La Follette Policy Report

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Director's Perspective

Work by New Faculty Showcases Relationships between Information, Decision-Making

Two themes link the articles in this issue of the *La Follette Policy Report*. The first is that they are contributed by four new members of the La Follette School faculty.

Mark Copelovitch joined us in fall 2006. His expertise on international monetary and financial relations is evident in his examination of how the International Monetary Fund (IMF) issues loans. His analysis shows that both staff members and the five countries that control the decision-making affect the size of loans. However, their relative influence shifts according to time period and IMF shareholder interest.

Another article of international interest is by Gregory Nemet,

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In This Issue

Welfare Reform's Influence on Childbearing by 15- to 17-Year-Olds

Thomas DeLeire and Leonard M. Lopoo

Before joining the La Follette School, where he is now an associate professor, Thomas DeLeire was a senior analyst at the Congressional Budget Office in Washington, D.C. Leonard M. Lopoo is assistant professor of public administration at the Maxwell School and senior research associate at the Center for Policy Research at Syracuse University.

A more extensive version of this article appeared in the Journal of Policy Analysis and Management, *volume 25, number 2, 2006, pp. 275–298.*

The creation of Temporary Assistance for Needy Families (TANF) in 1996 gave states considerable discretion in determining eligibility and the form of assistance for their cash-welfare programs and emphasized self-sufficiency through work. The Personal Responsibility and Work Opportunity Reconciliation Act of 1996 that initiated TANF made explicit the objective to influence the lives of low-income families by providing assistance so relatives can care for children; ending the dependence of parents on government benefits by promoting job preparation, work, and marriage; preventing and reducing the incidence of out-of-wedlock pregnancies; and encouraging the formation and maintenance of two-parent families.

Within this major focus on family structure, unwed teenagers younger than 18 received particular attention, and Congress used a multipronged strategy to reduce their childbearing. For instance, most states have used TANF money to fund efforts to reduce teen pregnancy and nonmarital childbearing, including after-school programs and mentoring. The act also created a federal funding source for abstinence-only education, and, by as early as November 1997, all 50 states and the District of Columbia had received approval of their applications for abstinence-only education funding.

One of the principal changes states made that may have reduced teenage childbearing was the implementation of two rules targeting minor parents. To receive benefits, unwed, minor mothers are required to attend school or a training program unless they have completed high school or its equivalent. TANF also forbids providing aid to these mothers unless they live with adult relatives or legal guardians. For clarity, we call these two rules the "minor parent rules."

Since the welfare reforms of the 1990s reduced the overall benefits due

an unwed mother, one might expect welfare reform to reduce nonmarital childbearing, all else equal. Because minors were singled out in these reforms, they may be affected to an even greater degree than older women.

Our objective is to document whether the changes created by these welfare reforms reduced childbearing among women younger than 18. We use state-level data to estimate the trend in childbearing among women aged 15 to 17 prior to and following the implementation of these minor parent rules compared to a control group of 18-year-olds who were not subject to these rules.

Understanding the impact of welfare reform is crucial. If, under the Aid to Families with Dependent Children program that preceded TANF, young women used welfare resources to attain independence and move out of their parents' homes, then the loss of this benefit under TANF should lead to reduced teenage childbearing. This in turn might improve outcomes for teen mothers and their children: improved educational attainment for teen mothers (particularly among those younger than 18), reductions in poverty, welfare receipt, and risky behaviors.

We use data on childbearing from the National Center for Health Statistics, population estimates from the U.S. Bureau of the Census, and other sources to identify the role welfare reform played, if any, in reducing childbearing by teens during the 1990s. Our results suggest that compared to 18-year-olds, the annual percent change in childbearing rates among young teenagers was about 0.7 percentage points lower (more than 22 percent) following the implementation of the minor parent rules. Furthermore, these differences were largest among African Americans and white teenagers.

Theoretical Background

Economists argue that providing welfare benefits only to low-income single mothers creates incentives for women to delay marriage, divorce or separate, postpone remarriage, and bear children out of wedlock. Welfare reform's reduction of net benefits through time limits, work requirements, and removal of entitlement, plus cuts in real benefits in most states, likely contributed to a decline in the proportion of low-income women having nonmarital births following welfare reform.

