Are Political Systems Poised between the “Order” of Friction and the “Chaos” of Urgency?
Public Budgeting in Comparative Perspective

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Abstract

Political dynamics are likely to proceed according to more general laws of human dynamics and information processing, but the specifics have yet to be outlined. Here we begin this task by examining public budgeting in comparative perspective. Budgets quantify collective political decisions made in response to incoming information, the preferences of decision-makers, and the institutions that structure how decisions are made, but most models to date stress preferences (organized by political parties) almost exclusively.

We begin by noting that input distributions for complex information-processing systems are Gaussian, providing a standard for comparing outputs against inputs. Then we show through a set of simulations that a properly modeled political system with friction and error accumulation features have outputs whose period-to-period changes are distributed as a double exponential (because policy change can go either in a positive or negative direction) when inputs are Gaussian. Next we examine public budget change distributions from a variety of countries and levels of government, finding that they are invariably distributed as double Paretians—two-tailed power functions. We found differences in exponents for increasing budgets than for cutting them (the latter are more punctuated) for most systems, and for levels of government (local governments are less punctuated).

We conclude that it is not likely that cognitive (preference-based) or institutional friction, alone or in combination, can account for budget change distributions. The fat tails of budget change distributions are unexplained. Policymaking systems require more than error accumulation of signals to account for their behaviors. The driver for budget fat tails is likely found in shifts in collective urgency. Budgets trace collective priorities, and priorities shift when a collective sense of urgency occurs. The re-prioritization associated with urgency (sometimes carried in elections, sometimes not) overcomes the inherent friction of political systems, resulting in signature power functions.

Are Political Systems Poised between the Order of Friction and the Chaos of Urgency?[1]

Political systems, like many social systems, are characterized by considerable friction. Standard operating procedures in organizations, cultural norms, and all sorts of facets of human cognitive architectures act to provide stability of behavior in a complex world. In politics, ideology and group identifications provide stable guides to behavior in complex circumstances. In politics, however, a second source of friction exists: institutional rules that constrain policy action. In the United States, policies can be enacted only when both houses of congress and the president reach agreement on a measure. In parliamentary democracies, action may be constrained by the necessity to put together multi-party governing coalitions. Institutional rules 'congeal' preferences (Riker 1980), making it difficult for new policies to enter the political arena.

In the past, scholars characterized these systems using *comparative statics*, a method of analysis that concentrated on equilibrium processes based on the preferences of decision-makers. (Shepsle and Weingast 1987, Krehbiel 1998). Change was admitted primarily though the replacement of governing parties through elections, which established a new preference-based equilibrium to which the policymaking system quickly adjusted. But comparative statics ignores the on-going information-processing needs of an adaptive system, and political systems are clearly adaptive systems. They dynamically respond to incoming information, not just the preferences of those making decisions.

Punctuated equilibrium has provided an alternate analytical frame (Baumgartner and Jones 1993; True, Jones, and Baumgartner 2007). The stability imposed by the two kinds of friction, cognitive/organizational friction and institutional friction, does not cause universal gridlock, with a system awaiting elections to point to change. But it is a retarding force that interferes with the smooth adjustment of a political system to changing information signals from the policymaking environment. This force resembles the friction that occurs in the physical world, in that change occurs but only when the informational signal from the external world either is extraordinarily strong or when the signals accumulate to overcome the friction. These latter processes are described as *error accumulation models* (Larkey 1978), in that the deviation between the external world and the system response gets increasingly out of kilter until the system can no longer ignore the deviation.[2]

Systems characterized by friction remain stable until the signals from outside exceed a threshold, and then they lurch forward; they will continue moving only if the external signal continues at greater than threshold strength. Otherwise they resume 'equilibrium'. It is likely that political systems overcome friction when a sense of urgency about the external world drives decision-makers to re-prioritize their

[1] We appreciate comments from Didier Sornette.

[2] Error accumulation models are a special case of non-linear error correction models—they lead to much larger deviations before the 'error' is corrected than the more typical model.

preferences. Urgency causes collective attention to focus on a very limited number of issues out of the panoply that are candidates for government action; these issues are rewarded by disproportionate attention, often leading to large changes in budget allocations. These dynamics lead to highly leptokurtic frequency distributions of policy change in the United States and elsewhere (Jones and Baumgartner 2005a; Breunig, Green-Pederson, and Mortensen 2005).

In this paper we report results from an analysis of ten separate budgetary datasets from six nations, using approaches common in natural sciences but only now being adopted in the social sciences. In particular, a new field of study known as 'econophysics' uses methods and concepts from physics to study financial market data (Matenga and Stanley 2000). Econophysics relies heavily on a branch of statistical study termed extreme value theory (Kotz and Nadarajah2000; Sornette 2006), as we do here. We use these stochastic process methods to examine the full budgetary frequency distributions rather than the typical social science focus on moments (means and variances when Gaussian, or normal-curve, statistics are employed).

Our results illustrate the power of incorporating policy punctuations as part and parcel of the dynamics of policy change, rather than exceptions that must be explained by reference to special conditions. Within that general framework, we show that institutional and cognitive friction cannot account for the distribution of budgetary policy changes. Friction is implicated, but cannot completely explain the patterns we observe. The driver of large punctuations (generating fat tails) is likely found in shifts in collective urgency when, for reasons having to do with interpretations of events, decision-makers sense an immediate need to make policy changes and act accordingly.

Change Distributions

Histograms may roughly be characterized by three aspects: peak(s), tails, and shoulders. Here we study change phenomena; that is, the difference between behavior at two times. In such distributions, there is typically a single peak at the mode, centered at zero, which represents no change from the previous period.[3] The shoulders of the distribution indicate moderate changes from the status quo, while the tails indicate extreme changes. Much of the literature on fat-tailed dynamics has concentrated on the extremes, but shoulders are important as well, and it is possible that different dynamics account for the peaks, shoulders and tails.

It seems reasonable to surmise that, if we were to examine the tails of a frequency distribution of budget changes, urgency would generate fat tails, while friction would cause slender central peaks, essentially indicating no change from the previous budget allocation, and weak shoulders. Friction alone should not generate particularly fat tails, because there is no 'driver' for really big changes, but it should account for weak shoulders—the lack of moderate adjustments to incoming information. We suggest that the process of problem definition infuses issues with a sense of urgency that can overcome the friction inherent in policymaking systems.

[3] In a dynamic growth process such as characterizes budgets, the mode would be a positive increment.

Budget allocations to issues that demand public action (including the issue of reducing the size of government) are poised between the ‘order’ of friction and the ‘chaos’ of urgency.

Budgets set public priorities; they are the outcomes of complex policy processes involving the nature of the decision-making institutions, the preferences of decision-makers (organized by political parties), and informational signals from a changing environment. Institutions and political preferences generate friction; they are resistant to change. Punctuated equilibrium theory predicts that changes in governmental priorities will be abrupt and disjoint. Normally policies are at equilibrium; only under conditions of strong mobilization will extreme changes occur; moderate changes normally do not occur. These processes generate highly leptokurtic frequency distributions for changes in policy commitments (Baumgartner and Jones 1993; True, Jones, and Baumgartner 2007).

One important class of leptokurtic frequency distributions are Paretian distributions, or power function distributions.[4] Such distributions are characteristic signatures for dynamical processes harboring critical regimes. There are a number of different processes that can lead to power functions, but generally change models involve systems occasionally getting into critical states in which large-scale punctuations are much more probable than in sub-critical states. Critical regimes are poised between ‘order and chaos’—that is, between ordered incremental change and rapid, discontinuous change (Bak 1997; Sornette 2006, 2003; Mandelbrot 2004).

What this means for public budgeting is that it would be possible for policymaking to be pushed into an area in which even small external disturbances can result in large, cascading changes. Major policy changes can be associated with electoral replacement, so that electoral changes can set the conditions for critical states in the policymaking process (Wlezien 1996; Peterson, Grossbeck, and Stimson 2003; Stimson 2004). But major changes also often occur in inter-election periods, at least in the US (Jones and Baumgartner 2005: 84). Clearly major policy punctuations occur; the issue we raise here is whether political systems can be generally characterized as complex, evolving systems displaying punctuated dynamics that are not always associated with large-scale changes in the environment. In a nutshell, that is what is conveyed by the notion of critical regimes.[5]

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[4] Paretian or power function probability distributions are defined as $p(x) = x^{-\alpha}$, where p(x) is the probability that the variable takes the value x. The cumulative probability distribution function, which is often easier to work with empirically, is defined as $P(x) = x^{-(1+\alpha)}$, where P(x) is the probability that the value of the variable is greater than x. These formulas describe one-tailed distributions; for budget distributions, in which reductions are possible, we use a two-tailed version.

[5] One particular mechanism of criticality that has gained considerable repute is Per Bak’s self-organized criticality (SOC). In this model, evolving systems get themselves continually into critical states. It is a more difficult claim to sustain than the contention that we advance here, which is that political systems can get into these critical states. SOC requires both power law distributions of changes and long-run power law decay of autocorrelations (Sornette 2006: 396). For evidence of the latter for US budgetary series, see Jones 2006.

We already know that frequency distributions of public budget changes are leptokurtic for all cases studied thus far (True, Jones, and Baumgartner 2007).[6] Can this invariance be extended to incorporate the theory of critical regimes? Do political systems display power function probability density functions? Power function frequency distributions characterize many market-based transactions, and the exponents for these transactions are similar for different kinds of markets and transactions (Mandelbrot 2004; Gabalx, Goplkrishnan, Plerou, and Stanley 2003). Market transactions differ from political interchanges in one very important sense: in modern markets, there are limited formal decision costs in choosing to pursue a transaction. In politics, collective decision-rules limit the freedom of choice of any set of actors. Markets may be governed by cognitive friction that is overwhelmed occasionally by the sense of urgency (to buy or to sell), but institutional friction is much less a limitation on the behavior of actors. Friction is greater in politics than in markets.

In this paper we first note that input distributions for complex information-processing systems are Gaussian, providing a standard for comparing outputs against inputs. Then we show through a set of simulations that a properly modeled political system with friction and error accumulation features have outputs whose period-to-period changes in output are distributed as a double exponential (because policy change can go either in a positive or negative direction).[7] In comparison to the Gaussian input distribution, the exponential output distribution is weak-shouldered, and it has tails that are less extreme than power functions (but much fatter than the Gaussian). That is, it fails to produce output distributions that are moderate; change is either very small, concentrated at the mean, or it jumps, but these jumps are of fairly limited magnitude (in comparison to the fat-tailed power function, for example).

Finally we examine public budget change distributions from a variety of countries and levels of government, we find that they are invariably distributed as double Paretians—two-tailed power functions; exponential distributions may be ruled out. Real outputs are both weak shouldered and fat-tailed. Real policymaking systems either move very little from equilibrium, or they lurch forward, and in some cases lurch forward in huge policymaking changes.

We conclude that it is not likely that cognitive and institutional friction, alone or in combination, can account for budget change distributions. The fat tails are unexplained. Policymaking systems require more than error accumulation of signals to account for their behaviors. It is probable that these systems require the positive feedback effects characteristic of fads and other cascades to account fully for the system's policy actions, and these are associated with urgency and re-prioritization.

A Gaussian Beginning

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[6] Cases include US Budget Authority, US states, US municipalities, Texas school district budgets, Danish municipalities, UK national government, and the national budgets of France, Germany, Belgium, and Denmark.

[7] Exponential probability density functions are described by the expression $p(x) = \mu e^{-\mu x}$, where e = 2.71828…

In many real-world information-processing situations, we do not have the luxury of observing the actual informational input, because we observe only whether the decision-maker attends to that information and what action he or she subsequently takes. Nevertheless we can make some sensible inferences about the structure of the incoming information. Central limit theorems guarantee that in any situation where a decision-maker combines numerous sources of information in an implicit index, the limit of the distribution of that information will be Gaussian, so long as any one stream is not too disproportionately weighted and the streams are not highly correlated (Jones and Baumgartner, 2005b). In making budget decisions, when decision-makers incrementally adjust this year's budget from a starting-point of last year's budgets, annual changes will be Gaussian. This is but a special case of the index-construction model (Jones and Baumgartner 2005b), and leads to outputs that are proportionate to the strengths of input signals. Moreover, it can be shown that the incremental model, which Padgett (1980) showed must generate a Gaussian distribution of changes, is a special case of the proportionate updating model (Jones and Baumgartner 2005b).[8]

It is important to understand that we distinguish between information *signals*, detectable changes in the environment that are potentially relevant for policymaking, and the *news*, which is that part of the set of signals that decision-makers (including newspaper editors) attend to. The Central Limit Theorems can be sensibly assumed to apply to signals, but of course cannot characterize the distribution of attention or news. In what follows, we use this assumption to justify the starting-point of our simulations (which is a step above many such exercises, which simply assume normality). But the assumption does not influence at all the analysis of the budgetary data sets.

