invested in this method will be seen as wasted. Indeed, it is possible that constituents, preferring older, more traditional forms of political communication may retaliate against the incumbent electorally.

Thus, at its very core, the question of who adopts new technology is really about legislators' relative emphasis on the prospective rewards and punishments for doing so. To formalize this, we introduce a simple model based on the logic described by Ramey, Klingler & Hollibaugh (2015). There is a set of legislators $i = 1, 2, \ldots, N$ who must decide whether or not to adopt at various time points, $t = 1, 2, \ldots, \infty$.

We assume that the decision of legislator $i$ to adopt at time $t$ to be a function of the signals s/he has received to date and their priors for whether or not the new technology is a valuable resource in which to invest their effort. Legislator $i$'s uninformative prior for the value of the technology is given by $v \sim \mathcal{N}(0, \sigma_v^2)$. We define the signals at each time point $t$ as a combination of the true value plus error, i.e., $s_t = v + \varepsilon_t$, where $\varepsilon_t \sim \mathcal{N}(0, \sigma_\varepsilon^2)$. In the Bayesian context, it is useful to redefine variances in terms of precisions (or inverse variances). As such, let $\tau_\varepsilon = \frac{1}{\sigma_\varepsilon^2}$ and $\tau_v = \frac{1}{\sigma_v^2}$. Having received $n_t$ signals by time $t$, legislator $i$'s Bayesian-updated belief of the variance of $v$ is, according to stand results from Bayesian updating, a weighted average of the $n_t$ signals with the prior belief about $v$, i.e.,

$$\mathrm{Var}(v|n_t) = \frac{1}{n_t \tau_\varepsilon + \tau_v}. \tag{1}$$

The updated belief for the mean is, similarly, a precision-weighted average of observed signals to date and prior. This is just

$$E[v|n_t] = \frac{n_t \bar{s}_t \tau_\varepsilon}{n_t \tau_\varepsilon + \tau_v}. \tag{2}$$

Note that as $n_t \to \infty$, $\tau_\varepsilon \to \infty$, or $\tau_v \to 0$, the expected value converges to the mean of observed signals to date, $\bar{s}_t$.[12] This makes sense, since an increase in the number of signals, an increase in the precision of knowledge of the error term, or a decrease in the precision of the prior leads the legislator to rely on only the available data.

We assume legislator $i$'s utility given these updated beliefs is a combination of a number of factors. First, we assume that they get value from the technology itself and model this as their current expected belief about $v$. Second, we assume that legislators also care about the noisiness of the signal received to date and model this by the current belief about the variance of $v$. Third, we assume that legislators accrue some reward, $r > 0$, to adoption if the technology is good ($v > 0$) and incur some punishment, $\lambda > 0$, if the technology is bad ($v < 0$). By assumption, the rewards are greater than the punishment, $r > \lambda$. We can think of these parameters as increased prestige or potentially attracting new voters if the new technology is valuable and loss in prestige or lost time from investment if the new technology turns out to be a dud.[13]

[12]The claim about $n_t \to \infty$ is, of course, contingent on $N \to \infty$.

[13]In the case of Twitter, there have been several notable instances of members of Congress facing setbacks—or even being forced to resign—because of either a misunderstanding of how Twitter works and its broad subscriber base, or an imperfect ability to utilize the new technology. Perhaps the best-known example of this is the saga of former Congressman Anthony Weiner (D–NY), who ended up resigning—and then later ran an aborted campaign for Mayor of New York City—after it came to public light that he was using the platform to send explicit photos of himself to young women; his explanation reflected the fact that he intended to send private messages as opposed to publicly posting them on his Twitter feed. However, former Congressman Weiner is not the only person to fall into the Twitter trap. Indeed, the PolitWoops website (`http://politwoops.sunlightfoundation.com/`), maintained