Under TANF, teenagers considering whether to have children face a work requirement and a five-year limit on benefits. To receive cash transfers they have to complete high school; and, if younger than 17 and

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Interest Group Competition on Federal Agency Rules

Susan Webb Yackee and Amy McKay

Susan Webb Yackee joined the La Follette School of Public Affairs in fall 2007. She is an assistant professor with a joint appointment in political science. She received the 2007 "Emerging Scholar Award" from the Political Parties and Organizations Section of the American Political Science Association. Her research interests include the public bureaucracy, interest groups, and the politics of the policymaking process. Amy McKay is an assistant professor at Georgia State University in the political science department. Her research interests focus on federal policymaking, particularly the intersection of interest groups, federal agencies, and Congress. *A more detailed version of this article appears in* American Politics Research*, volume 35, number 3, May 2007, pp. 336-357.*

For decades, scholars have been fascinated by the notion that competing interests wage lobbying wars to influence government decision-making. We know little, however, about the level of this competition during policymaking and, in particular, during a critical stage in the policymaking process — agency rulemaking. This lack of attention to lobbying during agency rulemaking is surprising, given that (a) interest groups report that participating in rulemaking is as important as lobbying Congress and more important than several other lobbying tactics and (b) agency officials often believe themselves to be responsive to interest group lobbying during rulemaking.

Here, we test two hypotheses regarding the level and the effects of competitive lobbying during rulemaking. First, we analyze the effects of lobbying on the bureaucracy. We hypothesize that agency rulemakers, in an effort to avoid conflict and public criticism, are less likely to alter rules when lobbying occurs on both sides of an issue, and are more likely to alter rules when one side of a policy issue dominates lobbying activity. In other words, we hypothesize that squeaky wheels get the grease during agency rulemaking. If the bureaucracy does in fact weigh lobbyists against one another, this implies that interest groups should pay attention to the lobbying efforts of their opponents. Our second hypothesis is that during rulemaking, lobbying by groups on one side of a policy issue will generate opposition lobbying.

To assess these relationships, we study 1,693 comments on 40 rules issued by U.S. agencies. We demonstrate that when one side of an issue dominates the public comment process, public policy tends to be implemented toward that side's preferred position. In spite of this, we find interest groups do not strategically respond to lobbying by opponents — there is little evidence of counteractive lobbying. We suggest that costs associated with submitting comments and monitoring the behavior of opposing interests discourage some groups from lobbying in a counteractive fashion, even when it likely would be advantageous to do so.

Previous Research

For this article's theoretical foundations, we draw on the literature on bureaucratic politics and the literature on competitive lobbying. The intersection of these literatures is important. First, an almost single-minded focus on lobbying in a legislative context means we do not understand the strategic and tactical role competitive lobbying may play in the bureaucracy. That relatively few studies have looked at the direct role interest groups play in influencing agency actions is surprising; scholarship shows that interest groups can be positive and negative forces on bureaucrats' decisions. Moreover, because interest groups may draw negative attention to the agency by their activities, agencies may preemptively cooperate with interest groups. Second, the literature on competitive lobbying is split, with one group of scholars providing some support for it and another group suggesting otherwise. One group finds that high levels of lobbying is competitive, conflictual, and responsive to other lobbying efforts, while others find little communication among lobbyists who are adversaries.

Federal Agency Rulemaking

The Administrative Procedure Act of 1946 governs the agency rulemaking process. The act requires agencies to publish most of their proposed rules before adopting them and to solicit comments from the public during a "notice-and-comment period" during which organized interests may send written comments to agencies. After the comment period, the agency issues a final rule, which is enforceable as law. A final rule may or may not differ from a proposed rule, as there is no specific legal obligation that an agency alters its proposed rule in response to the commenters. Yet the courts have construed the Administrative Procedure Act to require agencies to consider all information in the written record when making their final regulatory decisions — including public comments.

Hypotheses

We evaluate two questions:

1. Do government agencies respond to lobbying by changing agency policies?
2. Does lobbying on one side of a policy issue beget lobbying on the opposing side; is there competitive lobbying?

Our first hypothesis is that in bureaucratic rulemaking, the squeaky wheel gets the grease. Our specific focus is on the volume of interest group comments submitted to influence possible rule changes. When the two opposing sets of interest group commenters are approximately equal in number, we expect that the agency will not significantly alter its proposed rule in response to submitted comments. However, when one side dominates lobbying, we believe that agency officials will weigh the volume of comments from interest groups and grease the squeaky wheel. In these cases, interest groups send bureaucrats a clearer message regarding their preferences and, in turn, bureaucrats are more likely to respond.

Our second hypothesis follows logically: Interest group lobbying begets opposition lobbying. We argue that lobbyists have an incentive to be aware of the activities of groups in their policy space and to respond in similar levels to lobbying by the other side. Environmentalists, for instance, may mobilize their members and increase their submission of comments when business groups with opposing views pursue an issue; insurance companies may intensify lobbying when patients' groups begin to demand less expensive health care. Thus, given the costs associated with participation in the notice-and-comment period, we argue that a strategic lobbyist will be more likely to pay the lobbying costs when opponents are submitting comments.

Federal bureaucrats listen to interest groups and tend to favor the dominant side. Officials respond when they receive strong, loud, and united messages from interest groups. The volume of the interest group comments on either side of an issue matters to the content of final agency regulations.