In real-world situations, decision-makers prioritize information in a manner than invariably leads to deviations from this proportionate processing of information (Jones and Baumgartner 2005a). They prioritize, and prioritization leads to non-Gaussian dynamics. Indeed, setting priorities causes bursts of activity characterized by fat-tailed distributions. Studying email communications, Barabasi (2005) shows that waiting-time models of processing information, which follow Poisson distributions if inputs are not weighted by their importance (such FIFO inventory control systems or random processing), will follow power distributions if people prioritize the inputs based on the perceived urgencies of incoming messages. In more complex decision-making situations, decision-makers often do not update the set of indicators that guide their behavior—an example of friction. Then a sense of urgency will occasionally lead to overcoming the built-in friction that occurs in all human institutions. This implies that even if inputs are Gaussian, outputs from governments and other complex institutions will not be, but are likely to be characterized by fat-tailed dynamics.[9]

Many real distributions which involve combining diverse input streams are Gaussian. For example, quarterly change in real US GDP, assessed from the first of

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[8] Padgett further derived budget decisional models that are leptokurtic and in some cases Paretian.

[9] In Barabasi's model, the tails of a distribution of response time represent delayed action whereas the peak indicates the urgency associated with short processing times. In the study of shifting policy priorities, the peaks of a budget distribution indicates the lack of urgency, while the tails, indicating big shifts in budgetary allocations, point to urgency.

1947 through the end of 2005 is Gaussian (see Figure 1), because there are enough independent components of GDP to meet the necessary Central Limit Theorem assumptions. Moreover, the state of the economy affects government budgets. If governments directly keyed expenditures to the economy, they would be Gaussian. That is, in this key situation linking a budget to an over-weighted indicator will still yield Gaussian budgets. Many local governments are required constitutionally to balance their budgets, and hence are more likely to have less punctuated outputs—because a constitutional mandate chains the normally disproportionate policymaking process to a Gaussian input stream.

Simulating Political Friction

As Per Bak's sandpile experiments have shown, physical systems with friction are capable of generating power functions, even when inputs (grains of sand) are incrementally added. His sandpiles generated either very small landslides or very large ones, but no moderate-sized slides. But lots of sandpiles have friction, and only very special ones generate such phenomena—those 'poised at the brink of chaos' (Bak 1997). Bak's systems resemble error accumulation models in that the sandpile has 'under-adjusted' to the accumulation of pressures with small landslides, and then must adjust in one fell swoop. Because there is no theoretical reason to expect that the friction of policymaking systems mimics sandpiles (or any other physical model of friction), we need a model of the friction associated with policymaking systems. We present such a model here.

We have designed a computer simulation to examine the friction component of our approach, and we use it here to examine whether institutional friction can generate power functions. The simulation has four components:

- A *signal* that is input into a hypothetical policymaking system
- A *friction mechanism* that sets a threshold below which the system responds only partially
- An *error accumulation* feature that builds up pressure in the environment that may produce subsequent policy action
- A *response* that is dictated by the strength of the input signal and institutional friction that has accumulated from previous periods

In the simulation, we draw an input signal from a Gaussian distribution, and run it through a system that adds friction. Friction is modeled by a parameter that operates as a threshold. Above the user-specified threshold, the signal generates a response equivalent to the strength of the signal—the signal has overcome the friction. Below the threshold, it generates a partial response. The extensiveness of the response is governed by the user-specified efficiency parameter, λ; if $\lambda = 1$, then there is essentially no threshold and no institutional friction. The signal passes through the institutional frame unhindered, generating a response proportional to its strength. If $\lambda = 0$, then there is not even partial response to the signal, and friction is at its maximum. We have "gridlock"—no response whatsoever. (Gridlock is but a special case in this model.) If $0 < \lambda < 1$, then the system responds to the input signal with some fraction of the signal strength.

The model also has an "error accumulation" feature by which partial responses allow the system to get out of adjustment to its informational environment. If the signal is hindered, that portion of the signal that fails to generate a response cumulates and is added to the next period's signal strength. This simulates the build-up of pressure when problems fester and are only partially addressed. But it is possible that the whole situation will "blow over," and that happens in the model when an input signal receives a negative sign when the cumulated signal is positive (and vice versa). That is, the model allows accumulated pressures both to build up and to dissipate.

Finally β, the user-set amplification parameter, allows for the signal to be magnified or attenuated in the translation process. It is linear only, whereas positive feedback effects might be modeled in a more complex fashion. But at present we simply want to examine whether a simple dynamic friction process can generate power functions.[10]

The simulation relies on repeated random draws that are run through the system. These random draws are the S_t –that is, the hypothetical time series, and t is one million. Results of our hypothetical policymaking system that has run for a million time periods are input into a frequency distribution plotting categories of the response variable against the frequencies associated with these categories. This allows us to study the shape of the distribution.

Numerous runs of this simulation under appreciable friction always yield leptokurtic output distributions. Figure 2 shows a typical frequency distribution generated from the simulation. The x-axis plots the category midpoints of the response variable, and the y-axis plots the frequencies associated with these categories. But what kind of leptokurtic distribution underlies this figure? The likely candidates are the exponential and the Paretian. We decide between them by plotting the logarithm of the frequencies of the distribution against the category midpoints of the variable to test for the exponential distribution, and plot the logarithm of the

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[10] The model may be written as follows:

The variables:
R_t = Response
S_t = Input signal

The parameters:
C = friction parameter
λ= efficiency parameter
β = amplification parameter

$R_t = \beta S_t$ if $S_t + \Sigma S_{0<k} > C$; otherwise $R_t = \lambda\beta S_t$

Where: $0 < \lambda > 1$; [λ may vary between 0 and 1];
$0 < t > k$ [the time series goes from period 0 to period k]
$S_t = N(0,1)$ [each input signal is drawn from a Standard Normal distribution]

9frequencies against the logarithm of the category midpoints to test for the Paretian distribution (for further discussion, see Jones and Baumgartner 2005a: 161-64). [11]

Study of log-log and log-linear plots of the tails of the distributions generated over a multitude of simulations indicate that the friction simulation generates exponential distributions rather than power functions.[12] Figure 3 illustrates a typical result.

Essentially the friction simulation eliminates the possibility of moderate responses to input signals, but it does not automatically generate fat tails. Friction, at least as modeled here, cannot account for fat tailed dynamics in social systems. However, in studying year-to-year shifts in priorities where counts of activities are assessed, as in the case of the number of congressional hearings conducted on a topic, frequency distributions are clearly exponential (Jones and Baumgartner 2005a). Exponential distributions do occur in policymaking, and are likely a consequence of friction. Budgets differ from these distributions because, in effect, the room for expansion on the tails is much larger in the case of budgets; in the case of count data one cannot expand the number of hearings beyond the carrying capacity of the organization (that is, there are clear ceiling effects).

The Empirical Analysis of Budget Distributions

Several studies have shown that budget change distributions are highly leptokurtic, with strong central peaks and extended tails, and clearly not Gaussian (True, Jones, and Baumgartner 2007; Jones and Baumgartner 2005a; Jordan 2003; Robinson, 2003; Mortensen 2005; John and Margettts 2003; Breunig 2004; Soroka, Wlezien, and McLean 2006; Breunig and Koske 2006; Baumgartner, Foucault, and François 2006). Yet systematic comparisons across different political systems are lacking, and the particular probability distribution functions have only occasionally been studied.

To remedy this, we have assembled datasets on public budgets from seven national governments and three subnational governmental units. For two long series for France and the United States, we analyze year-to-year inflation-adjusted percentage changes; for the other datasets, we have pooled across budget categories (and across the sub-units for subnational governments), again using percentage changes. This is necessary in the latter case to ensure that the distributions are not dominated by one or two really large budget categories; it is desirable in the former to enable comparison. Table 1 briefly describes these datasets.

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[11] To test for the Paretian, we take the logarithm of both sides of the the expression $y = ax^b$, where x represents the category midpoints of the variable of interest and y represents the frequencies associated with the midpoints. This yields $\ln(y) = \ln(a) + b\ln(x)$, which will plot as a straight line if the distribution is Paretian. To test for the exponential, we take the logarithm of both sides of the expression $y = ae^{bx}$, which yields $\ln(y) = \ln(a) + bx$, again a straight line, but this time the logarithm of the frequencies is plotted against the actual values of the category midpoints. Whether one uses natural or common logarithms is immaterial.

[12] The simulation produces distributions such that peaks are not contiguous with tails by virtually collapsing the shoulders of the distribution. Peaks have exponential signatures, as do tails, but the full distribution cannot be described by a single lawlike probability density function because they have radically different slopes.

Government expenditure data is notoriously unreliable at any but the most aggregate level, because categories are added and subtracted for accounting purposes but are not generally adjusted backwards to ensure comparability with earlier data. "Off the shelf" budget datasets should generally not be used for analysis across categories. Moreover, national governments do not usually maintain separate capital budgets, so budget decisions and the outlays generated by those decisions can occur in different fiscal years. As a consequence, it has been necessary for us to make certain that all series are internally comparable, which has involved a great deal of tedious adjustments for each series. This accounts for the fairly short time periods covered by some of the datasets.

The somewhat shorter time series on disaggregated budget data is more than offset by the advantage this data offers: a direct assessment of changing priorities of government. "Off the shelf" budget data is not acceptable exactly because of this: the creation of new categories and the failure to up-date older series will cause the investigator to mistake accounting adjustments for shifts in priorities.

If priorities are changed moderately, in proportionate response to incoming signals, then budgetary outputs will approximate a Gaussian distribution. Changes in government policies will mimic the input distribution, which in a complex world will approximate the Gaussian. The Gaussian, unlike either the power or exponential family of distributions, has strong shoulders; moderate changes from the status quo are the norm.[13]

Our simulations suggest that friction alone generates exponential distributions. What happens when priorities are shifted abruptly, as decision-makers suddenly feel a sense of urgency about incoming information? The most likely outcome is a power distribution of outcomes, as limited attention spans of policymakers is devoted to one problem at the expense of the many others that remain components of the incoming mix of signals. Changing priorities to incoming signals will also be reflected in overall budget totals as well, but totals cannot be as sensitive to changing issue priorities.

The varieties of budgets we have examined pose a strong test for any general pattern for distributions of budget changes. Economies are far less volatile today than in the past as economic management in the developed world improves, so that volatility of budget series has damped down over time. This reduced budgetary volatility can be clearly seen in Figures 4 and 5, which show inflation-adjusted expenditures for the US national government from 1800 to 2004.[14] In the past, political systems were more subject to external events; today national systems, especially large nations, have more control over their economic affairs. In addition, they may borrow to cover current expenditures, allowing more government growth than if a strict revenue requirement were enforced. On the other hand, because of the demands of national governments or state constitutions, sub-national local governments generally

[13] If decision-makers are able to adjust proportionately, output distributions will be Gaussian even if decision-makers are up-dating from past information. See Jones and Baumgartner 2005b.

[14] Figure 5 also illustrates the 'war ratchet' of Peacock and Weisman (19xx): when war occurs, both defense and domestic expenditures go up, and domestic expenditures tend to stay at the higher level)

must match their expenditures to incoming revenues. Can all of this variability be summarized by a single law of change?

