THE UNEXPECTED INFLUENCE OF EDUCATION ON LEGISLATIVE ACTIVITY IN 1973

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Abstract. The influence of the affluent is clearly visible today. We can see it in enacted policy, in bill creation, in staffing resources. But the story was different in the 1970s. I show that in the 1970s, the influence of affluence reversed itself: in particular, politicians from rich districts were less successful in enacting laws. This result is unexpected. In order to show that this is not an artifact from failing to account for heteroskadasticity in the data, this paper will apply the most appropriate model to the data, a beta regression. Beta regressions are used for heteroskedastic proportional data, such as the proportion of bills enacted into law by a legislator. However, because R does not have an existing package that allows the heteroskedasticity parameter (dispersion) to be estimated from the data, I create my own R based implementation of the model presented by Smithson and Verkuilen (2006). This paper demonstrates that this unexpected result is not an artifact of the model. In fact, as is normally true, heteroskedasticity has little impact on the results. Each of the following models produce substantively and statistically similar results: a linear regression, linear regression with robust standard errors, Beta with constant dispersion, and Beta with the dispersion parameter estimated from the data. I cite results that demonstrate that although unexpected, the negative impact of the rich on enacted laws is in fact part of a broader pattern in American politics. As we look into the past, the influence of education and income flip. Thus, the finding that income has a negative influence on successful legislation is not an artifact of a problematic model. Four decades ago, legislators from wealthy districts sponsored less legislatively successful bills.

1. INTRODUCTION

When does social status matter for political representation? The Declaration of Independence holds that all men are created equal," but does this mean that all men (and women) should be equal in political representation? One prominent theorist, Robert Dahl, encapsulated a common answer: yes, governments ought to be responsive to the interests of all citizens, considered as political equals (Dahl 1971:1). That is, citizens should be represented equally, regardless of socioeconomic status or race. Yet the evidence to date indicates that socioeconomic status and race do matter. Over the past five years, multiple authors have shown that affluent constituents are more likely to see their preferred policies enacted (Bartels 2008, Gilens 2013, Gilens and Page 2015) and see overall more legislation passed by their representatives (Foster-Molina 2015a).

There is some evidence that the influence of the affluent was not as strong in earlier decades. Gilens shows that the importance of income steadily increased from the Johnson administration in the 1960s, the Reagan administration in the 1980s, the Clinton administration in the 1990s, and George W. Bush's administration in the 2000s. He finds that the influence of affluence was very close to zero during the 1960s (Gilens 2013:199-202). Thus far, his is the only work that delves into the legislative impact of affluence in previous decades.

This paper will show that not only did the influence of affluence diminish as we look into the past, it actually reversed itself in some aspects of legislation. In particular, I look at the proportion of all bills that a legislator sponsored that were successfully enacted. This measure examines the legislative success of members of Congress in order to connect district wealth with legislative success. In the 93rd Congress, which met from 1973-74, legislators from districts with high incomes were significantly less successful in legislation than legislators from low income districts.

The result that income might have a negative effect on legislation is much more unexpected than the null finding from the 1960s presented by Gilens. I will demonstrate that this results is consistent from the most naive model to the most sophisticated. The initial model presented is a simple linear regression, then a linear model with robust standard errors. However, a linear model is not the most appropriate fit. The data is proportional and linear regression does not account for the fact that the data is bounded below by zero and above by one. Both a logit transformation and a tobit transformation would create a model that accounts for this boundedness. However, the data is also strongly heteroskadastic. That is, the variance of the data is larger for small values of income. Unlike the tobit and logit transformations, a beta regression accounts for this heteroskedasticity with a dispersion parameter that depends on the mean value. I present two versions of this model. The first estimates the dispersion parameter across all independent variables. The second estimates the dispersion parameter for each of the independent variables separately. No matter the model used, the substantive interpretation of the results remains constant: district income has a negative effect on legislative success.

Results from a forthcoming paper show that this negative effect is part of a general trend in American politics. In the 1970s, income had a largely negative impact on legislative success. Education, on the other hand, has a largely positive impact on legislative success. Between 1970 and today, we see the direction of these two effects flip. Today, politicians from rich districts produce more legislation, while politicians from educated districts produce less legislation. The time trend from the 1970s is consistent. As the impact of education increases, the impact of income decreases and vice versa (Foster-Molina 2016c).

The constancy of the result across model specification is not surprising. It is well known that heteroskedasticity rarely impacts the direction, significance, or magnitude of the estimates (King and Roberts 2015), and we do not see any interesting change in the models presented here when using robust standard errors to correct for heteroskedasticity. Additionally, given that the data I use is monotonically decreasing, the direction of the effect for almost any monotonic model will be consistent in direction. The beta regressions and linear regressions are all monotonic functions, and therefore produce the same direction of effect. Thus, we can be confident that given the covariates included,[1] district income has a negative impact on legislative success.