Testing the Hypotheses

The 40 rules and 1,693 comments that we analyze were promulgated by the U.S. Department of Labor's Occupational Safety and Health Administration and Employment Standards Administration, and by the U.S. Department of Transportation's Federal Railroad Administration and Federal Highway Administration from 1994 to 2001. We selected the specific rules from those receiving fewer than 200 comments and more than one comment. Rules with unusually high numbers of comments were removed in part out of practicality and because we prefer to focus on the "normal" reactions of agency officials to interest group involvement in rulemaking.

The Squeaky Wheel Model

We measure rule change, the dependent variable, on a 3-point scale that assesses the direction of change in bureaucratic policy output between the initial writing of a rule and its final promulgation. Coders evaluated whether the final rule called for more government involvement (+1), the same level (0), or less regulation (–1) than the proposed rule.

We employ two variables to predict the level of conflict in the comments: interest group split and comment intensity differential. Interest group split is the difference between the number of proregulation and antiregulation comments on each rule. This difference takes into account both the direction and magnitude of the split in interest group comments. For example, when 10 commenters want less regulation and 10 commenters want more regulation (a split of 0), we would anticipate little to no change in the level of regulation in the final rule. However, if the split between the commenters is 40 for less regulation and 2 for more (a split of –38), we would expect a change toward less regulation in the final rule. Hence, as the interest group split moves away from 0 (in a negative or positive direction), so does the volume of the squeaking wheel.

Our alternate main predictor, comment intensity differential, measures the number and degree of change(s) commenters desired. Coders identified whether the commenter wanted a few minor changes toward more (+0.5) or less (–0.5) regulation or many minor changes/any major changes toward more (+1.0) or less (–1.0) regulation. Again, we sum the intensity of change desired by commenters advocating more regulation and subtract from it the sum of the intensity of change desired by commenters desiring less regulation.

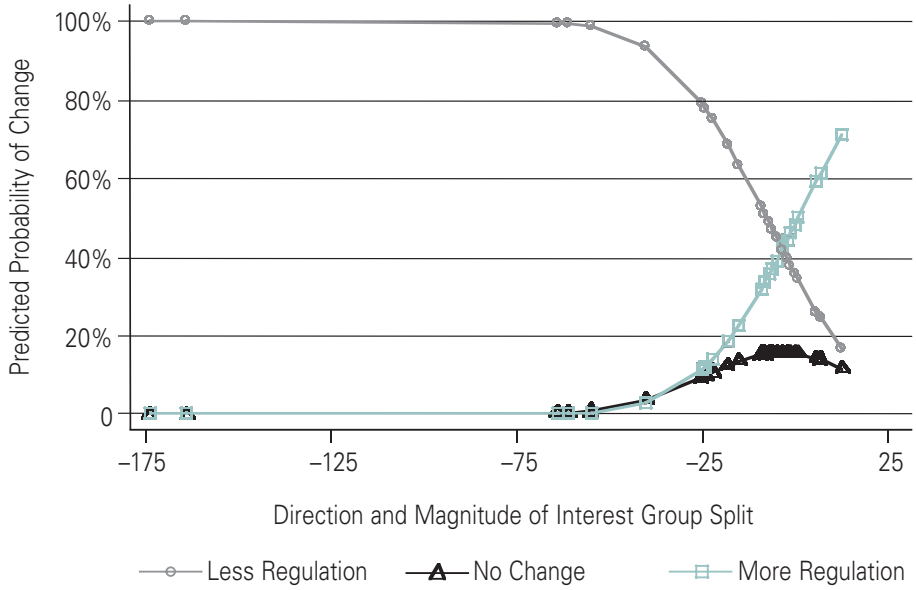
In addition, the squeaky wheel analyses tap the relative "political power" of commenters. One may argue that lobbyists with greater ability to contact, and by extension influence, bureaucrats may have a disproportionate effect on final rules. Thus, we include a variable measuring whether a commenter was from the Washington, D.C., area. We expect that these commenters will have, on average, greater

access to federal agencies, more resources, and lower lobbying costs than those from outside Washington.

The Lobbying Begets Lobbying Model

Because competitive lobbying reflects efforts undertaken in response to lobbying by opposing groups, we index the data by time period. We evaluate whether the number of interest groups seeking less regulation at a specific time can predict the number of interest groups seeking more regulation prior to that time (and vice versa). Hence, we use this time sequencing of efforts to infer whether lobbyists attempt to counter the efforts of opposing groups during the public comment period.