Figures 6, 7 and 8 depict frequency distributions and log-log plots for the long budget series. In the cases of both France and the US, inflation-adjusted outlays follow a power function distribution. For the US, both defense and domestic expenditures have signature power function frequency distributions. As Table 2 indicates, the exponents for both series center on -0.9 (with France slightly lower than the US) for the positive tail, but are higher for the negative tail. Higher positive (right) tail exponents but lower negative (left) tail exponents indicate fatter tails. These estimates indicate that it is easier to increase expenditures than to decrease them.[15] As we see, this is a general characteristic of all budget distributions.[16]

Figures 9, 10, 11 and 12 show both frequency distributions and log-log plots for US Budget Authority over Office of Management and Budget programmatic subfunctions, and German and French programmatic expenditures over several ministries. Because the data is pooled, the distributions represent shifts from one programmatic expenditure category to others—a direct estimate of shifting priorities of governments.

The distributions of all three series both follow power functions, and in all three cases growth punctuations are more probable than cutback punctuations. Indeed, the negative tail for the US is not discernibly distinct from an exponential fit. It is perhaps not surprising that modern governments find it more difficult to cut back programs significantly than to expand them dramatically.

Figure 13 depicts log-log plots for the rest of the national governments. All show power function frequency distributions, and most show a tendency to have more difficulties in cutting programs in a very large fashion than in increasing them greatly. None of the national governments, however, show the strong difference between the tails that is evident in the US plot.

We conclude that national governments shift priorities according to a power function, and in a manner generally consistent with punctuated equilibrium. This holds for both the United States, with its presidential system, and for parliamentary democracies. Moreover, the governments we studied generally experienced more resistance, or friction, in cutting programs than in expanding them. In particular, the shoulders of the negative tail for the national distributions are considerably stronger than those for the positive side, suggesting more resistance—to the point of approaching the exponential distribution for the US. This is most easily seen in Figures 9, 11b, and 12b.

It is likely that the positive tails of these distributions are affected by both institutional friction and the general sense of urgency—this end of budget distributions

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[15] Both increases and decreases of expenditures occur relative to a long-run positive mean due to increasing economies.

[16] We may rule out this being an artifact of using percentages (proportions), as the right tail of these distributions terminates before reaching 100%. Moreover an examination of first differences for these series indicates no censored data issues.

are poised between friction and urgency. The negative tail, however, may be mostly dominated by friction—it is normally less urgent to cut programs for national governments than to increase them. National governments can borrow money to fund operating expenses, and this allows a more mellow approach to cutting programs. Moreover, in harsh economic times, it is not a good economic idea to cut programs, contributing to declines in economic demand, and this adds a policy justification for the less extreme cuts in national budgets.

Making comparisons among governments is more difficult. One might think that the US, with its strong constitutionally-mandated institutional friction, would display a distinct pattern from the rest of the western democracies we studied, but that is not clearly the case. Urgency and re-prioritization seem to operate in roughly similar ways for budgetary changes in democratic societies regarding the general form of the relationship.

Turning to the sub-national governments, depicted in Figures 14 -16, we detect considerable differences from the national governments. All may be classified as power functions and the US state governments unambiguously so. But for the local governments (Danish local governments and Texas school districts), the situation is not quite as clear. Examining the Danish local government case in more detail, we can see the distribution falls somewhere between an exponential and a power function—and even a log-normal characterization is not out of the question. But they are clearly not Gaussian; these governments do not make proportional decisions any more than national-level governments do. But they are much less subject to immoderate punctuations than national governments.

In comparison to the national governments, the distributions of the sub-national governments we studied are remarkably symmetrical. Table 3 shows that the power function exponents are quite similar. Both increasing budgets and cutting them must overcome friction; neither tail comes anywhere close to the expected Gaussian for fully proportionate decision-making. But sub-national governments are about as likely to cut budgets as to raise them; one gets a sense of on-going reprioritization that is far more moderate than happens at the national level. It is likely that this is a function of mandates imposed on these governments by their superior governmental units. States in the US can borrow only for capital needs, and hence cannot borrow to tide over required cuts. Generally local governments meet restrictions on the money they raise locally and the grants they receive from higher levels of government. The result is a far more balanced fiscal system than what occurs at the national level.

Conclusions

1) Public budgets in modern democracies are invariably characterized by change distributions that follow power laws.
2) Exponents for national governments are variable, but a strong tendency exists for bursts of spending increases to dominate budget changes on the positive tail, while cuts are subject to less severe bursts. Orgies of spending are not fully offset by less exuberant cutting.

3) Exponents for sub-national governments are both very similar (for the three disparate situations we studied) and quite symmetrical. Subnational government budgets are less punctuated—less subject to bursts of budgetary activity--than national government budgets. While orgies of spending and cutting both occur, they are more muted than in the case of national governments. Exponent comparisons are presented in Table 3, along with associated L-kurtosis measures. While national governments exhibit considerable country-to-country variation, they tend to display more dramatic dynamics than the sub-national governments.
4) Friction is a characteristic of political systems; it holds in place the status quo through both formal means (such as supermajority requirements in the US, and the need to construct coalition governments in many parliamentary democracies) and informal means (such as the cognitive screen of political ideology). But stability will not allow a system to respond proportionally to changing external circumstances. Demands outside the political system build up, in an 'error accumulation' process; when these errors exceed a threshold, friction is overcome. Our simulations of this process indicate this will lead to exponential change distributions.
5) Budgets changes, however, follow power function distributions, and hence they display more bursts of frenetic activity than friction alone can explain. Because budgets are reflections of priorities, and budget change distributions reflect changing priorities, the dynamics of budget changes indicates the occasional occurrence of bursts of urgency about the external world. Urgency is contagious. It is an internal facet of political systems, so that external events alone cannot account for the dynamical properties of policymaking. Even if these external signals cumulate and overcome political friction only occasionally, they cannot account for the observed budgetary dynamics.
6) Only a combination of internal re-prioritization and organizational friction seems able to explain the patterns we have observed: strong budgetary conservatism represented by the peaks of the distribution of budget changes; weak shoulders, indicating the inability to respond to incoming information in a moderate, proportionate way; and fat tails, representing frenetic bursts of activity. The *contagion of urgency* overcomes the *friction of order* and leads to the dynamics of public budgeting.
7) At present, we have substantial confidence that friction alone cannot account for the observed budget change distributions, but we cannot directly confirm the processes that overcome friction. The notions of urgency and contagion nevertheless summarize models and findings from both capital markets (Sornette 2003) and agenda-setting in politics.

Final Speculations

National governments all display power distributions; sub-national governments are visibly different. But there are differences among national governments as well. Making comparisons is naturally difficult, because different countries use different categories for tabulating budgets. This does not seem to affect the structure of the dynamic system (all are Paretian), but we need further study to ascertain just how categorization affects differences in power law exponents (the slopes in the log-log plots).

Can we nevertheless develop expectations about how cognitive/organizational and institutional variance across national governments might drive the patterns evident in budgetary data? A distribution should approach Normal as a government increases its cognitive/organizational capacity, and reduces institutional impediments to reactive policymaking. More dramatic power function distributions should result from governments with poor cognitive/organization capacity, and many impediments to reactive policymaking. It's hard to assess cognitive/organizational capacity, but institutional impediments – veto players, in large part - are easier to think about. There is nevertheless little doubt that these aspects matter in driving punctuations, and need to be brought into the equation.

Table 1: Dataset Descriptions

Dataset	Type	Date	Units Pooled
National Governments (long series)			
United States	Outlays	1800-2005	years
US Domestic	Outlays	1800-2004	years
US Defense	Outlays	1800-2004	years
France	Outlays	1820-2002	years
National Governments (pooled)			
United States	Budget Authority	1947-2005	Years, 60 OMB programmatic subfunctions
France		1868-2004	Years, 7 ministries
Germany		1962-2000	Years, 26 functions
Great Britain		1981-1999	Years, 14 functions
Belgium		1991-2000	Years, 27 functions
Denmark		1974-2003	Years, 26 functions
Canada		1990-2004	Years, 12 functions
Sub-National Governments (pooled)			
US State	Operating Outlays	1984-2002	Years, 10 functions, 50 states
Danish Local	Operating Outlays	1991-2005	Years, 4 functions, 265 Municipalities
Texas School Districts	Operating Outlays	1989-2001	Years, 1130 districts

* Full descriptions available from the authors.

Table 2: Exponent Estimates for Power Functions of Tails of Distributions

Dataset	Positive Tail	R^2	Negative Tail	R^2	L-K
National Governments (long series)					
United States	-0.911	.982	1.396	.949	0.509
US Domestic	-1.094	.977	1.400	.933	
US Defense	-0.976	.976	1.602	.963	
France	-0.885	.973	1.091	.962	0.424
National Governments (pooled)					
United States	-1.024	.993	1.789	.916	0.512
France	-1.019	.983	1.353	.924	0.505
Germany	-1.387	.972	1.629	.960	0.456
Great Britain	-1.490	.981	1.797	.970	0.319
Belgium	-1.543	.970	1.293	.992	0.611
Denmark	-1.565	.982	2.179	.984	0.421
Canada	-1.245	.970	1.549	.915	0.379
Sub-National Governments (pooled)					
US State	-1.926	.992	2.007	.910	0.403
Danish Local	-1.810	.982	2.000	.965	0.363
Texas School Districts	-1.755	.983	2.575	.986	0.293

Table 3: Average Exponents [Range]

	$P(b > x) = x^{-.\xi}$	$P(b < x) = x^{-.\xi}$	Average L-Kurtosis
National Governments (long series)	0.9 [.89 , 91]	1.2 [1.09 , 1.40]	.467
National Governments (pooled)	1.3 [1.02 , 1.57]	1.67 [1.29 , 2.18]	.458
Sub-National Governments (pooled)	1.8 [1.76 , 1.93]	2.2 [2.01 , 2.58]	.353

Figure 1: Real US GDP Quarterly Change, 1947-2005.