Putting this together and denoting the decision of $i$ to adopt in period $t$ by $a_{i,t} = \{0, 1\}$, the expected utility of adopting today is

$$\begin{aligned}
Eu_i(a_{i,t}=1) &= E[v|n_t] - \rho \text{Var}(v|n_t) + \Pr(v>0|n_t)\alpha r - \Pr(v<0|n_t)\beta\lambda && (3)\\
&= E[v|n_t] - \rho \text{Var}(v|n_t) + \Pr(v>0|n_t)\alpha r + (1-\Pr(v>0|n_t))\beta\lambda && (4)\\
&= E[v|n_t] - \rho \text{Var}(v|n_t) - \beta\lambda + \Pr(v>0|n_t)(\alpha r + \beta\lambda) && (5)\\
&= \frac{n_t \bar{s}_t \tau_\varepsilon}{n_t \tau_\varepsilon + \tau_v} - \frac{\rho}{n_t \tau_\varepsilon + \tau_v} - \beta\lambda + \Phi\left(\frac{E[v|n_t]}{\sqrt{\text{Var}(v|n_t)}}\right)(\alpha r + \beta\lambda) && (6)\\
&= \frac{n_t \bar{s}_t \tau_\varepsilon - \rho}{n_t \tau_\varepsilon + \tau_v} - \beta\lambda + \Phi\left(\frac{n_t \bar{s}_t \tau_\varepsilon}{\sqrt{n_t \tau_\varepsilon + \tau_v}}\right)(\alpha r + \beta\lambda), && (7)
\end{aligned}$$

where $\rho$, $\alpha$, and $\beta$ are nonnegative constants that are weakly greater than 0 and $\Phi(\cdot)$ is the normal cdf. We can think of $\rho$ as a measure of $i$'s degree of risk-aversion, which is inversely related to $i$'s Openness. Thus, for $\rho \to 0$, the legislator only cares about the mean signal whereas for $\rho \to \infty$, the legislator maximizes the weight placed on the noisiness of the signals received. That is, more Open legislators are less negatively affected by the uncertainty of the technology's efficacy. The constants $\alpha$ and $\beta$ are, respectively, measures of the legislator's sensitivity to reward and punishment, or Extraversion and Neuroticism. These capture the extent to which legislators care about the benefits and costs of adopting the new technology. More Extraverted legislators place greater weights on the benefits, and more Neurotic legislators place greater weights on the costs. Additionally, we normalize the expected utility of not adopting to 0, i.e., $Eu_i(a_{i,t} = 0)$.

As we noted above, when $n_t \to \infty$—with all the attendant concerns about $N \to \infty$ described above—the expected value converges to the mean of signals to date and the variance goes to 0. The probabilities of the new technology being "good" converge to either 0 or 1 depending on the

by the Sunlight Foundation, is full of politicians' tweets that were deleted for various reasons.

sign of the expected value. Thus, the limiting value of the expected utility for adoption is

$$\lim_{n_t \to \infty} E u_i(a_{i,t} = 1 | \bar{s}_t > 0) = \bar{s}_t + \alpha r \quad (8)$$