Figure 1
Predicted Probability of Rule Change, Given Direction and Magnitude of Split in Interest Group Comments



As in the squeaky wheel model, comments were coded according to whether they favored more (+1), the same level (0), or less (–1) regulation in the final rule compared to the proposal. We then transformed these numbers into the dependent variable (proregulation) and the main predictor variable (antiregulation) by summing the number of comments advocating more or less regulation, respectively, in each week of the comment period for each rule. If lobbying is strategic and counteractive lobbying takes place as we have hypothesized, then we should find a positive relationship between the numbers of comments made at specific points in time.

Results

For both models, we use statistical models to test the hypotheses. We also control for alternate explanations that could have affected the outcomes, such as the salience of the regulation.

The Squeaky Wheel Model

We find strong support in the data for the squeaky wheel hypothesis. The analyses indicate that agencies alter the level of government regulation in a rule based on the split in the public comments by people seeking more or less regulation. Bureaucrats seem to respond to the number of comments made on whether to change a regulation in much the same way that the depth of feelings among constituents sways legislators. The two predictor variables, interest group split and comment intensity differential, are strong and significant.

The analysis indicates that the bureaucracy responds to the magnitude of the split in commenter preferences in addition to the direction of this split. As the split between the commenters who want the greatest amount of regulation and those who want the least becomes increasingly lopsided, agencies are more likely to shift the content of final rules in concert with the preferences expressed by the side with the most comments. These results strongly suggest that commenter volume matters to rule promulgation.

Figure 1 provides a simple picture of the relationship between rule change and interest group split. The predicted probabilities for the dependent variable, rule change, show the effect of the predictor variable, interest group split. For instance, when the antiregulation comments outnumber the pro-regulation comments, final rules are predicted to have less regulation than the proposed rules. In addition, although the general trend is for the bureaucracy to reduce regulation in response to comments, high levels of proregulation comments can override this trend. The figure also indicates that for those rules in which the comments were closely split in volume (approximating the 0 point on the x-axis), neither the proregulation nor the antiregulation side has an advantage. In fact, the highest probability (albeit

only 16 percent) that final rules experience no change between the proposal and final stages occurs when the comments were evenly split.

A main alternative hypothesis we considered was that political power, rather than relative comment volume, drives rule change. If so, then whether a commenter is from Washington, D.C., should matter more than the split between the numbers of commenters. But neither the percentage of D.C.-area commenters seeking more regulation nor the percentage for less regulation has a significant effect on the direction of regulatory change in the final rule, whereas the main predictor variable, interest group split, remains significant. Additional analysis finds little support for the contention that being from Washington, D.C., increases a commenter's chance of realizing the desired outcome. We conclude that the phenomenon observed in our squeaky wheel analysis is not a product of the from-D.C. variable.

In sum, the results from the squeaky wheel model demonstrate that when interest group commenters who desire less (or more) regulation face little opposition from other groups, there is a high probability of shifting the implementation of public policy toward their preferred outcome. Furthermore, the findings suggest that agencies weigh the number of comments they receive for and against government regulation against each other, as well as take into account the intensity of these comments.

Interest groups do not appear to respond strategically to the quantity of comments from the opposing side.

The Lobbying Begets Lobbying Model

Contrary to our expectations, we find little support for the lobbying begets lobbying hypothesis. An increase in comments seeking less regulation in one time period was not correlated with an increase in comments favoring more regulation or the status quo in a subsequent period. Overall, our multiagency, multiyear study provides the first empirical evidence against competitive lobbying during administrative rulemaking, and sheds new light on the lobbying strategies used by organized interests in low-salience agency policymaking. We know from previous scholarship that interest groups believe their submission of comments to rules to be important and influential. However, the results of our analyses do not support the assumption that organized interests strategically respond to the quantity of comments submitted by their opponents by adjusting their own commenting.

In short, our analysis indicates that competitive lobbying is uncommon and groups that fundamentally disagree tend not to communicate. We interpret this finding to mean interest groups lack information about their competitors' lobbying activities. Moreover, given that organized interests are generally strategic in spending their lobbying resources, the "costs" of commenting — including the possibility of what we view as a new cost, the observation of opponent behavior — must be high enough to dissuade some from taking an active role in commenting.

Conclusions

We find strong evidence that federal bureaucrats listen to interest groups and tend to favor the dominant side. These results diverge from the common picture of bureaucrats as unresponsiveness technocrats. We find that federal agency officials respond when they receive strong, loud, and united messages from interest groups, and that the volume of the interest group comments on either side of an issue matters to the content of final agency regulations.

Our second hypothesis — that lobbying begets lobbying — is not supported. We expected that groups on opposing sides of a policy proposal would respond to each other's lobbying efforts. But the interest groups in these rulemaking data do not appear to follow such a strategy. The lack of evidence for this hypothesis is surprising given that the squeaky wheel analysis suggests that by monitoring opposition groups' submission of public comments, groups could adjust their own tactics to become the dominant squeaky wheel and, thereby, shift the rule in their preferred direction.