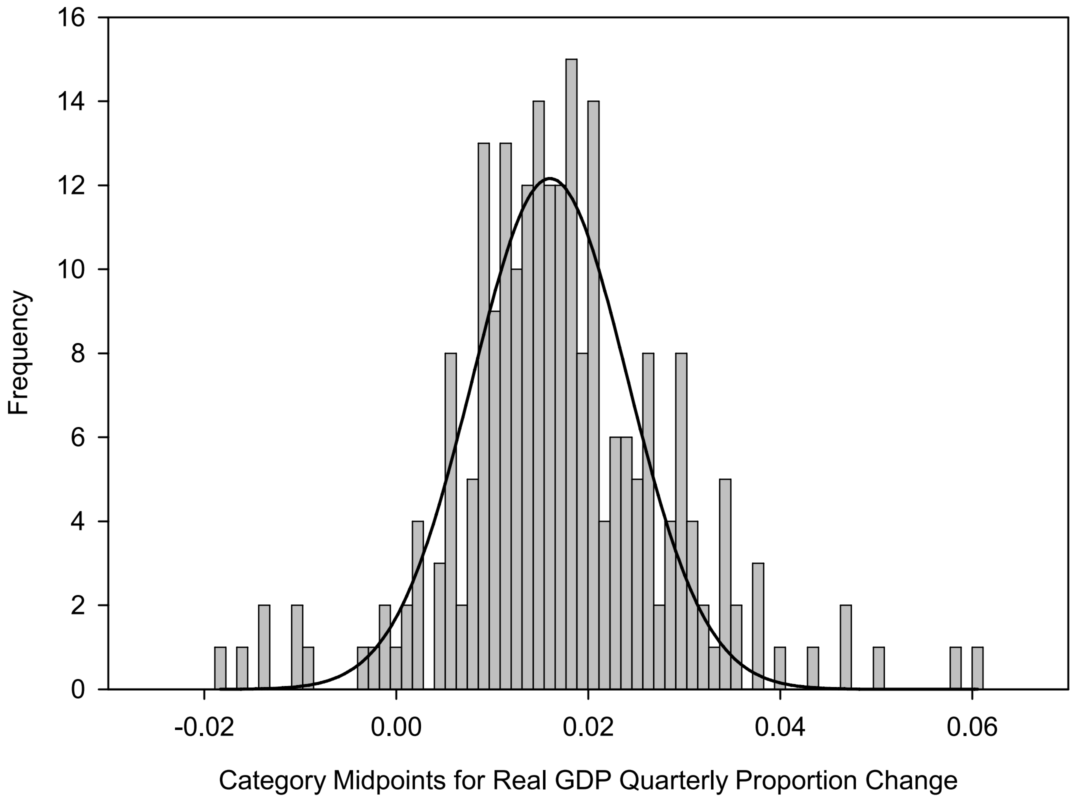


Figure 2: Typical Output from Simulation

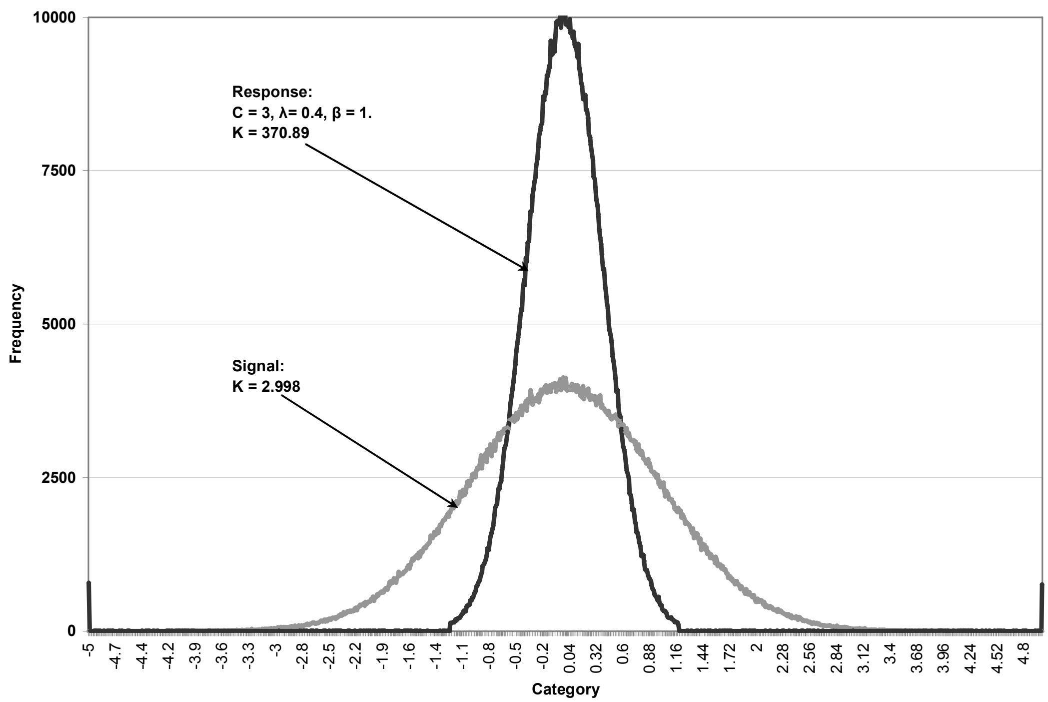
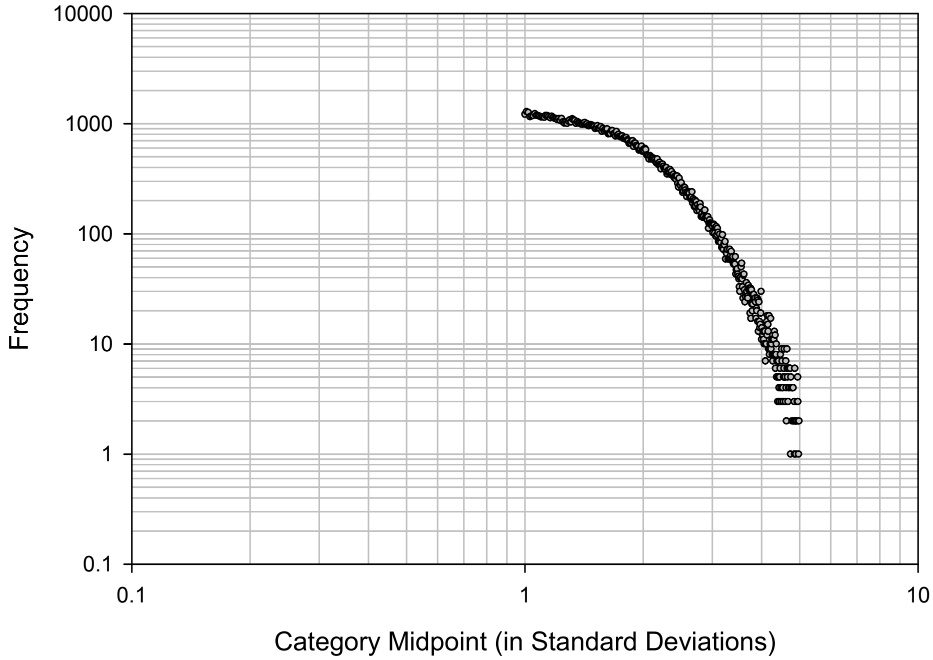


Figure 3: Log-Log and Log-Linear Plots of Positive Tail for a Typical Simulation



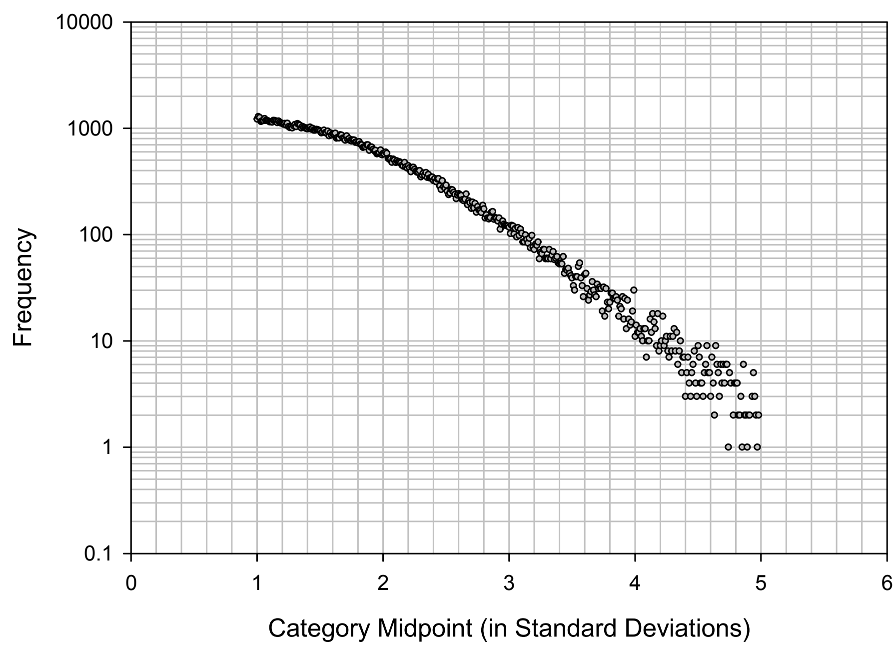


Figure 4: Percentage Change in US Real Outlays, 1800-2004

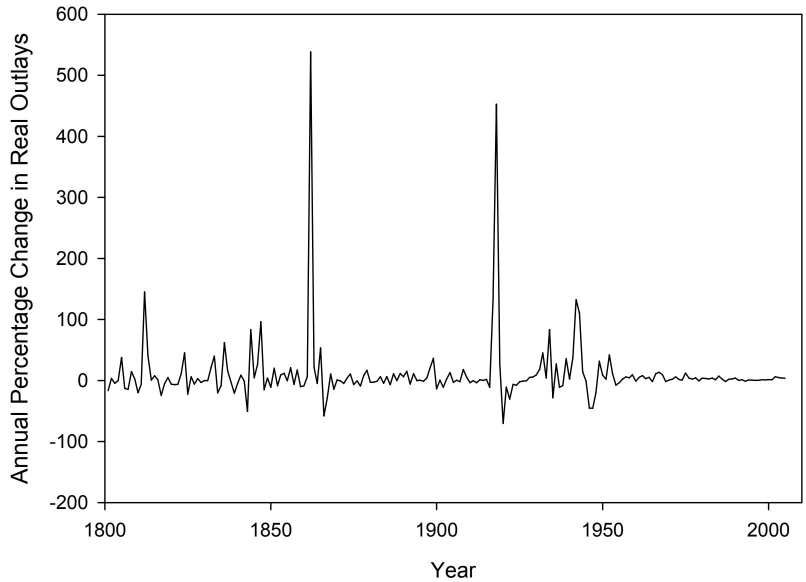


Figure 5: US Real Outlays, Domestic and Defense, 1800-2004

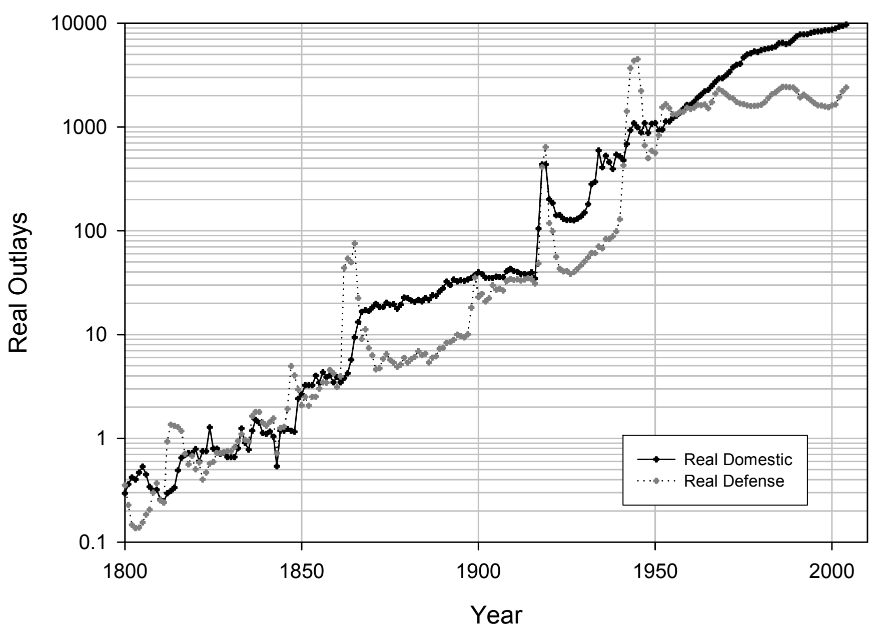
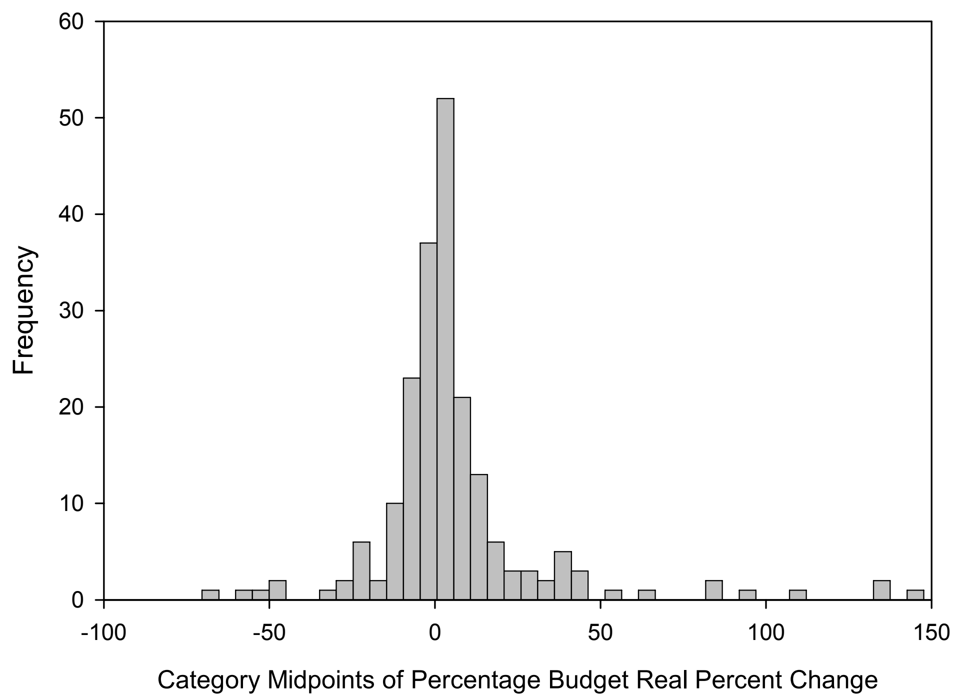