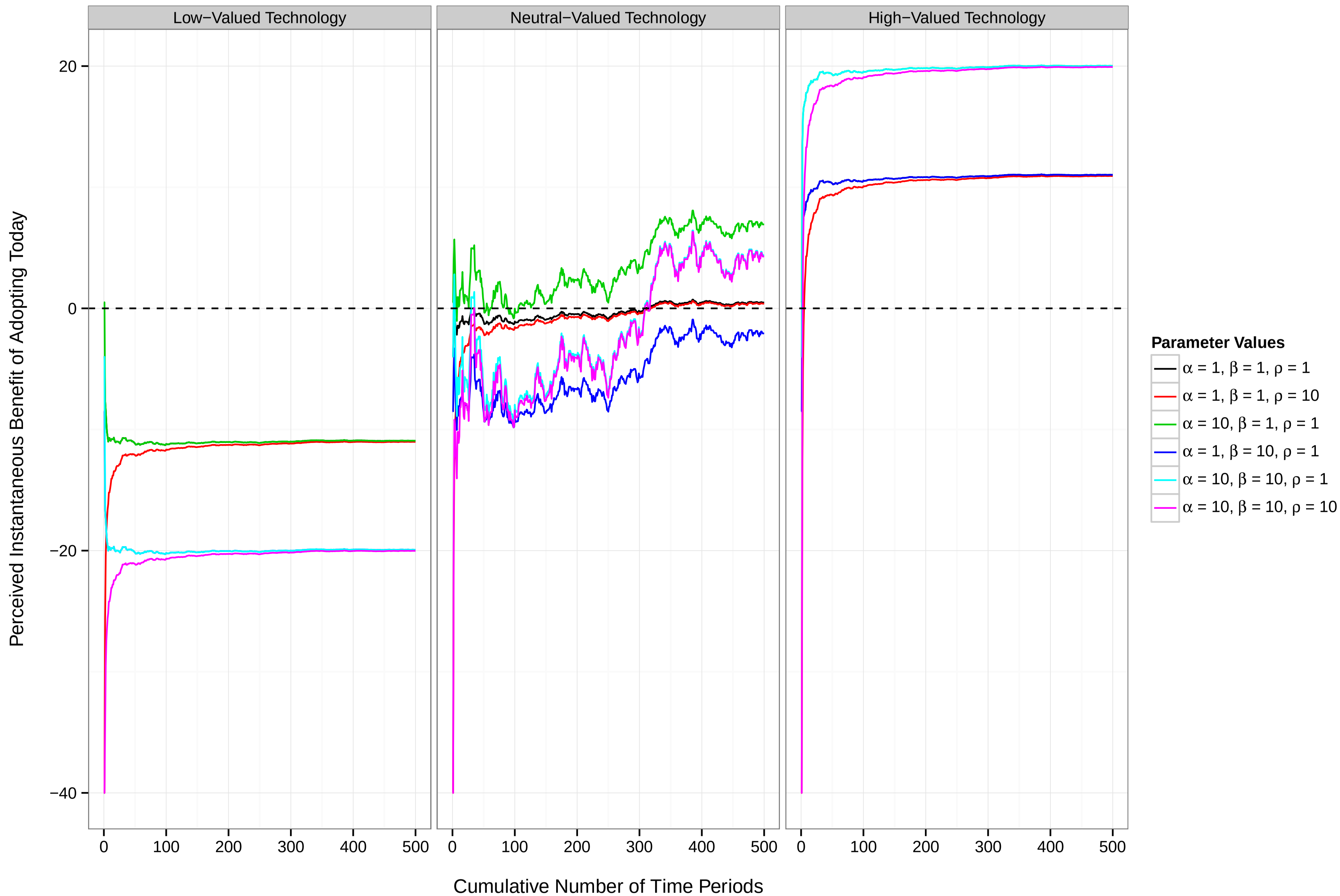
$$\lim_{n_t \to \infty} E u_i(a_{i,t} = 1 | \bar{s}_t < 0) = \bar{s}_t - \beta \lambda. \quad (9)$$

The upper limit is always positive and the lower is always negative. Thus, when the number of existing signals is sufficiently large, legislators will adopt or not simply on the basis of the sign of the signals received to date. This is because, in this limiting case, all legislators will join when the average signal is positive (since both $\alpha$ and $r$ are strictly greater than zero), and no legislators wil when the signal is negative (since both $\beta$ and $\lambda$ are strictly greater than zero). Additionally, since the variance decreases to zero, the risk-aversion/Openness term $\rho$ also drops out of the equation. These results suggest that in the current Twitter environment, when many legislators have joined and the number of members is in the millions, the number of existing signals is rather high and the role of personality in determining whether or not to join *now* is rather small. However, in the early days of any new technology, including Twitter, the number of existing signals will be relatively small.

We can examine how the perceived benefits of the new technology vary over time as the number of signals increases. Figure 2 presents the results of a simulation with several parameter profiles. We include six profiles: (1) The legislator is Open and neither Extraverted nor Neurotic ($\rho = 1, \alpha = 1$, and $\beta = 1$); (2) the legislator neither Open nor Extraverted nor Neurotic ($\rho = 10, \alpha = 1$, and $\beta = 1$); (3) the legislator is Open and Extraverted, but not Neurotic ($\rho = 1, \alpha = 10$, and $\beta = 1$); (4) the legislator is Open and Neurotic, but not Extraverted ($\rho = 1, \alpha = 1$, and $\beta = 10$); (5) the legislator is Open and both Extraverted and Neurotic ($\rho = 1, \alpha = 10$, and $\beta = 10$); and (6) the legislator is both Extraverted and Neurotic, and not Open ($\rho = 10, \alpha = 10$, and $\beta = 10$).[14]

[14]The other parameters in the simulation include $t = 500$, $\pi = 0.75$, $\sigma_\varepsilon = 2$, $\sigma_v = 2$, $r = 1$, and $\lambda = 1$. Over the course of the simulation, 383 signals were received.