2. PREVIOUS RESEARCH ON INEQUALITY AND LEGISLATION

Given the importance of who has a political voice to the theories of political representation, it may be surprising that empirical evidence connecting socioeconomic factors such as income inequality with representation has not been explored in greater detail. The paucity of empirical investigations connecting economic inequality and political representation has been noted as recently as 2008 by Larry Bartels (p. 252). This dearth has been substantially remedied for one aspect of representation: the degree to which enacted policy is congruent with citizen preferences, also known as policy congruence. Larry Bartels (2008) and Martin Gilens (2012) demonstrate a general lack of representation through policy congruence for the poor. The rich are overrepresented overall (Bartels 2008: 259), in abortion

[1]Note that the variables included are more likely to change the results of the regression than the type of model used. This is due to the power of omitted variables that are correlated with the variables of interest. I have run these models with a variety of included variables. The results are similar across specifications, but not presented here.

policy (Bartels 2008:267), foreign policy, economic policy, religious issues, and much of social welfare (Gilens 2012: 101). The only significant areas in which the less affluent hold their own are a few social welfare policies, such as Social Security, Medicare, school vouchers, and public works (Gilens 2012: 122). Both scholars show a strong overall bias toward the privileged in policy congruence.

Two works in particular have focused on the history of income inequality: McCarty, Poole, and Rosenthal's Polarized America and Gilen's Affluence and Influence. McCarty, Poole, and Rosenthal look at economic inequality over time, but they are primarily explaining polarization, not legislation for the rich. Their primary finding is that as inequality has increased, so has political polarization. This does not help us understand the historical impact of affluence on legislation.

Gilens focused primarily on the influence of affluence in the present, but provides tantalizing evidence of low economically induced political inequality in the 1960s. The results of this paper show a negative relationship in contrast to the null finding for a related measure found by Gilens. That is, Gilens shows that there was no statistically significant relationship between policy outcomes and the policy preferences of the rich versus poor. I show that there is a statistically significant negative relationship between income and legislative outcomes in the 1970s. My measure is different, getting at one potential reason that the policy enacted generally favors the preferences of the rich: their representatives are more legislatively active. If members of Congress enact laws that match the preferences of their districts, which has generally been shown to be the case, and members of Congress from rich districts enact more laws, then the preferences of the rich will generally prevail.

3. DATA

I introduce a dataset of House bills, district demographics, characteristics of representatives, and votes for the 93rd and 109th Congresses. The House bills data encompasses all proposed legislation scraped and formatted from the bulk data website govtrack.us[2] for the data on proposed bills, as well as basic information on the members of Congress.[3]

Demographic data on economic and ethnic characteristics of each Congressional district came from the U.S. Census.[4] The oddity of the 93rd Congress merits some attention. First, there was an overwhelming Democratic majority. Second, many republican Congressmen left office, and all were replaced by Democrats. Third, both legislation was overwhelmingly sponsored and passed by

[2]From http://www.govtrack.us/data/us/109/, accessed August 2015

[3]Data on members consists of name, party affiliation, committee membership, date entered into current Congress.

[4]ICPSR provided the census information at the district level for 93rd Congress, while the census.gov provided data for the 109th.

Democrats. The Republican record for the legislator who passed the most legislation stood at a measly 4 bills. The Democratic record was 22 bills. The Republican party as a whole passed 72 bills; the Democratic party passed 338. All of these anomalies are driven by Watergate, which came to a head in 1974.

This data gives us a perspective the influence of affluence that is grounded in the legislative activity of members of Congress. The goal is to understand where the influence of affluence comes from, and one way to control policy is by having likeminded legislators focusing heavily on policy. This focus can be measured by looking how successful members of Congress are at enacting their desired legislation. The process of deciding the kind of bill that will likely be passed, then lobbying colleagues to ensure its passage, requires more time and effort than the traditional measure of bill sponsorship (Griffin and Keane 2009, Rocca and Sanchez 2008, Volden et al 2010, Woon 2008, Frantzich 1979). All one has to do to sponsor a bill is tell the House clerk that you want to sponsor a bill. The vast majority never make any progress at all through the legislative process, but many members of Congress use them to claim credit for caring about an issue for their constituents. After all, constituents are not likely to track what happens to a bill their representative claimed credit for sponsoring.[5] It is safe to say that many of these bills were never intended to make progress, but were simply cheap talk. A bill that progresses through the House is less likely to be cheap talk compared to the traditional measure of bill sponsorship. In addition to being a technically interesting problem, the proportion of bills sponsored by a politician that become law is a good indication of how effective a politician is at creating policy.

4. THEORY

The analysis will seek to answer the following question:

Do wealthy, educated, and white districts have increased legislative activity?

To answer this question, the focus will be on legislative activities that have a positive influence on policy changes and that require personal effort by the legislator. This focus on activities that require personal time is used to link this analysis back to how representatives choose to allocate their resources between various representational activities. This analysis therefore excludes activities such as filibustering which are instead designed to halt policy changes. It also excludes floor speeches, cosponsorship, and roll call votes which can and are done merely by showing up or telling a clerk to add your name to a bill.

[5] or blame their representative for failure to progress. It's too easy to blame the rest of Congress if a bill stays in committee. It's not your fault. It's their fault.

Thus, I will analyze the percent of sponsored laws that become law, measured by legislator (which is the equivalent of district).[6] I will demonstrate that a linear model is inappropriate for the data, and then program two versions of a beta model, in line with the work of Smithson and Verkuilen (2006) as well as Ferrari and Cribari-Neto (2004). The results for each model are consistent. This consistency is expected due to the relatively well behaved monotonic data I use.