Figure 6: Frequency Distribution (a) and Log-Log Plot (b) for Annual Percentage Change in US Total Outlays

(a)



(b)

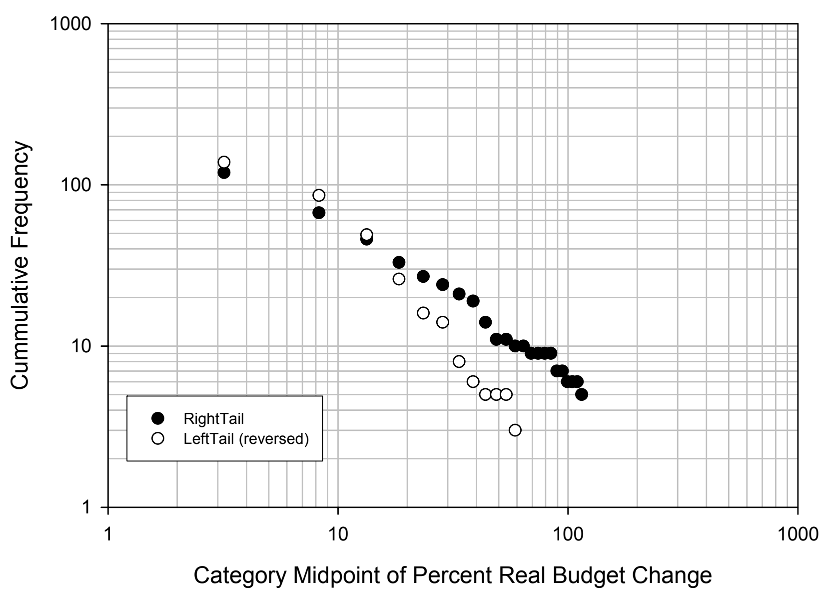
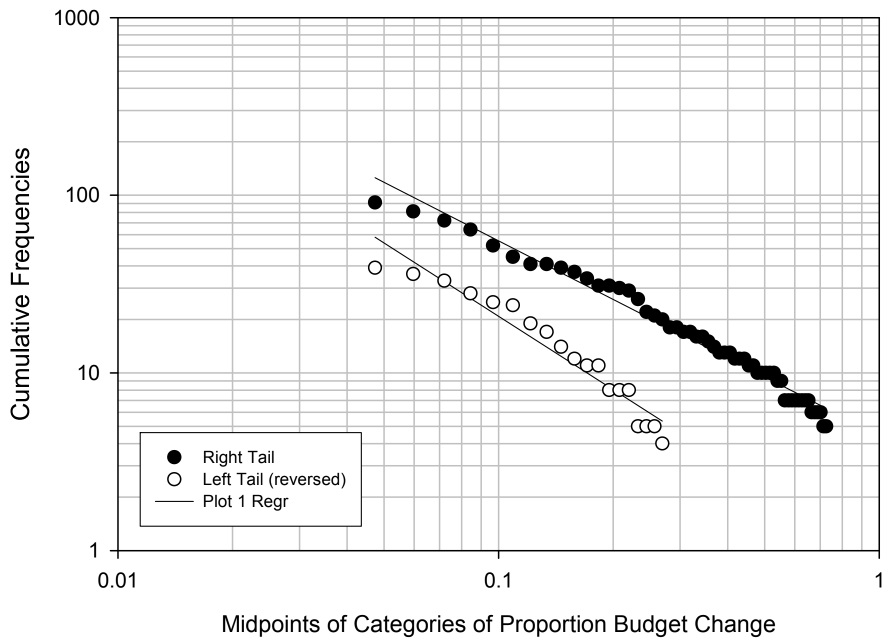


Figure 7: Log-Log Plots for Tails of Distributions for US Domestic (a) and Defense (b) Outlays

(a)



(b)

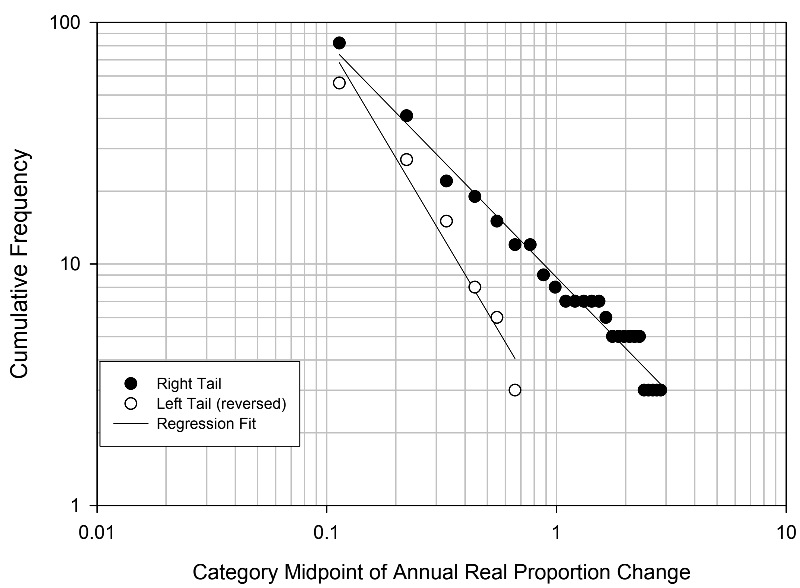
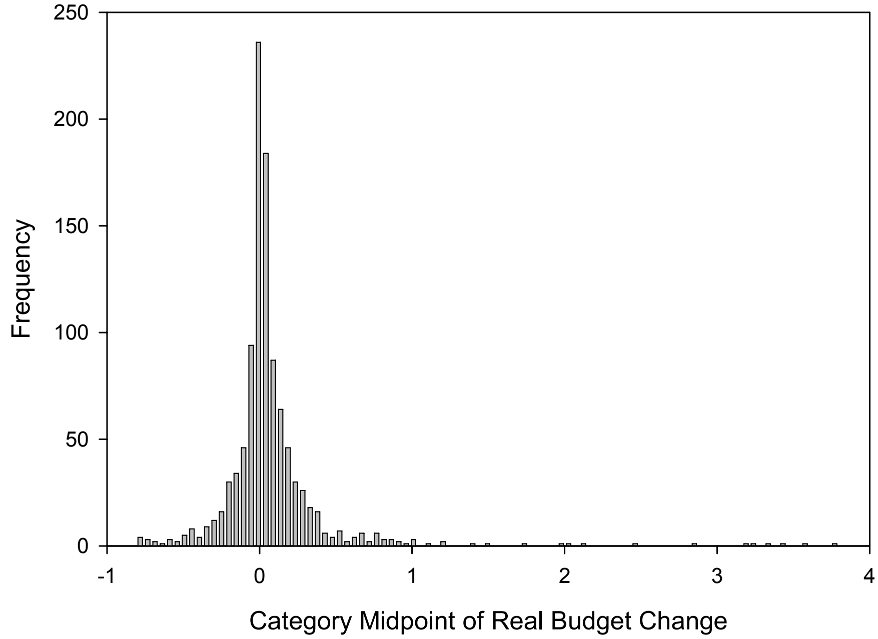


Figure 8: Frequency Distribution (a) and Log-log Plot (b) for Annual Proportion Change for French Total Expenditures

(a)



(b)

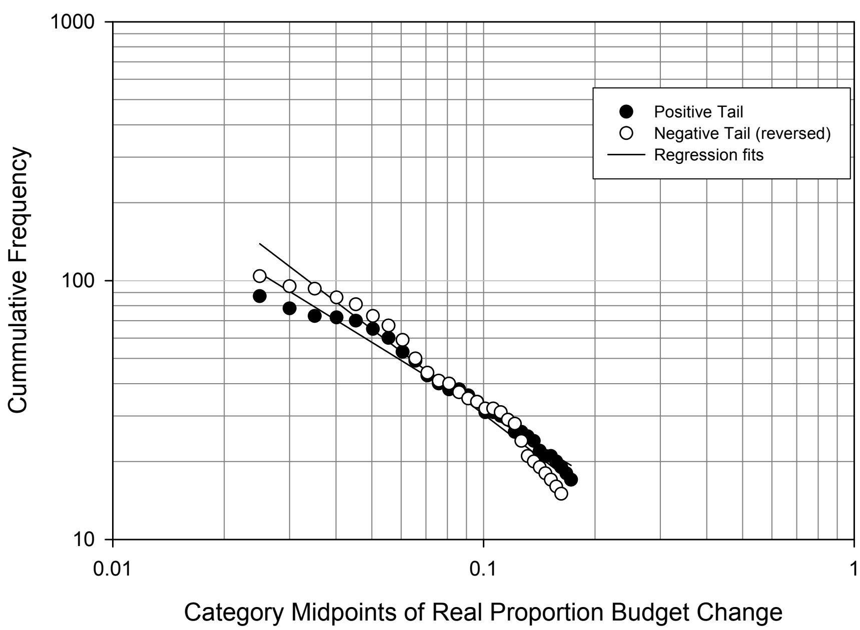


Figure 9: Frequency Distribution for Annual Proportion Change for US Budget Authority, 1947-2005

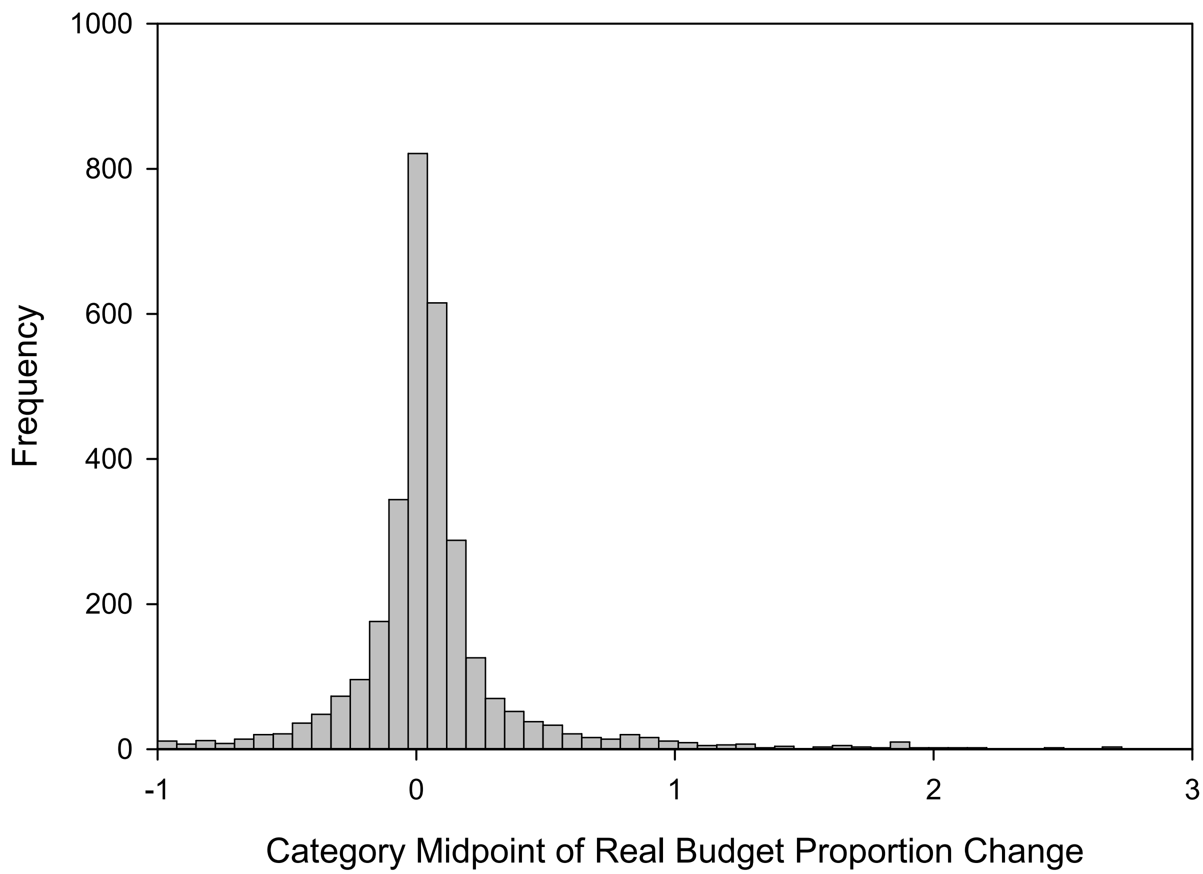
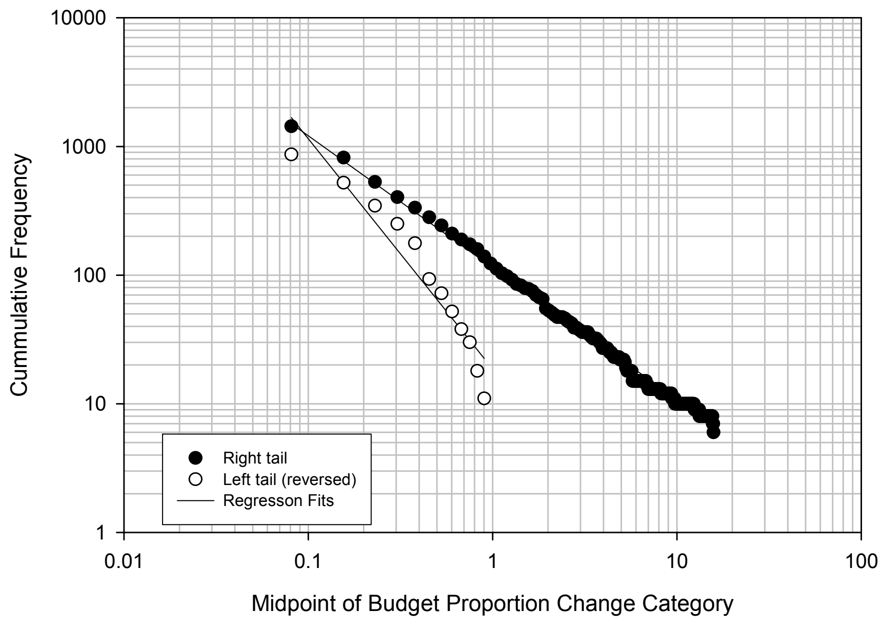