Figure 2: Simulated Instantaneous Benefits of Adoption



We first focus on the left and right panels of Figure 2. Though it may be difficult to see due to the large degree of overlap (which is by design here), all three Neurotic profiles overlap when the latent value of the technology is low (leftmost panel), and all three Extraverted profiles overlap when the value is high (rightmost panel). Additionally, those who are *not* highly Neurotic all generally overlap in the leftmost plot, and the same can be said for those who are not highly Extraverted in the rightmost plot. This suggests that in the presence of high punishment, the most important trait is Neuroticism; highly Neurotic members act similarly, as do those who are not. The same is true for Extraversion in the presence of high levels of reward. Moreover, when the expected punishment is high, the (small) expected reward does not matter. Similar results hold for expected punishment in the presence of high expected rewards. We also note the role of Openness in the early stages; even in the absence of any information, Open individuals will immediately adopt even when the technology is low-valued, and those who are not Open will not immediately adopt high-valued technology. Finally, we note that the sensitivity to individual signals is relatively low, and within-profile variance in expected benefits is very low once a sufficient number of signals have been observed.

Things look different when the value of the technology is ambiguous (middle panel). The most immediate difference between the middle plot and the outer plots is the much higher degree of within-profile variance, largely due to the much higher degree of uncertainty about the directon of the technology's value (whether it is positive or negative). As such, the variance in the individual signals becomes much more important. Additionally, for legislators who are Open and neither Extraverted nor Neurotic, their perceived benefits of adoption do not change much once a sufficiently-high number of signals have been observed. Neither overweighting expected rewards nor punishments, their perception of the expected benefits of adoption hew very closely to the true values. Moreover, they will be willing to adopt relatively early on, even in the absence of data. However, they do not expect large rewards from doing so. It should also be noted that after a sufficiently high number of observed signals ($n_t > 100$ or so) their behavioral petterns do not meaningfully differ from those who are neither Open nor Extraverted nor Neurotic. However, when data are scarce, those who are less Open are much more reluctant to adopt. This suggests that Openness only really matters when uncertainty is present; in the absence of uncertainty, the effects of Openness are minimal.

We can also look at the effects of Extraversion and Neuroticism. Those who are more Extraverted, since they overweight the potential rewards from the new technology, have higher perceived benefits across the board. Those who are more Neurotic, since they focus more on the potential punishments, generally have lower perceived benefits; the one exception to this dynamic is in the early stages, when less Open individuals (those with high $\rho$) are so discouraged by the lack of information about the utility of the technology that they actually see fewer benefits than even those who are highly Neurotic. Additionally, interesting patterns emerge when we look at those who are both Neurotic and Extraverted. For these individuals, the Neurotic tendencies seem to dominate when the perceived latent value of the technology is negative (when those who are neither Extraverted nor Neurotic perceive negative utility from adoption), whereas the Extraverted tendencies dominate otherwise. We also see the same Openness dynamic in these cases; in the very beginning, those who are both Extraverted and Neurotic but not Open see *much* less benefit from the technology than those who are similarly Extraverted and Neurotic but much more Open. This provides additional information about the limited effects of Openness.

However, while these results are intriguing, their applicability is somewhat limited, as the decision to adopt or not adopt incorporates expectations about what the future might hold. Indeed, we are arguably more interested in whether a legislator will adopt today or delay until later when the informational environment will be more useful. That said, this depends on whether or not waiting will result in someone else adopting today and, hence, improving the estimate of the value of the technology via additional signals. If a legislator $i$ adopts today, his/her utility is simply $Eu_i(a_{i,t} = 1)$. If s/he waits until tomorrow, it is possible that another legislator adopts today or that no one does. Suppose that with probability $\pi \in [0, 1]$, another legislator adopts today and with probability $1-\pi$, no one else takes the plunge. In the first case, the legislator will acquire one additional signal.

In the event that the legislator observes a new signal tomorrow, we need to compute what his/her expected utility would be *given the information available today*. Since the expected utility involves the mean and variance of the parameter given the data, we need to re-compute the expectations over future signals conditional on the available information available at present. Applied the Law of Iterated Expectations, we obtain

$$\begin{aligned} E\left[E\left[v|n_t+1\right]|n_t\right] &= E\left[v|n_t\right] && (10)\\ E\left[\mathrm{Var}\left(v|n_t+1\right)|n_t\right] &= \frac{1}{\left(n_t+1\right)\tau_\varepsilon+\tau_v}. && (11)\end{aligned}$$

The expectation of the value tomorrow given signals today is simply today's estimate. For the variance, since it is independent of the signal and only depends on $n_t$, it is updated accordingly.