Several reasonable explanations shed light on this puzzling finding. First, groups that fundamentally disagree tend not to associate with one another, just as ordinary people do not. It is easy to understand why dedicated environmentalists may not want to spend much time with oil company executives, for instance. Second, lobbying requires considerable time and money to monitor agencies, research policies, and convince the bureaucrats that a group's position is the right one. These participation costs may be much higher than we previously thought. Moreover, this account suggests an additional cost associated with successfully participating in notice-and-comment periods: the cost of monitoring the behavior of rival interests.

Given that the traditional paper-based processes related to public commenting are evolving, interest groups may find that responding to each other's comments will become easier. Recent developments in

technology initiatives — in particular, electronic rulemaking or "e-rulemaking" — seek to fully digitize the regulatory process by making agency proposals available online; e-rulemaking may make it easier for interest groups to monitor agencies and to respond to agency proposals with critiques or suggestions. E-rulemaking promises to improve the quality of commenter-agency interactions by allowing real-time or near-real-time exchanges. These more ambitious advances are especially important because they allow, in theory, interest group commenters to better monitor and respond to the arguments of other commenters prior to the promulgation of a final rule.

Government bureaucracies are often portrayed as large, dense institutions that have a difficult time communicating with themselves, let alone the broader public. A large part of the problem is that agencies are perceived as being unresponsive to public preferences. Our results dispute this conventional wisdom. Although competition between opposing interest groups may not be direct or intentional, groups from both sides of a policy debate do have access to and, more important, influence on agency bureaucrats. The concerns of the affected population — when people take the time to submit written comments to agency officials and when others are active in the cause — do seem to make their way into final agency rules. ◆

Director's Perspective *continued from page 1*

whose research on public and private investment in energy research and global warming was featured in the December 6 issue of the journal *Nature*. In the *Policy Report*, he discusses a common analysis tool for predicting improvements in technology. He finds that the learning curve is just one of several models policymakers should consider when weighing how to support emerging energy technologies.

Greg joined La Follette last fall with two other scholars, Susan Webb Yackee and Thomas DeLeire. Like Mark, Susan examines the role of bureaucrats in decision-making, more specifically, how federal employees in the United States respond to interest groups during the notice-and-comment periods for proposed rules to be issued by federal agencies. The bureaucrats do listen, Susan finds, and they tend to back the dominant side. Surprisingly, lobbyists are not strategic in countering comments their opponents make.

The fourth article in this issue focuses on an outcome of policy rather than the process of policymaking. Tom DeLeire looks at the effect of welfare reform on childbearing by 15- to 17-year-olds. He shows that rules requiring parents in this age group to live with a parent or guardian and to complete high school in order to receive cash transfers as part of their welfare benefits have led to a modest decrease in childbearing by 15- to 17-year-olds.

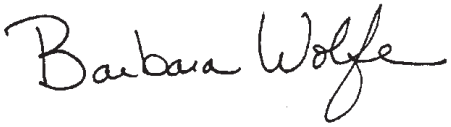
The second theme linking these four pieces is that they all illustrate how individuals — whether policymakers or teenagers — make decisions. The technology learning curve that Greg has studied is one component that informs decisions, but he shows that people need to consider more than that single factor.

Mark and Susan examine the role of bureaucrats and political forces in agency decision-making. Both show that bureaucrats are influenced by concerns that multiple groups express. At the IMF, whether the five countries that dominate the decision-making have a high degree of unified interest in an applicant affects the size of a loan. When interest is low and varied, IMF staff can further their interests in terms of budget, autonomy, and influence.

Susan also finds that consonant input from interest groups, like unified interest in some IMF loan applications, affects the outcome of decisions to change or not change agency rules. The likelihood of a rule change increases with the number of comments demanding an alteration. Agency employees are more likely to leave a rule intact if comments support the status quo. The squeaky wheel does "get the grease."

Just as information plays a role in the making of policy, so does policy influence the decisions people make. The requirements for young mothers to complete high school and live with a parent or guardian in order to receive government financial support seems to have reduced childbearing in the 15- to 17-year-old group by 22 percent. Clearly, then, a policy change is influencing the choice that some teenage girls make.

These findings all have important economic and social consequences. They point to the importance of good information in policymaking. Whether we look at the best use of government subsidies of technology in the hope of generating greater production efficiencies, loans to developing countries, or welfare policy, good information should lead to better public policy. Cognizance of costs of policies, the value to society, and possible repercussions are just some of the factors that policymakers should take into account in policy design and implementation.



unmarried, they cannot live separately from their adult relatives or guardians.