Figure 10: Log-Log (a) and Log-Linear (b) Plots for US Budget Authority



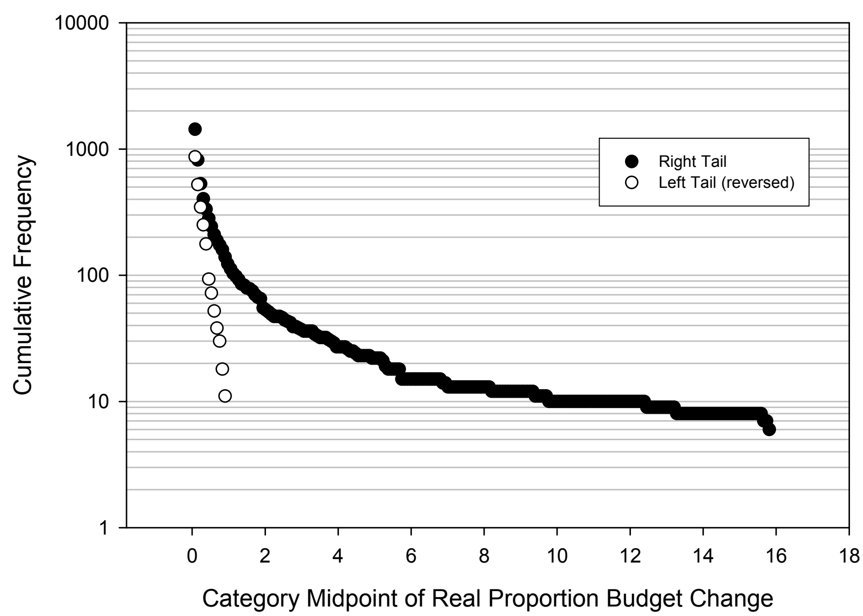
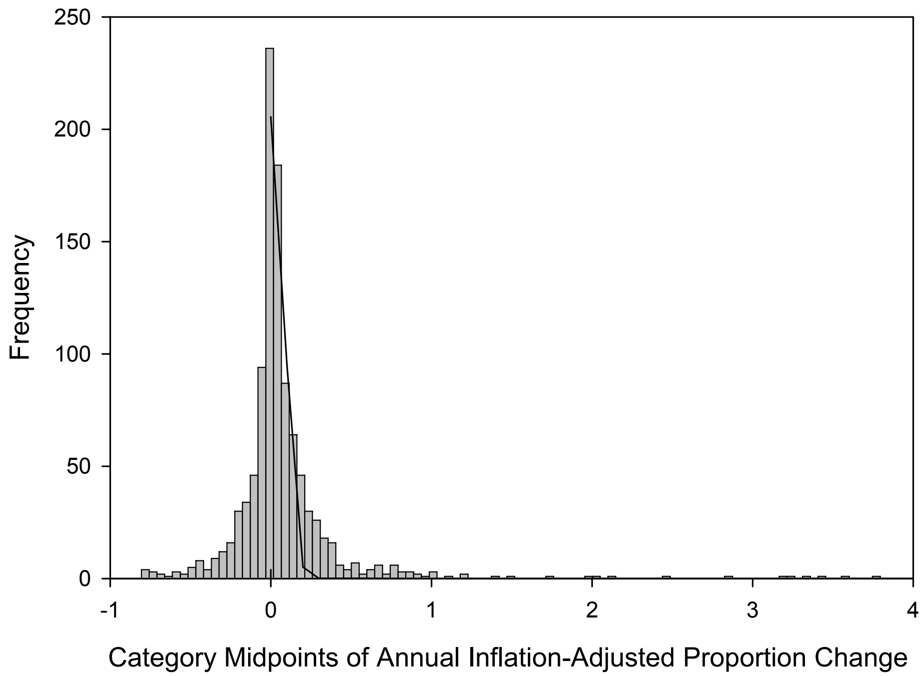


Figure 11: Frequency Distribution (a) and Log-Log Plot (b) for French Programmatic Spending

(a)



(b)

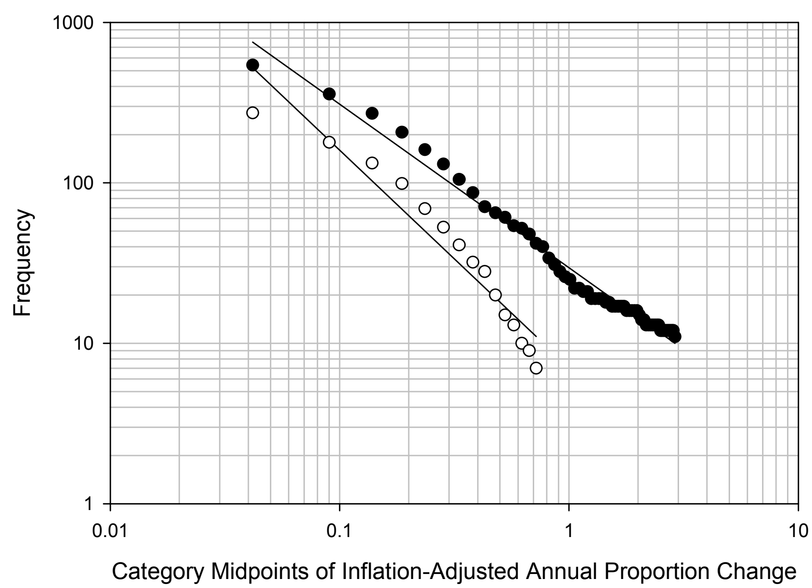
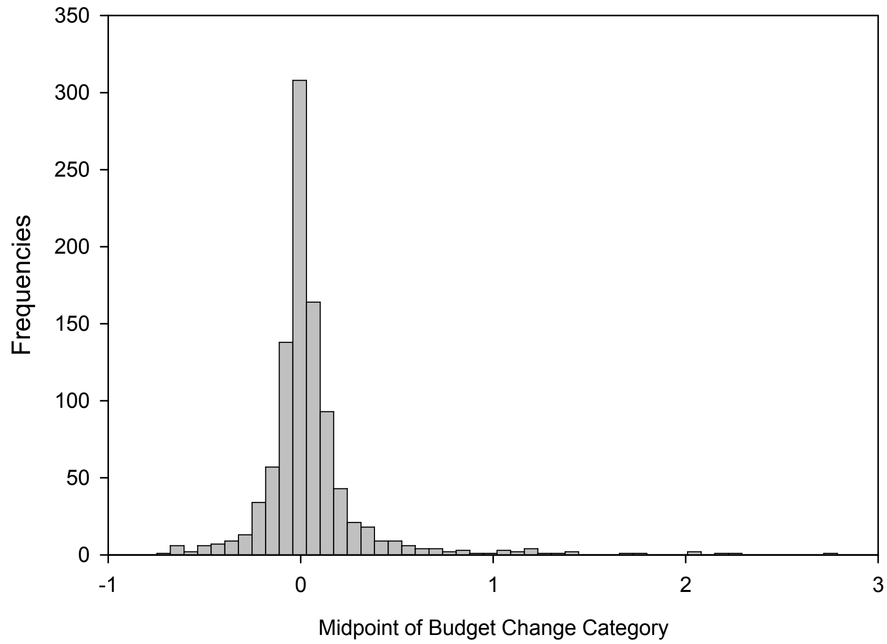


Figure 12: Frequency Distribution (a) and Log-Log Plot (b) for German Central Government

(a)



(b)

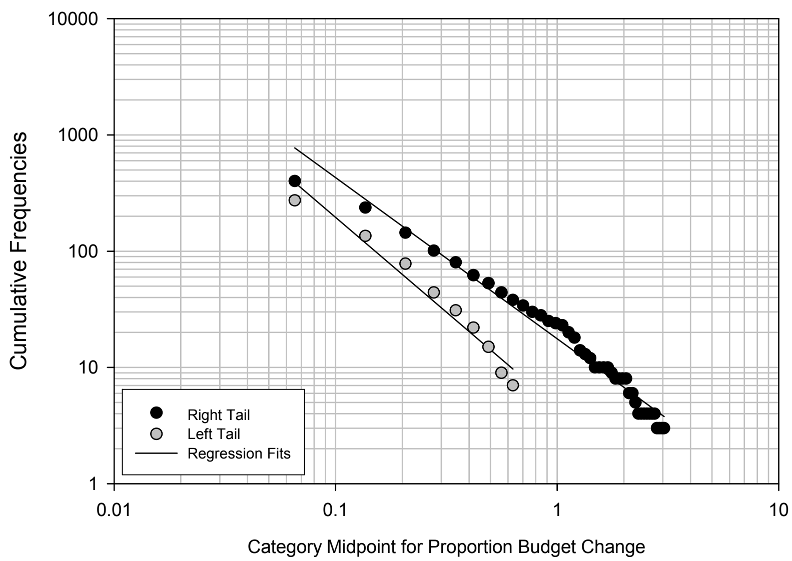
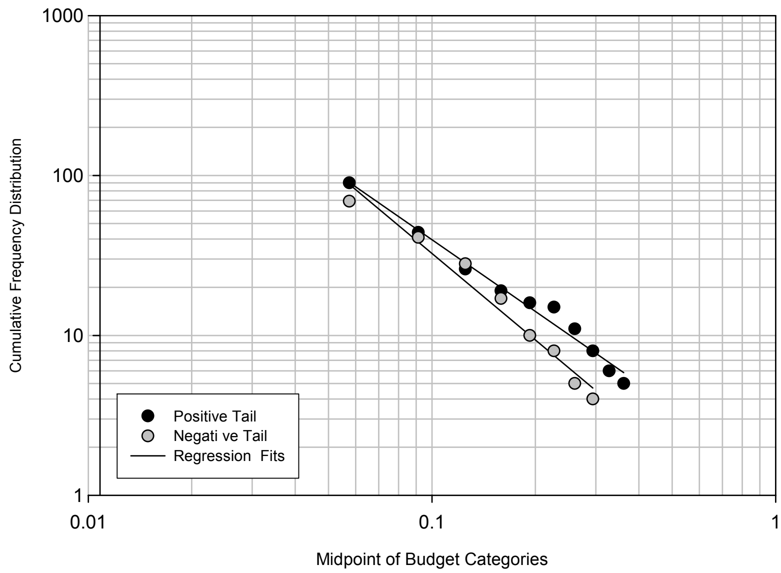
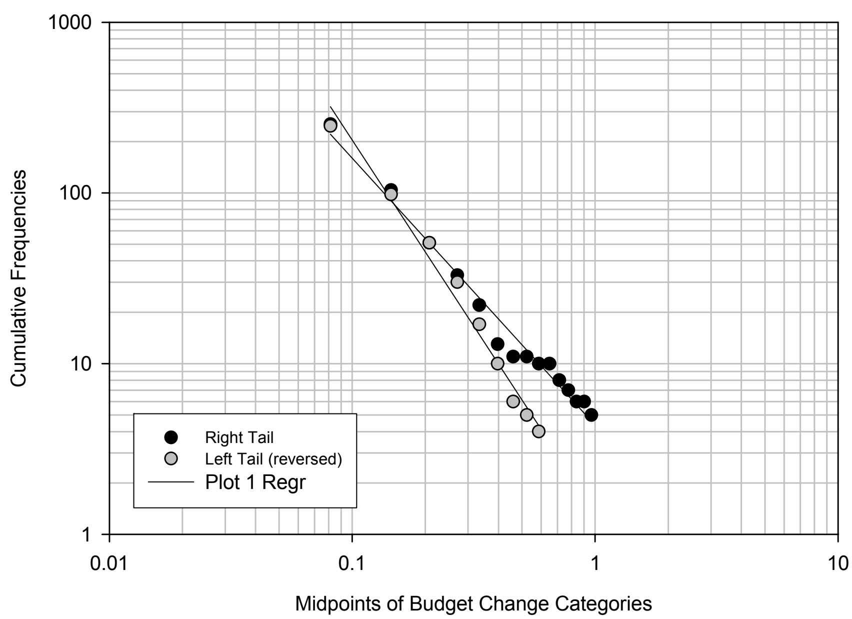