Thus, legislator $i$'s expected utility for adoption tomorrow (given their information today) is

$$\begin{aligned} Eu_i(a_{i,t+1}=1) &= \pi E\left[Eu_i(a_{i,t}=1|n_t+1)|n_t\right]+(1-\pi)Eu_i(a_{i,t}=1)\\ &= \pi\left\{E\left[v|n_t\right]-\rho E\left[\mathrm{Var}(v|n_t+1)|n_t\right]-\beta\lambda+\Phi_{t+1}\cdot(\alpha r+\beta\lambda)\right\}\\ &\quad +(1-\pi)\left\{E\left[v|n_t\right]-\rho\mathrm{Var}(v|n_t)-\beta\lambda+\Phi_t\cdot(\alpha r+\beta\lambda)\right\}\\ &= E\left[v|n_t\right]-\beta\lambda+\pi\left\{-\rho E\left[\mathrm{Var}(v|n_t+1)|n_t\right]+\Phi_{t+1}\cdot(\alpha r+\beta\lambda)\right\}\\ &\quad +(1-\pi)\left\{-\rho\mathrm{Var}(v|n_t)+\Phi_t\cdot(\alpha r+\beta\lambda)\right\}\\ &= E\left[v|n_t\right]-\beta\lambda-\rho\mathrm{Var}(v|n_t)+\Phi_t\cdot(\alpha r+\beta\lambda)\\ &\quad +\pi\left\{\rho(\mathrm{Var}(v|n_t)-E\left[\mathrm{Var}(v|n_t+1)|n_t\right])+(\alpha r+\beta\lambda)\cdot(\Phi_{t+1}-\Phi_t)\right\},\end{aligned}$$

where $\Phi_t=\Phi\left(\frac{E[v|n_t]}{\sqrt{\mathrm{Var}(v|n_t)}}\right)$ and $\Phi_{t+1}=\Phi\left(\frac{E[v|n_t]}{\sqrt{E[\mathrm{Var}(v|n_t+1)|n_t]}}\right)$. Therefore, since $\mathrm{Var}(v|n_t)=\frac{1}{n_t\tau_\varepsilon+\tau_v}$ and $E\left[\mathrm{Var}\left(v|n_t+1\right)|n_t\right]=\frac{1}{(n_t+1)\tau_\varepsilon+\tau_v}$, it follows that the difference between $\Phi_{t+1}$ and $\Phi_t$ will be positive if and only if $E\left[v|n_t\right]>0$, and will be negative if and only if $E\left[v|n_t\right]<0$; if $E\left[v|n_t\right]=0$, then $\Phi_{t+1} = \Phi_t$.

We assume that legislators discount the future at a rate $\delta \in (0,1)$, which captures his or her underlying Conscientiousness; more Conscientious legislators are more willing to forgo gains in the present for potentially larger gains in the future. If a legislator adopts today, s/he receives the expected utility of adoption both today and tomorrow (discounted by $\delta$); adopting tomorrow leads to 0 utility today plus the $\delta$-discounted expected utility for tomorrow. Thus, a legislator will adopt today *over tomorrow* if the net benefit of doing so is positive, i.e.,

$$
\begin{aligned}
(1+\delta)Eu_i(a_{i,t}=1) - \delta Eu_i(a_{i,t+1}=1) &\geq 0 \qquad (12) \\
Eu_i(a_{i,t}=1) - \frac{\delta}{1+\delta} Eu_i(a_{i,t+1}=1) &\geq 0 \qquad (13) \\
(1+\delta\pi)\{E[v|n_t] - \rho \mathrm{Var}(v|n_t) - \beta\lambda + \Phi_t \cdot (\alpha r + \beta\lambda)\} & \\
-\delta\pi \left\{E[v|n_t] - \rho E[\mathrm{Var}(v|n_t+1)|n_t] - \beta\lambda + \Phi_{t+1} \cdot (\alpha r + \beta\lambda)\right\} &\geq 0 \qquad (14)
\end{aligned}
$$

The expression above has a number of interesting properties. First, we examine the effect of the discount factor, $\delta$. Defining the net benefit of adopting today over tomorrow as $B_{it} = Eu_i(a_{i,t}=1) - \delta Eu_i(a_{i,t+1}=1)$ and differentiating the expression above with respect to $\delta$,

$$
\frac{\partial B_{it}}{\partial \delta} = \pi \left\{\rho(E[\mathrm{Var}(v|n_t+1)|n_t] - \mathrm{Var}(v|n_t)) + (\Phi_t - \Phi_{t+1}) \cdot (\alpha r + \beta\lambda)\right\} \qquad (15)
$$

The difference in the variances is always negative, since the variance tomorrow will always be less than today. The term involving the differences in probabilities that the value of the technology is positive or negative will vary in sign according to the signals observed to date. If the signals to date are negative, the term will be negative, thus making the entire derivative negative. This is sensible, as the legislator's signals to date are not good and the s/he knows that waiting will lead to less variance. However, as mentioned when the signals to date are positive, $\Phi_t - \Phi_{t+1}$ will be positive. Thus, the partial derivative with respect to $\delta$ might still be negative (if the signals to date suggest the technology is negatively-valued *and* the legislator is either sufficiently Extraverted and/or Neurotic and/or insufficiently Open) or it may be positive.