I measure district income as the percent of district's households that earn over $75,000 per year in 2005 and households that earn over $15,000 in 1973. The threshold of $15,000 in 1973 dollars corresponds to around $66,000 in 2005. While not exact, this gives the closest comparable bracket for wealth between the two censuses. Because goal is to measure the relative influence of the wealthy and the size of the coefficients are not being compared, it is entirely reasonable to use a comparable but not exact threshold for wealth between the eras.[7] Education is measured as the percent of the district that graduated college. African-American population is measured as the percent of the district that identifies as African-American according to the decennial census. This variable has an exponential distribution, seen below, so I take the log of their population. I control for party status of the legislator. My results indicate that contrary to expectation, and contrary to results found for the 109th Congress, legislators from wealthy districts have a lower percentage of bills pass than legislators from poor districts.

The remainder of the paper progresses as follows: (1) set up the substantive puzzle behind the technical aspect of this paper by noting the disparities between the 109th Congressional results and the 93rd using linear regressions, (2) examine and discuss impact of data that potentially violates core assumptions behind linear regressions, (3) describe and derive the maximum likelihood function for the more appropriate and flexible beta regression, (4) analyze the results from the beta regressions, (5) cite results that put the unexpected results into context, and (6) conclude.

5. NAIVE LINEAR REGRESSIONS

The technical aspect of this paper seeks to validate the unusual results presented in Table 1. There is a substantial amount of evidence that the affluent are more influential than the poor in politics (Bartels 2008, Gilens 2012, Gilens and Page 2014). Many political observers, including myself, would claim that the influence of affluence has increased over the past few decades. Although there is not

[6]In other papers, I expand the analysis to include other measures including the number of successful bills, the number of sponsored bills, the amount of money allocated to staffers who focus on policy, and the amount of communication via Twitter to policy related issues. All measures except sponsorship alone provide similar conclusions.

[7]The effect of income is not skewed in a way that creates different results for different thresholds of wealth. The results for all eras remain the same whether I use median income, mean income, or any threshold for measuring wealth.

much empirical evidence of any sort, few would consider the idea that the influence of affluence was nonexistent, much less reversed in earlier decades. However, this is precisely what I find for legislative success in the 93rd Congress. Between 1973 and 1974, during the 93rd Congress, representatives of poor districts were more successful in legislation.

Table 1: Percent Bills Passed

	109th Congress (p-val)	93rd Congress (p-val)
% over $75k or $15k	0.09 (0.02)*	-0.13 (0.02)*
% college	-0.05 (0.17)	0.06 (0.52)
log % black population	-0.00 (0.75)	-0.00 (0.36)
Republican member	0.10 (0.00)***	-0.01 (0.00)***

Note: $^{*}p < 0.05$, $^{**}p < 0.01$,$^{***}p < 0.001$

Table 1 and Figure 1 show the results of a linear regression for both the 109th Congress (2005-2006) and for the 93rd Congress. The p-values are reported in parenthesis next to the coefficient estimates. Recall that $75,000 per year in household income was used as a threshold for wealth for the 109th Congress, while the rough equivalent in inflation adjusted dollars was used for the 93rd Congress, $15,000 per year per household.

In the 109th Congress, the effect is statistically significant and in the expected direction. As the percent of a district that earns over $75,000 per year goes up, the legislative success of their representative goes up. Specifically, for each one percentage increase in the wealthy population of a district, the legislative success of the representative increases by .09%. Looking at a district that is 20% wealthy versus one that is 50% wealthy, the wealthier district can expect to have 2.7% more successful bills. Given that the average percent of successful bills is only 2.5%, this is a large difference.

The 93rd Congress features the opposite effect. As the percentage of a district that is wealthy increases, the district's legislator's legislative success goes down. Not only does the sign of the coefficient flip between these two Congresses, but the magnitude of the effect increases. That is, the less affluent were more influential in the 1970s than the affluent were in the 2000s. A district that is 20% wealthy can expect to have a legislative success rate that is 3.9 percentage points higher than the more affluent district that is 50% wealthy. Less affluent districts, on average, were represented by legislators who were substantially more successful than their wealthy counterparts.

The regressions control for district education, race, and the partisan affiliation fo the district's representative. These are each common socioeconomic factors that are thought to influence political

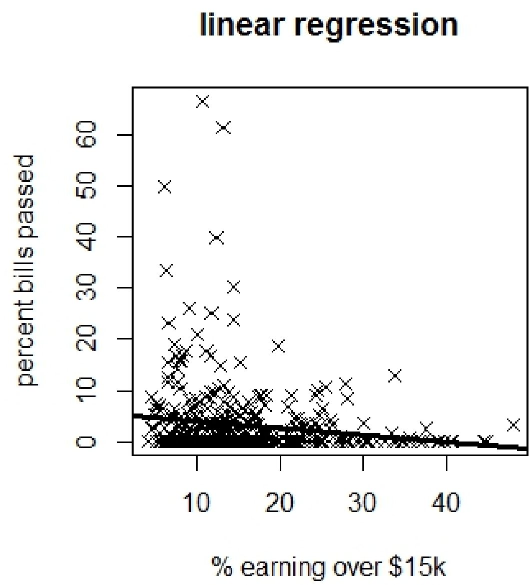


Figure 1. Linear Regression Scatterplot

preferences. Unsurprisingly, being a Republican leads to more legislative success in the 109th Congress which had a Republican majority, while the opposite is true in the 73rd Congress with a Democratic majority. Neither race nor education are statistically significant. That said, I will come back to the fact that the effect of district education, as measured by the percent of the district that completed college, is always in the opposite direction of the effect of income. As I show in the last section of this paper, this is consistent finding across all four decades. As the influence of affluence goes down, the influence of education goes up.