Those teenagers who chose not to have children under Aid to Families with Dependent Children (AFDC) likely would have also chosen not to have children under TANF, as to do so garnered even fewer benefits. However, some teenagers who had children under AFDC would have chosen not to have children under TANF because the benefits of having children are lower under TANF. Given this argument, therefore, we expect a decline in childbearing among all teenage women after the 1996 welfare reform act, with an even larger decline for those 17 or younger. Since prior to welfare reform, about three-quarters of all unwed teenage mothers received AFDC within five years of the births of their children, welfare reform may have had a large impact on teenage childbearing in the United States.

Some evidence shows that the rules for minor parents are being enforced. One study uses data from a 2000 survey from the Center for Law and Social Policy asking state administrators about their enforcement rules. While all responding states reported that teenagers who violated the stay-in-school rule were never denied access, many explained that they had sanctioned teen mothers for violations. Of all teens subject to the stay-in-school rule, 5.6 percent of those in California were sanctioned, 6.4 percent of those in Arizona, 9.9 percent of those in Ohio, 10.5 percent of those in Illinois, and 22.7 percent of those in Texas were sanctioned.

The literature on welfare and teenage childbearing is extensive and ambiguous. Many studies by economists and demographers have examined the potential effects of the AFDC program on teenage childbearing but these studies, which differ in terms of data, empirical methods, and racial/ethnic group being studied, did not achieve a consensus. For example, several studies show no statistically significant effect of AFDC. One finds weak evidence of a positive link between AFDC and childbearing for white and African American teenagers but no effect for Hispanics. Another finds a strong positive association for white teens but no effect for African American or Hispanic teens.

Four additional studies have investigated the relationship between welfare reform and teenage childbearing and, like the earlier literature on AFDC, found mixed results. One finds that states that received waivers to change welfare policy (prior to TANF) and that required teenagers to live at home and attend school had higher nonmarital birth ratios, all else equal, compared to states without waivers. A second study found large and statistically significant reductions in the probability of a teen birth due to welfare reform. A third analysis found a large, but statistically insignificant, decline in teenage childbearing in response to welfare reform.

Data

To achieve less ambiguous results than the previous literature, we use several strategies. This study generates 7,624 birth rates for each age and race/ethnicity for each year and state using data from the National Center for Health Statistics, a source that records nearly all births to teenagers in the United States. The use of these data reduces bias due to undercoverage and non-response. Second, the current study compares the results from minors (women aged 15 to 17) to a control group of 18-year-olds, a strategy that may more accurately measure the effect of the minor parent rules than found in earlier work. Finally, this project includes data from the period before the minor parent rules were implemented and terminates only after every state had implemented these policies. For each state from 1992 to 1999, the National Center for Health Statistics provides population data on the number of births to females aged 15, 16, 17, and 18 by race/ethnicity, that is, non-Hispanic white (hereafter referred to as "white"), non-Hispanic African American (hereafter referred to as "African American"), Hispanic (which includes Hispanic white and Hispanic African American), Asian or Pacific Islander (Hispanic and non-Hispanic), and American Indian (Hispanic and non-Hispanic). We supplement these data with the corresponding annual state population estimates by age, race/ethnicity, state, and year, from the U.S. Bureau of the Census.

To determine whether welfare reform's minor parent rules (stay-in-school and living arrangement) affect teen childbearing, we need to determine the date at which these rules took effect for teens in each state. For the 15 states that instigated such rules under waivers (prior to TANF), we identify the year each state implemented its rules and assume that the minor parent rules took effect the following year. For the states without waivers, we assume that the minor parent rules took effect the years following TANF implementation. In addition, we use as controls the welfare benefit for a family of two, adjusted for inflation, state unemployment rates, and abortion policies as controls. Table 1 contains descriptive statistics for our data.

Empirical Strategy

We devise three models to determine whether changes in welfare reform affected teen childbearing rates. Limited to childbearing rates of women aged 15 to 18, our analysis takes into account gestation, whether a state required parental consent for teens younger than 18 to receive abortions, and whether a state had a mandatory delay for abortion.

From a high of 61.8 births per 1,000 teenagers in 1991, teenage childbearing rates in the United States fell every year, reaching a low of 48.8 births in 1999. Given this trend, we should find childbearing for 15- to 17-year-olds declined. However, this does not necessarily imply that welfare reform is the source of the difference. Our second model addresses this by asking whether the decline occurred more rapidly after states implemented the minor parent rules.

Our third model takes into account potential bias from unobserved factors by comparing changes in childbearing among 15- to 17-year-olds, who were subject to the minor parent rules, to the trend in the childbearing of 18-year-olds, who were not, after the rules were implemented. If the minor parent rules are effective, we should see a statistically significant decline in the trend post-implementation for the young teens compared to the 18-year-olds.