For the risk-aversion factor, $\rho$, the comparative statics are easier to see. When $\rho$ is close to 0, the legislator is risk-seeking and Open, and the net benefit of adoption is always non-negative so long as the precision-weighted mean of the signals to date is nonnegative. For large $\rho$, the legislator is so risk averse that the available signals today are dwarfed by potential gains tomorrow. This is seen clearly by differentiating the net benefit of adoption by $\rho$:

$$\begin{aligned} \frac{\partial B_{it}}{\partial \rho} &= -(1+\delta\pi)\mathrm{Var}(v|n_t)+\delta\pi\mathrm{Var}(v|(n_t+1) && (16) \\ &= -\mathrm{Var}(v|n_t)+\delta\pi\{E[\mathrm{Var}(v|n_t+1)|n_t]-\mathrm{Var}(v|n_t)\} && (17) \end{aligned}$$

Regardless of the value of the discount factor, the effect of increased $\rho$ is always negative. To see why, note that the variances are decreasing in $n_t$. This means the first term is always larger in magnitude than the term that is multiplied by the discount factor. Moreover, this means that sufficiently risk-averse legislators will expect to never adopt the technology in the future. Absent some difference in the distribution of signals received to date and future signals (or priors that are sufficiently divergent from the true quality), they will never adopt the technology in finite time.

Adjusting the sensitivity to reward and punishment also has important effects on the net benefits. Differentiating with respect to $\alpha$ and $\beta$,

$$\begin{aligned} \frac{\partial B_{it}}{\partial \alpha} &= r\left\{\Phi_t+\delta\pi(\Phi_t-\Phi_{t+1})\right\} && (18) \\ \frac{\partial B_{it}}{\partial \beta} &= \lambda\left\{-1+\Phi_t+\delta\pi(\Phi_t-\Phi_{t+1})\right\}. && (19) \end{aligned}$$

When the signals to date are sufficiently high on average (that is, $(1+\delta\pi)\Phi_t-\delta\pi\Phi_{t+1}>1$), then the effects of increases in Extraversion/sensitivity to reward (measured by the $\alpha$ parameter) and Neuroticism/sensitivity to punishment (measured by the $\beta$ parameter) on the expected benefit are always positive. Conversely, when the signals to date are sufficiently low on average (that is, $(1+\delta\pi)\Phi_t - \delta\pi\Phi_{t+1} < 0$), then the effects of increases in $\alpha$ and/or $\beta$ are always negative. However, when the signals to date are sufficiently ambiguous (that is, $(1+\delta\pi)\Phi_t - \delta\pi\Phi_{t+1} \in (0,1)$), then increases in $\alpha$ increase the expected benefit and increases in $\beta$ reduce the expected benefit. Therefore, when uncertainty is low, and the signals to date are relatively clear, highly Extraverted and highly Neurotic legislators will act similarly. However, when uncertainty is high and the signals are weak and ambiguous at best, the behaviors of Extraverted and Neurotic legislators will diverge, a dynamic previously suggested in Figure 2. In other words, when the proverbial glass is half-full, Extraverted legislators will focus on the water that is present, and Neurotic legislators will focus on the empty space.