One explanation for this unexpected result is that a linear model is inappropriate for the data. It is possible that the heteroskedasticity evident in the scatterplot is artificially creating a statistically significant result. Note that it is not possible that the heteroskedasticity alone obscures a positive trend. There are only two ways the effect of income could be positive instead of negative given the results of the linear regression: (1) omitted variable bias, which I do not cover in this paper, or (2) extremely influential outliers. The result that omitted variables can often influence the direction of an effect is well known. For (1) see Foster-Molina 2016a for a paper that covers the robustness of these results to the variables included. For (2), the outliers in this graph are highly legislatively successful representatives from non-wealthy districts. While in theory outliers can reverse the direction of an effect, given the location of these outliers they could only artificially inflate the effect, not reverse the effect. The remainder of this paper will show that the statistical significance of the effect presented in Table 1 remains after controlling for the heteroskedasticity and outliers using a variety of tools.

Another way in which the model is inappropriate to the data is that the response variable, percent bills passed, is proportional. Thus, the data is bounded by 0 and 100. The linear model assumes that the response variable is unbounded. A more appropriate model is one that curtails possible responses to be between 0 and 100. A tobit or logit transformation are both possibilities for this, but a beta model is more flexible and has a dispersion parameter to directly deal with the heteroskedasticity. Note that the direction of the effect in both the beta and linear regressions must be the same because both models are monotonic and the scatterplot does not support the possibility of an inflection point. Thus, with monotonic models and data with a monotonic trend, the direction of the effect must be the same whenever the covariates are the same. What might change is the magnitude of the effect and the statistical significance. The better the model fits the data, the more precise the coefficient estimate will be.

The next section will identify outliers and heteroskedasticity, and describe how to account for the outliers. The section that comes after will implement a model that accounts for the heteroskedasticity and proportionality of the data.

6. OUTLIERS, VARIABLE DISPERSION/HETEROSKEDASTICITY

Outliers and heteroskedasticity are two issues that can be dealt with through small modifications of the linear regression. This section identifies the outliers and validates the heteroskedasticity of the data. In addition, it demonstrates that the potential outliers do not affect the interpretation of the model.

Outliers generally violate two assumptions of the linear model: homoskedasticity and normally distributed residuals. If the outliers are clearly not theoretically relevant to the question being asked, then they can be excluded. For example, imagine the height of trees in an oak tree forest is being regressed against soil quality. If one of the trees is much taller than the rest, then if that tree is a redwood it makes sense to exclude it. However, if the tree is an unusually tall oak tree, with no other unusual characteristics, then it cannot be summarily excluded. One way to deal with outliers that seem to belong in the analysis is to run the model with and without the outliers. Strong outliers can change the magnitude of the effect and the statistical significance. If the magnitude, direction, and significance of the effect are similar, then the outliers do not affect the interpretation of the model. If any of these changes between the model with and without the outliers, then there is no statistically valid way to reconcile the conflict short of collecting more data and examining the outliers more closely.

There are some clear outliers here, so I calculate the Cook's distance and the expected Cook's distance cutoff point to find points with excessively high leverage. There are a full 12 such points, consisting of 3% of the dataset. Interestingly, 10 of the districts that have excessively high leverage are districts with Southern democratic representatives. All of these representative left office within 3 years of Watergate, and almost all of them were very senior members of Congress. However, while this is an interesting pattern, I'm not convinced that these members don't belong in the dataset. It's true that they are part of a fading system of seniority, but this should not on its face change how they respond to affluent constituents when it comes to legislation. Additionally, this is a substantial portion of the dataset, not merely a couple of points. Since I am uncertain on this point I will generally calculate models both with and without these high leverage districts.

Table 2: Percent Bills Passed by District, linear models

	Full	Full	Omit leverage	Omit leverage	Robust	Robust
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
(Intercept)	0.05	0.01***	0.03	0.00***	0.05	0.00***
% over $15k	-0.13	0.05*	-0.07	0.03*	-0.13	0.04**
log % black	-0.00	0.00	-0.00	0.00	-0.00	0.00
% college	0.06	0.10	0.03	0.05	0.06	0.07
Republican member	-0.03	0.00***	-0.01	0.00***	-0.02	0.00***
	n=435		n=422		n=435	

Signif codes: '***' <0.001, '**' <0.01, '*' <0.05

The results in Table 2 compare the linear regression for the 93rd Congress in three forms. The first is the model that includes the outliers, which was also presented in Table 1. The second is a model that omits the high leverage points. The third is a linear model with robust standard errors that I discuss in the remainder of this section. It modifies the standard errors equation to account for heteroskedastic data. Note that the direction and significance of each of the coefficients are the same across all models. The magnitude of the effect changes substantially, but both models claim that wealthy districts were represented by legislators who were less successful in legislation than were less wealthy districts.