In addition, we restrict our sample to 17- and 18-year-olds. When contrasting 15-year-olds with 18-year-olds, we may fail to control for unobserved factors that correlate with age and teenage childbearing, thereby potentially biasing our post-rule-implementation estimates. For example, the levels of physical and emotional maturation of 17- and 18-year-olds should be more similar than those of, say, 15- and 18-year-olds. Seventeen- and 18-year-olds also have roughly equivalent levels of education and are old enough to work, making their short-term opportunity costs roughly equivalent. Thus, the sample of 17- and 18-year-olds should be more homogenous than the full sample with teenagers aged 15 to 18.

Table 1
Characteristics of Teen Childbearing, 1992-99

Childbearing Rates	Mean
Total births per year per 1,000 women	44.3
15- to 17-year-olds	33.7
18-year-olds	77.0
Non-Hispanic African Americans	83.0
Non-Hispanic whites	29.3
Hispanic African Americans and Hispanic whites	82.0
Asian or Pacific Islanders	19.5
American Indians	58.4
Other Characteristics	**Mean**
Age	16.5
Welfare benefits (in 1999 dollars)	513.9
State unemployment rate	5.9

Source: Authors' calculations

Results

Our first model shows that, all else equal, the mean childbearing rate for 15- to 17-year-olds following implementation of the minor parent rules was 10.6 percent lower than the mean rate prior to implementation. As expected, African Americans, Hispanics, and American Indians have higher teenage childbearing rates than whites, while Asians or Pacific Islanders have lower teenage childbearing rates. State unemployment rates are positively and statistically significantly related to teen birth rates, while the influence of welfare benefits and abortion policies is statistically insignificant.

The second model suggests a 3.5 percent annual reduction in childbearing rates prior to the implementation of the minor parent rules. Following the implementation, the annual change in the trend for minor teens began to decline more rapidly, by an additional 0.8 percentage points.

In our third model, which takes into account differences among age groups, analysis of the full sample of teenagers aged 15 to 18 indicates that childbearing rates declined roughly 3.1 percent each year for 18-year-olds prior to the implementation of the minor parent rules (see Figure 1). The change after implementation is not statistically significant for this group, suggesting that the change in rules did not affect childbearing by 18-year-olds. Before welfare reform, childbearing among younger teens also was declining, but following the implementation of the minor parent rules, the rate began to drop an additional 0.7 percentage points more rapidly than the trend for 18-year-olds, a difference of 22.6 percent.

Collectively, these results support the hypothesis that the minor parent rules reduced childbearing among young teenagers. Prior to implementation, the childbearing rates for 15- to 17-year-olds were declining at the same proportionate amount, roughly

3.1 percent per year, as that of 18-year-olds. After implementation, 18-year-olds continued along the same trajectory, while the rates for teens younger than 18 began to decline much more rapidly. When we remove 15- and 16-year-olds from the analysis, the decline falls to 0.6 percentage points, which is still statistically significant.

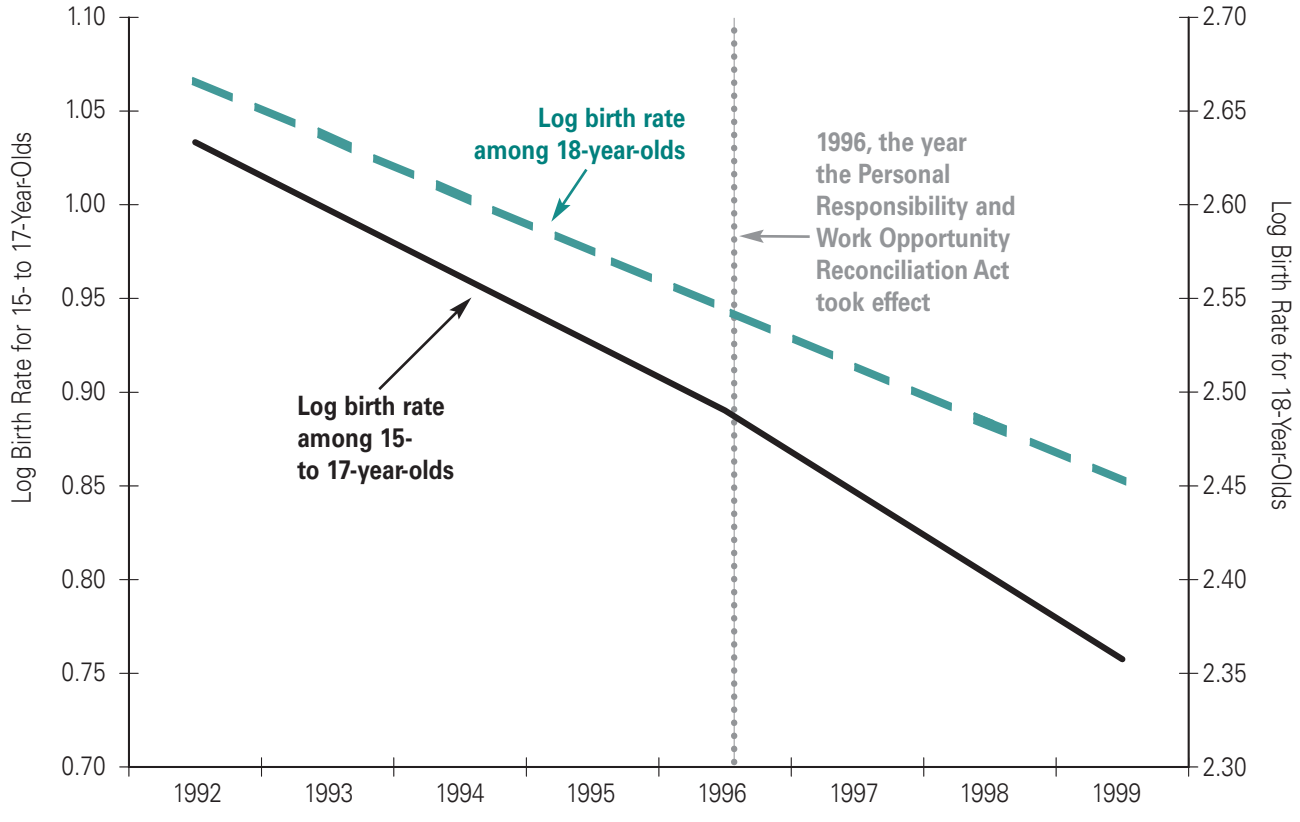
Our results show a general decline in childbearing rates for all racial and ethnic groups during the period studied. However, the childbearing of African Americans and whites primarily drives our analysis. For African Americans, the trend post-implementation for 17-year-olds declines by 0.6 percentage points. For young white teens the decline is 0.7 percentage points. Both differences are statistically significant. The declines for the other racial and ethnic groups are much smaller in size and statistically insignificant.