Last, what happens when we adjust the prior precision for the value of adoption, $\tau_v$? When this parameter is close to 0, the legislator is incredibly uncertain about the value of adoption. The net benefit of adoption is thus

$$\begin{aligned}\lim_{\tau_v\to 0} B_{it} &= (1+\delta\pi)\left\{\bar{s}_t - \frac{\rho}{n_t\tau_\varepsilon} - \beta\lambda + \Phi(\bar{s}_t\sqrt{n_t\tau_\varepsilon})\cdot(\alpha r+\beta\lambda)\right\} \\ &\quad -\delta\pi\left\{\bar{s}_t - \frac{\rho}{(n_t+1)\tau_\varepsilon} - \beta\lambda + \Phi\left(\bar{s}_t\sqrt{(n_t+1)\tau_\varepsilon}\right)\cdot(\alpha r+\beta\lambda)\right\} \qquad (20)\\ &= \bar{s}_t - \beta\lambda - \frac{\rho}{\tau_\varepsilon}\left(\frac{1+\delta\pi}{n_t} + \frac{\delta\pi}{n_t+1}\right) \\ &\quad +(\alpha r+\beta\lambda)\cdot\left\{(1+\delta\pi)\Phi(\bar{s}_t\sqrt{n_t\tau_\varepsilon}) - \delta\pi\Phi\left(\bar{s}_t\sqrt{(n_t+1)\tau_\varepsilon}\right)\right\} \qquad (21)\end{aligned}$$

Here, a lot hinges on the discount factor/Conscientiousness, which can be more clearly illustrated by taking the derivative of $\lim_{\tau_v\to 0} B_{it}$ with respect to $\delta$.

$$\frac{\partial\left(\lim_{\tau_v\to 0} B_{it}\right)}{\partial\delta} = -\frac{\rho}{\tau_\varepsilon}\left(\frac{p(1+2n_t)}{n_t^2+n_t}\right) + \pi(\alpha r+\beta\lambda)\cdot\left(\Phi(\bar{s}_t\sqrt{n_t\tau_\varepsilon}) - \Phi\left(\bar{s}_t\sqrt{(n_t+1)\tau_\varepsilon}\right)\right) \quad (22)$$

Note that $-\frac{\rho}{\tau_\varepsilon}\left(\frac{\pi(1+2n_t)}{n_t^2+n_t}\right)$ is always negative. Additionally, $\pi(\alpha r+\beta\lambda)$ is always positive, as are

$\Phi\left(\bar{s}_t\sqrt{n_t\tau_\varepsilon}\right)$ and $\Phi\left(\bar{s}_t\sqrt{(n_t+1)\tau_\varepsilon}\right)$. Therefore, the decision will largely hinge on the signals to date. If they have been sufficiently high, then increases in Conscientiousness will reduce the benefits from adoption today as opposed to tomorrow, since legislators will be more cognizant of future losses in the presence of almost complete uncertainty. In this case, they will be willing to wait until tomorrow, when they will be more certain of the benefits. However, if the cumulative signals thus far have been sufficiently low, then increases in Conscientiousness will increase the *net* benefits (though not necessarily the absolute benefits), since more Conscientious members will place more weight on the draw from the the narrower distribution with the same low mean in the next period. However, it should be reiterated that decreases in the expected quality of the technology will always decrease the expected instantaneous (that is, not the *relative* or *net* benefit) utility from adoption.

Conversely, when $\tau_v$ is very large (and, hence, the legislator is precisely informed about $v$), the expected net benefits from adopting today over tomorrow reduce to a simple weighted trade-off between the instantaneous reward and the instantaneous punishment:

$$\lim_{\tau_v \to \infty} B_{it} = \frac{\alpha r - \beta \lambda}{2}. \tag{23}$$

This makes sense, intuitively; we assumed the legislator's prior for the mean of $v$ is 0, so as $\tau_v \to \infty$, the prior trumps the data. Waiting indefinitely will be preferable when one's sensitivity to punishment multiplied by the expected punishment is less than one's sensitivity to reward multiplied by the expected reward. When this is not true, then the technology will be immediately adopted. Put more simply, when legislators are precisely informed, the technology will be adopted when legislators are sufficiently Extraverted and it will not be adopted when they are sufficiently Neurotic.

Overall, the intuitions from this model line up cleanly with the cognitive constraint framework we proposed. Recall that Extraversion and Neuroticism are related to sensitivity to reward and punishment, respectively. Specifically, Extraverts are more sensitive to reward than Introverts and Neurotic legislators are more sensitive to punishment than those who are Emotionally Stable. In our model above, the parameters $\alpha$ and $\beta$ are defined as sensitivity to reward and punishment, respectively. Linking the comparative statics for these parameters with the Big Five, we should expect legislators who are Extraverted (Neurotic) should be more willing to undertake the risks associated with adopting the new platform *sooner* (*later*).