The next assumption of linear models that is violated is homoskedasticity. The plots of the fitted values against the studentized standard residuals are presented in Figures 2 and 3, one for the model including the high leverage points, and one excluding them. There is apparent heteroskedasticity in both plots. A check with a test for non-constant variance (bptest) confirms this conclusion, as

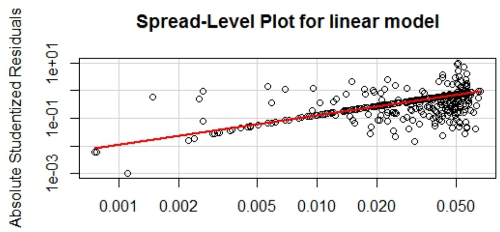


FIGURE 2. Heteroskedastic Data, including outliers

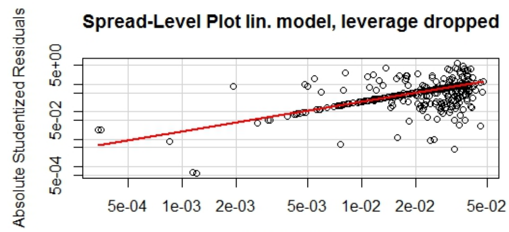


FIGURE 3. Heteroskedastic Data, excluding outliers

the null hypothesis of constant variance is clearly rejected. Thus, this is a dataset that displays heteroskedasticity with the dependent variable a proportion between 0 and 1. This heteroskedasticity exists even after excluding the outliers, which are a common cause of heteroskedastic data.

The last model described in Table 2 runs a linear regression with robust standard errors to account for the heteroskedasticity present. As was the case with the first two models in Table 2, the direction and statistical significance of the coefficients remain the same, although the magnitude of the effect changes. As described by King and Roberts (2015), this is the expected outcome of models that account for robust standard errors. Heteroskedasticity rarely impacts the substantive interpretation of a model, although it will change the magnitude of the coefficients. While these modifications provide some evidence that heteroskedasticity and outliers do not change the substantive interpretation of the model substantially, the linear model still does not account for the proportionality of the data. Thus, the next section implements a more appropriate model which accounts for heteroskedasticity of proportional data. As I explain in the next section, the most appropriate model for this data is a beta model.

7. BETA MODEL

The model that best accounts for this data is a beta model. It allows for both a location (μ) estimate, as well as a measure of the dispersion of the model. The dispersion of the model is related to the variance by the following equation, where ϕ is the dispersion estimate, μ is the location parameter, and σ is the standard deviation:

$$\sigma^2 = \frac{\mu(1-\mu)}{\phi+1}.$$

This allows the variance to fit the data more precisely, as ϕ is estimated from the data based on the standard deviation and the mean value. By isolating ϕ, we can see this relationship more clearly:

$$\phi = \frac{\mu(1-\mu)}{\sigma^2} - 1.$$

The traditional parameterization of the beta model is (57 Smithson and Verkuilen)

$$f(y|\omega,\tau) = \frac{\Gamma(\omega+\tau)}{\Gamma(\omega)\Gamma(\tau)} y^{\omega-1}(1-y)^{\tau-1} \tag{1}$$

where both ω and τ are functions of the dispersion parameter ϕ and the location parameter μ:

$$\omega = \mu\phi$$

$$\tau = \phi - \mu\phi.$$

The two parameters, ω and τ, provide flexibility for the shape of the distribution. Depending on these two shape parameters, the probability distribution can be uniform, Bernoulli, nearly normal, or a host of shapes in between. See Smithson and Verkuilen for more details on the technical assumptions behind this model.

Note that this model requires that $0 < y_i < 1$ for all $i \in N$. If an observation is in fact 0 or 1, then the probability density function given above, as well as the cumulative probability of that observation, will be 0. This is simply because $y^{\omega-1} = 0$ when $y = 0$, and $(1-y)^{\tau-1} = 0$ when $y = 1$. This violates a fundamental assumption that these probabilities must be strictly larger than 0. However, my data has 239 observations where $y_i = 0$. These are observations where the legislator sponsored a number of bills, but none of them were enacted into law.[8] In short, the majority of all legislators successfully enacted zero bills in the 93rd Congress. The standard fix (55 Smithson and Verkuilin) is to squeeze the data with the function

$$y' = \frac{y(N-1)+.5}{N}$$

where N is the number of observations in the dataset. This simply ensures that each observation is increased if it is below .5 by a very small fraction, and decreased in the same manner if it is below .5. Effectively, it transforms all zero's into $.5/N = .5/435 = .001149$. This squeeze does not change the substantive interpretation of the model. It merely allows the functional form to function properly.

[8]As I explain below, this is almost entirely due to legislators who sponsored bills but were not successful. One a couple of legislators failed to sponsor any bills in this Congress.

The alternate fix, to create a zero-inflated model, is not appropriate for this data. A zero-inflated model requires that a large portion of the zero's in the data are derived from a process that is fundamentally different that the data generating process for the nonzero values. The functional form this takes would be to create a dummy variable for whether a legislator was successful at all and create a model based both on the dummy variable and the proportional variable. That is, it combines a logit or probit function based on the dummy variable with the beta function based on the proportional variable. The results would report both a coefficient for the binomial aspect as well as the beta coefficients.

In effect, this would require that those politicians who are completely unsuccessful in shepherding their sponsored bills into law are somehow responding differently to their districts than those who are successful. If there were many legislators who were completely absent from the process by not bothering to even sponsor any bills, I would consider this. However, only a couple of legislators sponsored zero bills in this Congress, which is typical. The vast majority of the zero observations are legislators who sponsored bills, but were successful with none. They were trying, but not succeeding. There is no reason to think they respond to income in a fundamentally different manner than those who were successful.