Figure 13: Log-Log Plots for the Central Governments of Great Britain (a), Denmark (b), Canada (c) and Belgium (d)

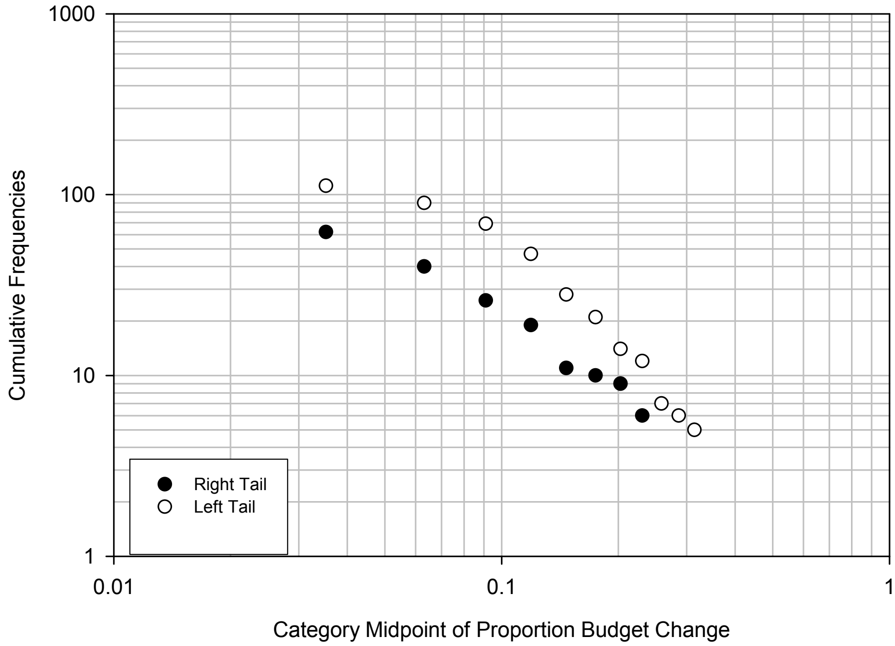
(a) Great Britain



[b] Denmark



(c) Canada



(d) Belgium

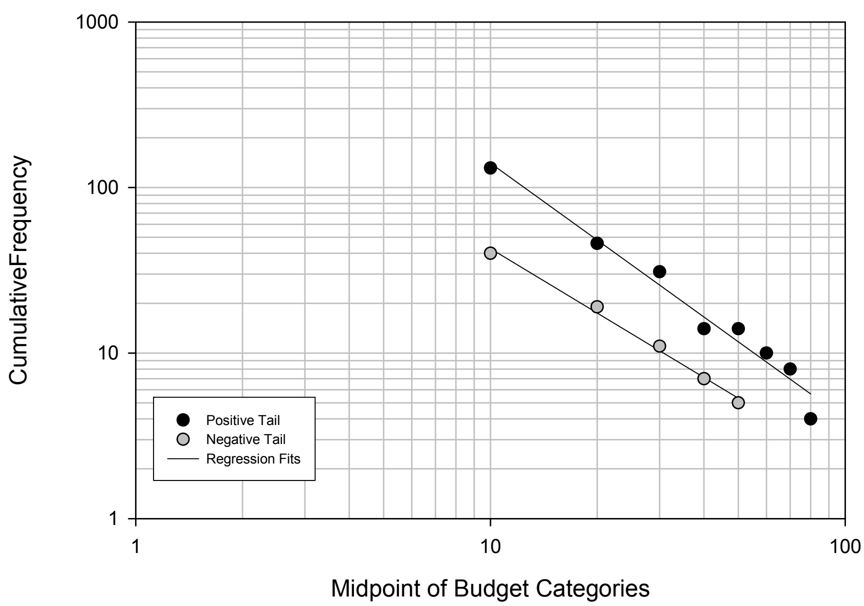
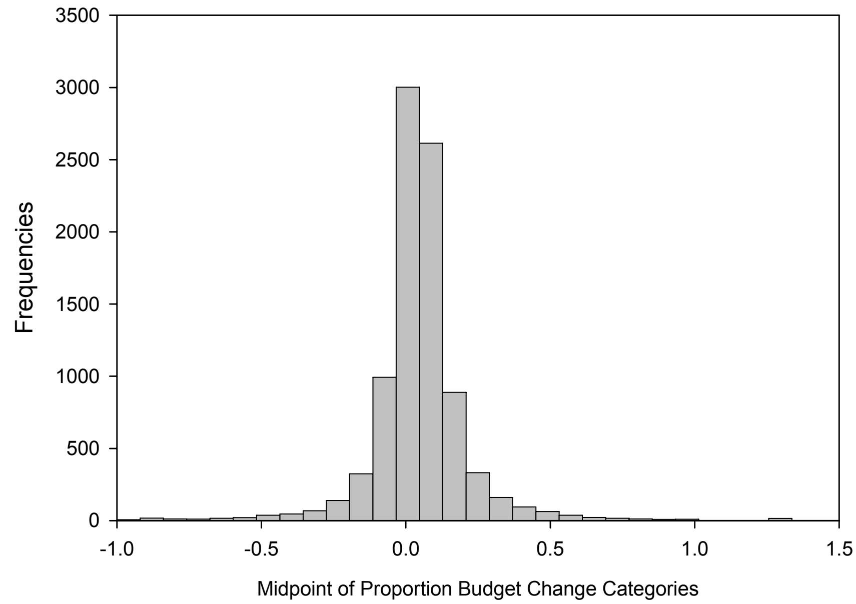


Figure 14: Frequency Distribution (a) and Log-Log Plot (Tails of Distribution) (b) for US State Outlays

(a)



(b)

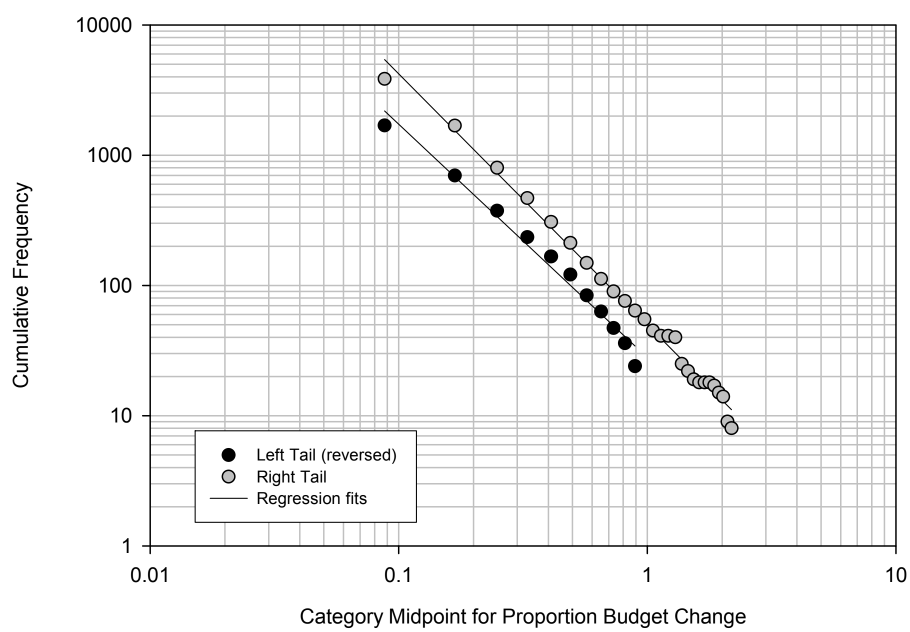
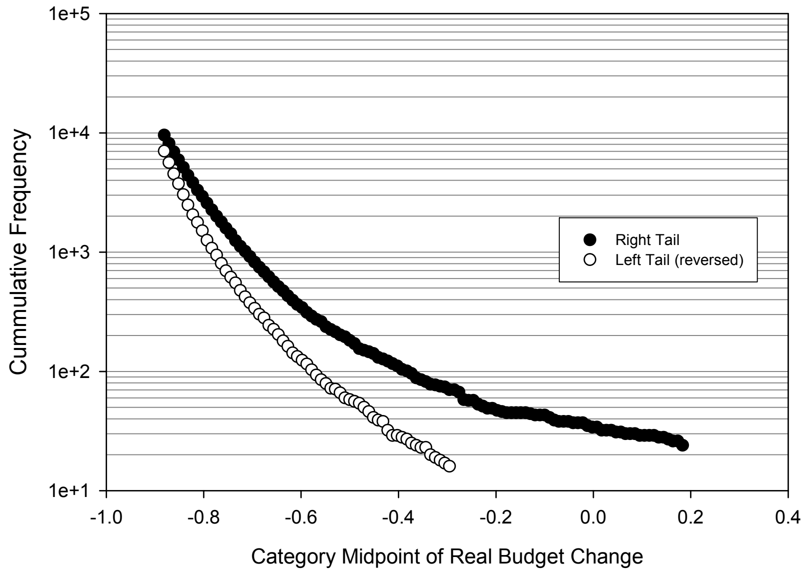
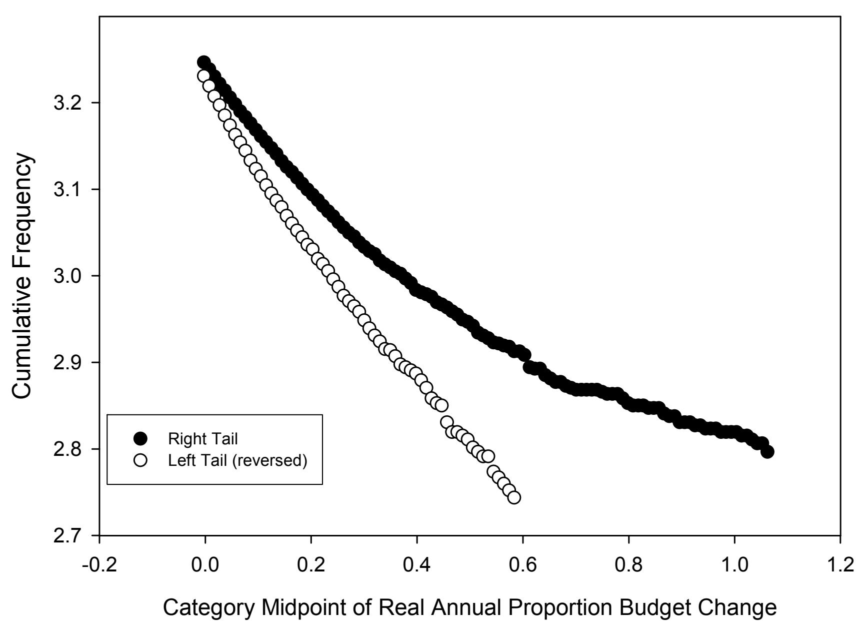