Going further, it seems natural to think that, as time goes on and information is revealed, the risks associated with adopting the new platform will dissipate. Recall that $\rho$ captures the degree of risk aversion, as this is multiplied by the variance term. Since the variance goes to 0 as $n_t$ increases to infinity, we should expect that adoption should speed up with an accumulation of favorable signals about the technology's worth.[15] However, those with lower $\rho$s—that is, those who are more Open—will be more willing to adopt the technology under greater uncertainty. Finally, we also show that the discount factor $\delta$—which captures the personality trait of Conscientiousness—plays an important role, as it enhances/mitigates the roles played by the other traits.

## Discussion and Next Steps

Our findings highlight an opportunity to enrich models of legislative behavior with parameterizations of cognitive constraints informed by personality. Psychology is accumulating evidence that the traits discussed here are particularly important individual differences, and we can learn a great deal from that field and in turn apply the clarity of formal modeling to develop theories about how cognitive constraints affect behavior. We see no reason why this framework is only applicable to legislative institutions, and we believe it can be applied to create novel models of the presidency, bureaucracy, and judiciary, and even international relations.

[15] Chi & Yang (2010) approximate this idea for Twitter by controlling for the average of the number of followers divided by the number of tweets for legislators who adopted *prior to* legislator $i$ as a proxy for this evolving uncertainty. When the number of Twitter users among Congress was low, prospective users would have to rely on few signals in making their decision to enter or not.

A logical next step in this project is to incorporate the decision to adopt new technology into a strategic interaction. A potential option along this pathway is to allow two candidates to compete by adopting new media, and allowing a donor to invest in the candidate who reveals the most favorable personality profile. Conversely, candidates from the same party who are not competing against each other could potentially coordinate on technology adoption in order to present a unified party image. This would be one way to incorporate Agreeableness into the model, as candidates who are not the most tech-savvy might adopt new technologies for the benefit of the larger party (or, alternatively, technophilic candidates might spurn adoption in order to not detract from a larger party mission.)

Additionally, this model could be extended to a number of legislative decisions which involve an uncertain investment with learning, including the decision to make political endorsements or cosponsor specific pieces of legislation. The objectives of these decisions could affect the utilities of others, offering yet another opportunity to incorporate Agreeableness and ensure that each of the Big Five traits are considered. For example, the decision to endorse candidates can also include a term capturing the degree to which potential endorsers weigh united partisan fronts versus their own preferences; this would be another way to incorporate Agreeableness into the model.

We might also consider the possibility that Extraversion and Neuroticism are not only weights respectively placed on reward and punishment, but that they also capture the prior distributions placed on them. More Extraverted members might not only place greater weights on the potential rewards, but they may also believe the potential rewards themselves to be greater and more certain (that is, with a higher mean and lower variance). Conversely, it might be that more Neurotic individuals not only place greater weight on the potential punishments that may result from their actions, but that they also believe the potential punishments to be greater and less certain due to self-doubt (Gray & McNaughton 2003, Heatherton, Macrae & Kelley 2004, DeYoung et al. 2010). Relatedly, more Neurotic members may perceive the status quos differently than more Extraverted members; for example, in the current example, more Extraverted members might see the status quo as a world in which they have not yet adopted the technology—and therefore gain rewards by joining—whereas more Neurotic members might see the status quo as a world in which they are missing out by not yet having adopted—and are therefore punished if they fail to join. Alternatively, they may simply have priors of different strengths. Considering these dynamics would undoubtedly complicate the model, but might provide a richer description of the underlying decision-theoretic process.

Finally, the overall framework can be developed further, with more nuanced parameterizations of the Big Five, as additional evidence from personality neuroscience and experimental economics becomes available. Additionally, it will likely prove fruitful to consider the 30 lower-level facets within the five factor structure for adaptation into modeling parameters as well. For example, Openness to Experience consists of six facets, Imagination, Artistic Interests, Emotionality, Adventurousness, Intellect, and Liberalism. As examined by DeYoung & Gray (2009), Intellect is a distinct entity from the other components of Openness to Experience, and a parameterization of cognitive ability may enrich many models. This would be a major undertaking and is largely dependent on the availability of new findings linking the thirty facets with brain functions.

Overall, focusing on elites' personalities can offer new insights into why politicians vary in how they pursue their goals. We believe personality trait measures capture underlying cognitive constraints associated with officeholders' decisions to choose certain political tactics in a manner conducive to formal modeling. These findings suggest voters have reason to pay attention to representatives' personalities, and also suggest additional work to connect personality with specific legislative actions—both theoretically and empirically—are in order, which will significantly enrich our understanding of how citizens, their elected officials, and policy interact.

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