The beta model comes in two forms relevant to this paper. The first assumes that ϕ is the same for all covariates. That is, it assumes that the variance/dispersion of the data increases or decreases at the same rate for all variables. We can see from figure 1 that variance changes in the bivariate relationship between wealth and bill success. As district wealth increases, the variance around the percent of bills passed decreases. That is, the dispersion parameter would be negatively associated with district wealth. If the dispersion parameter ϕ is constant for all variables, then in a multivariate model the dispersion would be have the same value and sign for each of the covariates.

The second beta model assumes that ϕ is influenced by each observations, and can be modeled separately for some or all of the covariates. This allows for the heteroskedasticity to be influenced in different ways by different variables. Perhaps the heteroskedasticity is entirely based on level of income, so the variance based on race and education is constant across all potential values of these two variables. That is, perhaps once we control for the changes in variation caused by income, there is no heteroskedasticity due to race and education. This allows for a more powerful and flexible model in the face of heteroskedastic data.

8. BETA RESULTS

8.1. **Derivation: ϕ constant.** For the first beta model, ϕ is be constant for all observations. This means that only μ must be linked to the data. There are multiple link functions available, but the standard one is the logit link (59 Smithson and Verkuilen),

$$X\beta = g(\mu) = \log(\frac{\mu}{1-\mu}).$$

This link function forces μ to reside between 0 and 1. Quick algebra demonstrates that

$$\mu = \frac{e^{X\beta}}{1+e^{X\beta}}.$$

Because ϕ is constant, I use a constant vector of six values. To simplify the code, I use the starting values for the optimizing function, which I set to:

$$\phi = (-3.14, -1.18, -.05, .89, -.38, 10)$$

In order to parameterize the function in terms of X, β, and y, the following equations are used:

$$\omega = \mu\phi$$

$$\tau = \phi - \mu\phi$$

These equations allow me to program this regression in R in terms of X, Y, and β. The code I wrote is attached in the appendix. The following log-likelihood function derived from the functional form of the probability density function given in equation 1:[9]

$$\log\, L(y|\tau,\omega) = \log\, \Gamma(\omega+\tau) - \log\, \Gamma(\omega) - \log\, \Gamma(\tau) + (\omega-1)\log\,(y) + (\tau-1)\log\,(1-y).$$

This is the result of taking the log of the probability density function, then taking the derivative. The goal here is to find the value of β that optimizes the log-likelihood function, thereby providing the coefficients that provide the highest probability for the entire function. This is equivalent to the

[9]The results in which ϕ is held constant match the canned beta regression betareg() to within a few hundredths. The results using a non-constant ϕ are derived and double checked on my own without the aid of an external package.

best fit parameters of a linear regression using least squares. The optimization is performed using the standard R function optim().

8.2. **Results: ϕ constant.** The following analysis presents the results including and excluding the high leverage points identified above. Without excluding the high leverage points, I obtain results presented in Table 3:

Table 3: Percent Bills Passed by District, Beta regression

	Full	Full	Exclude leverage	Exclude leverage
	Estimate	Std. Error	Estimate	Std. Error
(Intercept)	-2.85	0.17***	-3.29	0.17***
% over $15k	-1.56	0.81*	-1.57	0.80*
% college	1.12	1.34	1.18	1.32
log % black	-0.05	0.03	-0.06	0.03*
Republican member	-0.38	0.10***	-0.35	0.10***
phi	11.16	1.01***	18.98	1.71***
	n=435		n=423	

Signif codes: '***' <0.001, '**' <0.01, '*' <0.05

In other words, the two models are virtually identical. The only difference from the linear model is that the control variable for race dances on the edge of traditional statistical significance. Thus, we can be confident that the model's results are not influenced by the high leverage points.

The primary explanatory variable, percent of the district earning more than $15,000, can be interpreted easily with the logit link function used. In particular,

$$e^{X\beta} = \frac{\mu}{1-\mu}$$

so $e^{-1.56} = .21$ is the odds ratio. Holding all other variables constant, one thousand extra dollars of income will translate to a reduction in the odds that your legislator passes a bill by 21%. Note that this is a change in the odds ration, which is not the same as a 21% decrease in the probability that your legislator passes a bill. These results indicate the same phenomenon found in the linear regressions: wealthier districts are represented by legislators who are not as successful in legislation.

Phi, the dispersion parameter is positive and statistically significant in both models. This validates what I showed in the previous section: the data is heteroskedastic under a beta model as well. A more useful interpretation of the dispersion parameter will come in the next section.

8.3. ϕ **not constant.** The second model I run allows ϕ to vary by observation. In particular, in accordance with Smithson and Verkuilen (pg 59), I let

$$\phi = e^{-X\beta}.$$

In theory, I could let the variables be a subset of the variables I use to estimate the location parameter, but I have no reason to think that the dispersion parameter will vary according to some of the variables but not others. The equations given above remain the same, but instead of substituting the constant vector for ϕ, I substitute the above equation. Allowing ϕ to be specified for each variable, just like β is specified for each variable, allows each variable's heteroskedasticity to be estimated. In other words, income will be allowed to have a different level of dispersion/heteroskedasticity than education.

I now have 10 coefficients to estimate: the five original coefficients for the location parameter μ, and the five coefficients for the dispersion parameter ϕ. The results are presented in Table 4.