Figure 15: Plots of Log-Linear (a), Probit of Log-Linear (b), Log-Log (c), and Frequency Distribution for Danish Local Government

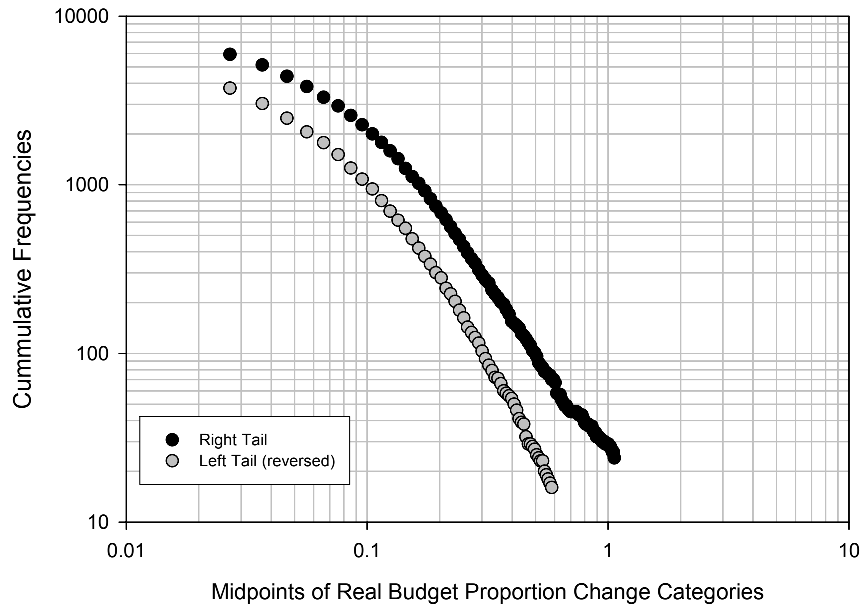
(a)



(b)



[c]


10000
1000
100
10
Cummulative Frequencies
Right Tail
Left Tail (reversed)
0.01
0.1
1
10
Midpoints of Real Budget Proportion Change Categories

(d)

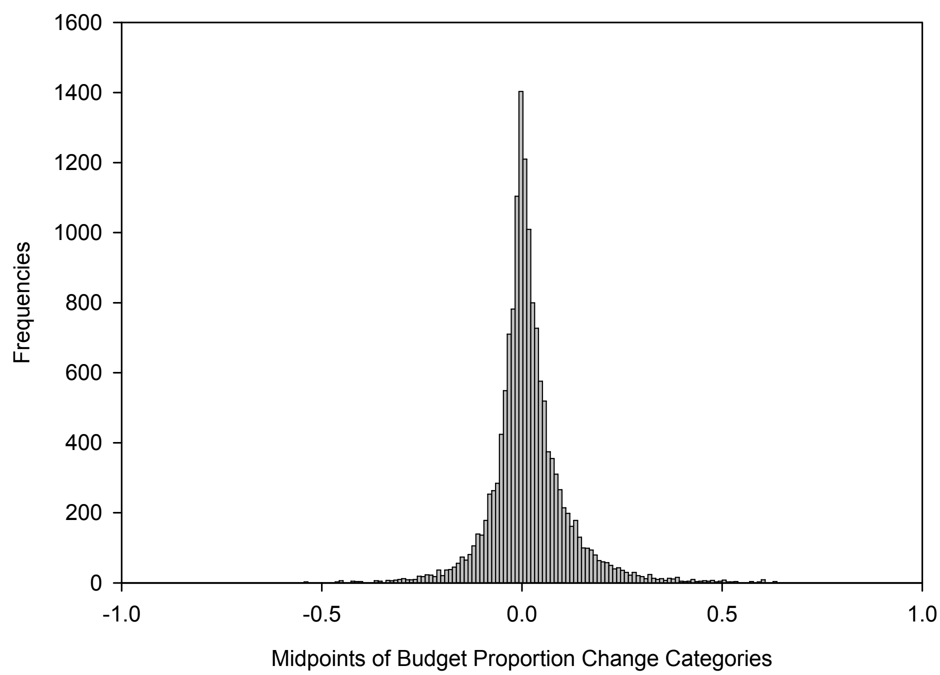
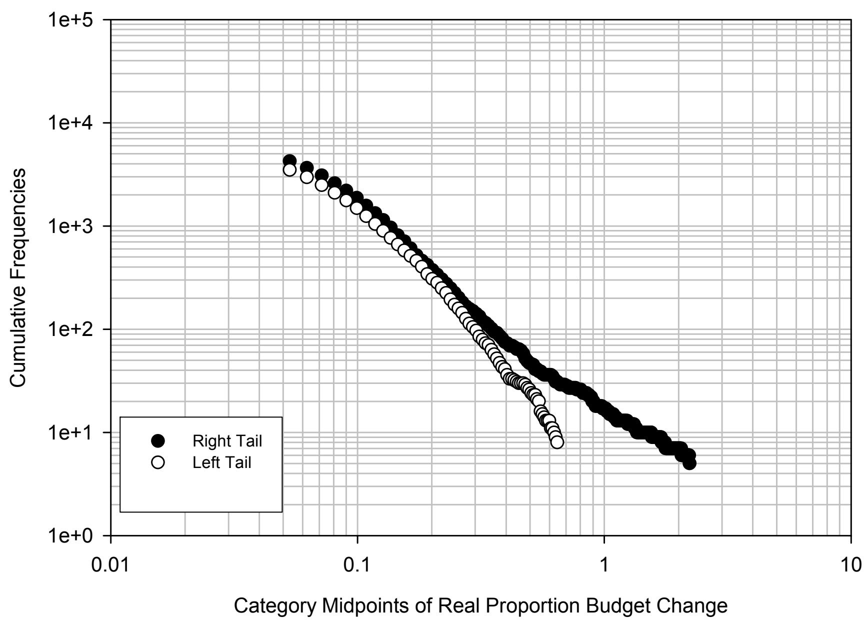
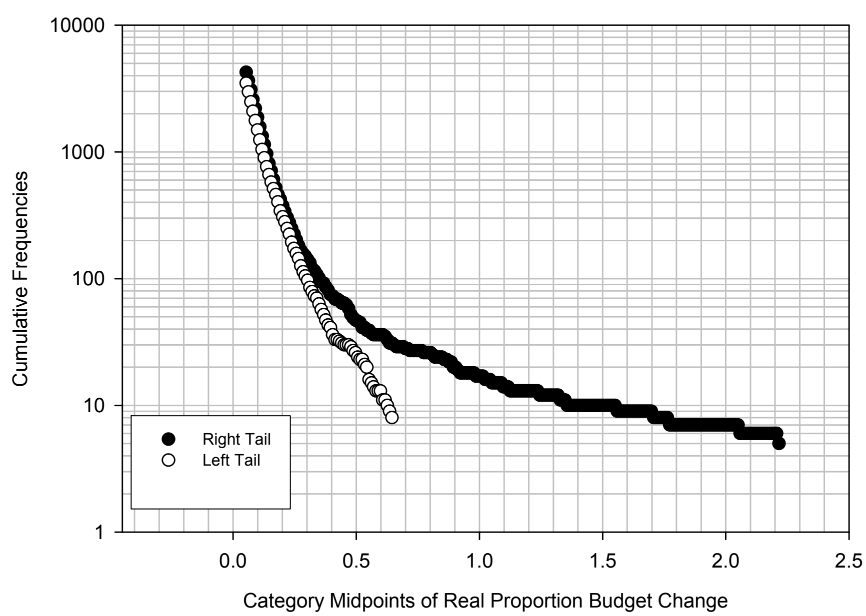

1600
1400
1200
1000
800
600
400
200
0
Frequencies
-1.0
-0.5
0.0
0.5
1.0
Midpoints of Budget Proportion Change Categories

Figure 16: Texas School Districts, Log-Log (a) and Log-Linear (b) Plots for Distribution Tails

(a)



(b)



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Appendix
Budget data source descriptions

All of the series we studied were corrected for category consistency, or the issue was not relevant to the dataset (as in the case of fully aggregated data).

UK budgetary data consist of data for 14 major functions, consistently defined from fiscal years 1980 to 1999. Data are from Stuart Soroka and Christopher Wlezien, Total Expenditure on Government Services in the United Kingdom, 1980-2000, UK Data Archive (SN 4980). Details are available at http://www.data-archive.ac.uk/. Fiscal years in the UK run from April of one year to March of the following year.

Canadian budgetary data are for the 12 major functions for Federal General Government Expenditure, consistently defined from fiscal years 1989 to 2002. Data are available from CANSIM (Matrix 3950002). Details are available at http://cansim2.statcan.ca/. Note that the dataset used here excludes a few very minor expenditure categories as well as some unspecified intergovernmental transfers (mainly to provincial governments) which cannot be allocated by function. Fiscal years in Canada run from April of one year to March of the following year.

Belgian budget data are for 27 categories of spending over the period of 1991 to 2000, and originate from the Belgian Political Agenda-setting Project. The project (2001-2004) was funded by the "Federale Diensten voor Wetenschappelijke, Technische en Culturele Aangelegenheden" (DWTC). It was conducted by Stefaan Walgrave (coordinator, UA), Lieven De Winter, André Frognier, Frédéric Varone and Benoît Rihoux (UCL), Patrick Stouthuysen (VUB), and Marc Swyngedouw (KUL). Details are available at: http://www.ua.ac.be/main.aspx?c=m2p.

Danish local spending data consist of inflation-adjusted local spending figures using four consistently defined categories of spending from 1991 to 2005 pooled across 271 Danish municipalities. The data originally come from Tables "BUD32" and "BUD32X", available online from Statistics Denmark (http://www.statistikbanken.dk). See Mortensen (2005) and "the link to the comparative budget projects website" for further documentation.

The dataset on Danish national spending consist of inflation-adjusted public spending figures using 26 consistently defined categories of spending from 1971 to 2003, using data originally made available by Statistics Denmark, Section of Public Finances (www.dst.dk). Further documentation is available at "the link to the website of the comparative budget project."

The sources for national-level French budgetary data are the INSEE (*Institut National de la Statistique et des Etudes Economiques*) Statistical Handbook (annual). The historical data (1868 through 1939) are gathered through a retrospective series published in the 1951 French Statistical Handbook. All other data have been computed from the annual INSEE Statistical Handbooks. For data after the Second World War, we have used the Statistical Handbook 1947–1987 published by the INSEE. From 1988 onwards, we have used the annual publication of INSEE called *Tableaux de l'Economie Française* which provides a complete presentation of public spending adopted by the Parliament through the Finance Law. Total expenditure is made up of separate series for Defense and Civilian public spending. Each statistical series is originally produced and delivered by the Direction of National Public Accounts (a division of the Ministry of Finance). Data are expressed in current francs and were then adjusted into constant francs using the Consumer Price Index (CPI) as supplied in the INSEE publications.

Texas school budgets data include "instructional spending per pupil" for all public school districts in Texas from 1989 to 2001. All data are available from http://www.tea.state.tx.us/. School years run from August through May (with the year based on the year in which school year ends). Enrollment data is included to allow researchers to drop cases for smaller districts, as is done in many uses of the data in political science. The budgetary data is corrected for inflation using the "Cost of Living Index for the American States, 1960-2003" (ICPSR-1275).

US Budget Authority Data are derived from Office of Management and Budget Sources, which adjust categories for consistency after 1976. The Policy Agendas Project (www.policyagendas.org) applied consistent adjustments back to 1947. Data are adjusted for inflation using GDP deflators, with 2005 as the base year.

US Government Outlays are from *Historical Statistics of the United States*, compiled by the US Census Bureau, updated from the Office of Management and Budget website, Historical Statistics, Table 1.1. The Consumer Price Index was used to adjust for inflation due to the absence of GDP deflators for the early part of the series, with June 1984 = 100.