Table 4: Percent Bills Passed by District, Beta regression, phi variable

	Full	Full	Exclude leverage	Exclude leverage
	Estimate	Std. Error	Estimate	Std. Error
(Intercept)μ	-1.80	0.25***	-2.57	0.25***
% over \$ 15k μ	-6.43	1.45***	-4.36	1.33***
% college μ	5.51	2.55*	1.47	2.53
log % black μ	-0.13	0.05*	-0.11	0.05*
Republican member μ	-1.22	0.17***	-0.74	0.16***
(Intercept) ϕ	-0.75	0.30*	-1.76	0.31***
% over \$ 15k ϕ	-7.21	1.87***	-4.30	1.71*
% college ϕ	5.85	3.21	0.23	3.35
log % black ϕ	-0.10	0.07	-0.07	0.06
Republican member ϕ	-1.25	0.20***	-0.61	0.20**
	n=435		n=423	

Signif codes: '***' <0.001, '**' <0.01, '*' <0.05

The main substantive result is that the effect of income is consistently negative and significant. However, the dispersion parameters also provide interesting information. As expected, the dispersion parameter for income is negative and statistically significant, with a p-value below 0.05. This is in line with the earlier findings from the linear model that showed that income was heteroskedastic. That is, the variance of the effect of income was higher for low values of income than it was for high values of income. This is exactly what a negative dispersion parameter shows: the higher the value of income, the lower the dispersion of the data. The dispersion parameter for party is also negative. This shows that Republicans (coded 1), the minority party, had more variance in their success than did Democrats (coded 0). This is sensible, as there were likely some Republicans who were in favor with Democrats and thus fairly successful, and some who were not in favor and therefore were excluded from the legislative process. The dispersion of education is close to being statistically significant in the model that includes the high leverage points with $p = 0.06$, but not at all close when the high leverage points are excluded.

Interestingly, now that ϕ is allowed to vary along with each variable, the substantive impact of income increases dramatically, from a odds ratio of .29 in the previous model to an odds ratio of at least $e^{-4.36} = 0.01$ in this model. Note that in an odds ratio, the closer the coefficient is to 1, the lower the effect. Thus, odds ratios closer to 0 have a stronger impact than an odds ratio close to 1.

Additionally, the impact of college education in a district depends dramatically on the inclusion of the income outliers. Note that in both models, as expected, the direction of the effect remains the same although the standard errors vary wildly. Including the high leverage points/outliers, district education is significantly positive, with an odds ratio of $e^{5.58} = 347.23$. That is, the impact of one unit change in district education on bill success is 347.23 times greater. This is a massive odds ratio, but keep in mind that the starting values are also low. Excluding the high leverage points, the effect of college is a much smaller, and not statistically significant, $e^{.23} = 1.26$. The reason for this comes back to the fact that the outliers were highly senior southern Democrats. They generally represented low income districts, yet were extremely successful in the legislative process. They clearly had high leverage on the results for education in addition to the results for income.

Note that due to the strong collinearity between education and income, the direction and size of each effect can be substantially different based on how and if they are included in the model. Figure 4 presents a simple scatterplot of the relationship between these two variables. Using the theory of omitted variable bias, if two highly correlated variables have opposing effects, then the signs of the cofficients will change depending on how the model controls for them. The relationship between education and income is examined in the next section.

Finally, note that as might be expected by a more flexible model, the statistical significance of all the variables tended to improve, including the statistical significance of race. In all previous models, the effect of the black population was negative and insignificant. Once the dispersion parameters are accounted for, the effect of black population remains negative but becomes significant. That is, the model that includes multiple dispersion parameters finds that when the black population in a district is larger, their representatives are less legislatively successful. Other studies have found that this may

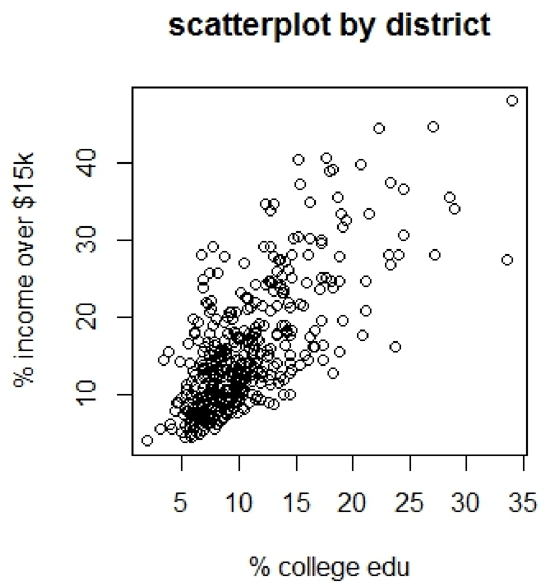


FIGURE 4. College Education and Income by District

be partially due to the effect of minority representatives in Congress, where black representatives tend to be more legislatively successful in districts with larger black populations (Foster-Molina 2016b).

Importantly, although the magnitude of the effect of income has changed, the direction and significance of the effect is the same as it has been in each model. Namely, no matter the model I use, district wealth has a negative effect on legislative success in the 93rd Congress. This is a regular result of regressions whenever monotonic trends are being described. No matter what monotonic model is used, if the data follows a monotonic positive or negative trend, then the model will pick it up. If the model fits the data particularly poorly, then the statistical significance of the model may be lower than would be uncovered in a more appropriate model, but the direction of the effect will almost never change.

9. PATTERNS OVER TIME

Recall the results presented in Table 1, replicated in Table 6 below.

Table 5: Percent Bills Passed

	109th Congress (p-val)	93rd Congress (p-val)
% over \$75k or \$15k	.09 (0.02)*	-0.13 (0.02)*
% college	-0.05 (0.17)	0.06 (0.52)
log % black population	-0.00 (0.75)	-0.00 (0.36)
Republican member	0.10 (0.00)***	-0.01 (0.00)***

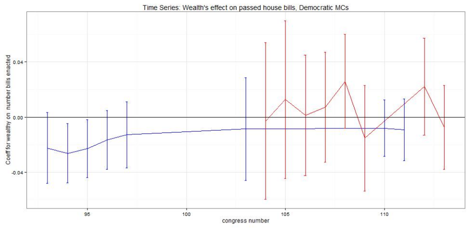
Note: Republicans: $n = 237$. Democrats: $n = 207$.
$^{*}p < 0.05$, $^{**}p < 0.01$,$^{***}p < 0.001$

These results indicated a substantial change from the 1970s (93rd Congress) to the 2000s (109th Congress). In particular, the effect of income flipped. Although not statistically significant in the linear regression, the effect of education may also have flipped. I have shown that this is not an artifact of an inappropriate model. I cite results from a forthcoming paper that show that these results are not only real, but part of a long standing evolution in American politics. For the purpose of this analysis, Republican legislators are examined separately from Democratic legislators, as there is reason to believe that they respond in different ways to class based preferences.

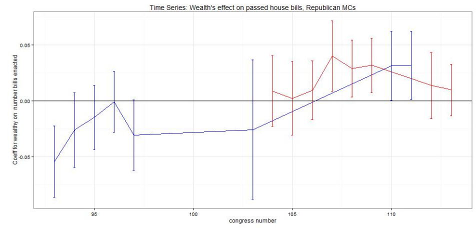
The following graphs drawn from Foster-Molina (2016c) clearly indicate that not only has income had an increasing impact on legislative output, but the effect was negative throughout the 1970s. This paper draws on a novel dataset that spans Congresses from the 1970s through the 2010s, although it is currently missing data for the 1980s. The measure used is slightly different from the measure I use in this paper. Instead of using percentage of successful bills, the paper in which these figures are first presented uses the number of bills sponsored by a House member that were approved by the House of Representatives. The direction of the effects and the significance are similar to those found using the proportional measure seen throughout the current paper.

Figure 5 below shows the magnitude of the coefficient for the percentage of a district earning the equivalent of over \$75,000 per year, inflation adjusted to 2015 dollars, for all Congresses in the 1970s, 1990s, 2000s, and 2010s. The color of the line indicates which party controlled Congress: Democrats in blue throughout the 1970s, and Republicans in red for most of the remaining decades. Any Congress that shows the confidence interval not overlapping the zero line is a Congress where the effect was statistically significantly positive or negative. For both Republican members of Congress and Democratic members, income had a statistically significant negative impact on legislative output in the 1970s (93rd to 97th Congresses).

Figure 5. Effect of district wealth on legislative success: Democrats vs Republicans

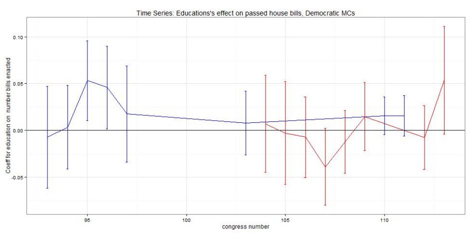


(a) Democrats: Wealth

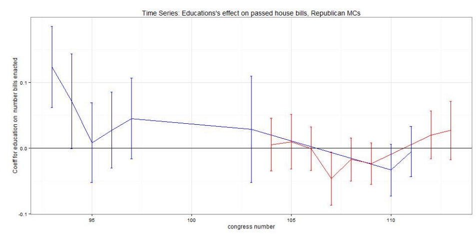


(b) Republicans: Wealth

Figure 7. Effect of district education on legislative success: Democrats vs Republicans



(a) Democrats: Education



(b) Republicans: Education

Figures B in both 5 and 7 focuses on Republicans. The magnitude of the impact of income in Figure 5 is strongest for Republican members of Congress, both negative and positive. Not all years feature statistical significance, but many do and the trend is clear. Districts with high incomes are getting more legislation passed over time, although there has been a recent downtick for the 110th-113th Congresses.

Figure 7 shows the effect of education for both Democrats and Republicans. Note that the effect of education generally mirrors the effect of income. In decades where the effect of education is generally positive, the effect of income is generally negative, and vice versa.

Thus, we can see that the unexpected results from this paper are not an artifact of the model, but instead reflect a real trend in American politics. Depending on the model and the measure of legislative success used, education may have had a positive effect or a null effect. Income, on the other hand, was always statistically significant and in the same direction. Income used to be negatively associated with legislative success.

10. CONCLUSION

The existing findings on economic inequality and representation say that the affluent are disproportionately influential in the modern era. The analysis presented shows that this was not true in the

1970s. The affluent clearly got less legislation, yet the educated may get more legislation after income is controlled for. These two highly correlated measures pull in opposite directions.

Neither the heteroskedasticity of the data nor the outliers impacted the direction of the effect of income. No matter what model I used, income always had a negative association with legislative success. This is generally true for well behaved data: as long as the data shows a monotonic trend and uses the same covariates, any model that is inherently monotonic will produce the same coefficient sign, and often similar significance.

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