Conclusion

We hypothesized that the probability that women aged 15 to 17 had children after welfare reform's minor parent rules were implemented should have declined. Our results, which we subjected to additional analysis to ensure they were robust, support this hypothesis. We find that, prior to implementation of the minor parent rules, childbearing rates for 18-year-olds were comparable to those for women aged 15 to 17. After implementation, however, childbearing rates began to decline more rapidly, proportionately, for young teens relative to 18-year-olds. More specifically, each year under investigation in this study led to a 3.1 percent decline in birth rates for 18-year-olds. Before implementation of the minor parent rules, young teen childbearing rates declined at the same pace. After implementation, however, the childbearing rates of women younger than 18 began to drop more rapidly: 3.8 percent per year. Further, it appears that these changes can be attributed primarily to African American and white teens.

While we cannot rule out every alternative explanation, we believe the implementation of the minor parent rules are most likely a primary cause for this change. If correct, this research suggests that welfare reform in the 1990s was successful in reducing childbearing among minors. ◆

Figure 1
Trends in Fertility Rate among 15- to 17-Year-Olds and 18-Year Olds, 1992-1999



Master or Servant? Agency Slack and the Politics of IMF Lending

Mark Copelovitch

Mark Copelovitch joined the La Follette School of Public Affairs in fall 2006 as an assistant professor of public affairs and political science. His research and teaching focus on the politics of international monetary and financial relations. He is particularly interested in international financial institutions, the interaction between domestic politics and international cooperation, and the effect of international capital flows on national economic policies.

Over the last two decades, the International Monetary Fund (IMF) has played an increasingly prominent role in global financial governance by providing short-term loans to developing countries experiencing difficulty paying their international debts. The IMF operates much like a credit union: each member-state provides a "quota" of the Fund's resources and is eligible to borrow in proportion to these contributions. Each country's quota correlates closely to the overall size of its economy and its importance in the global financial system.

The IMF provided 197 short-term loans to 47 emerging market countries between 1984 and 2003. These loans totaled 253.8 billion of the IMF's unit of account, the Standard Depository Receipt (SDR). One SDR equaled about 1.58 U.S. dollars in December 2007. While the average loan size was SDR 1.21 billion, these loans ranged from SDR 7.1 million to Belize in 1984 to SDR 22.8 billion to Brazil in 2002.

When examined in comparison to a recipient country's quota share of the IMF, this variation in loan size is puzzling. For example, Turkey, with the 18th largest quota among developing countries within the IMF, received three of the 10 largest loans between 1984 and 2003. Uruguay, with the 33rd largest quota, received in 2002 the fifth largest loan to date (SDR 2.1 billion, 694 percent of its quota), and Thailand, with the 22nd largest quota, received a loan of SDR 2.9 billion (505 percent of its quota) in 1997. On the other hand, many larger countries received relatively modest loans (e.g., Russia, 1999, 56 percent of quota; Brazil, 1992, 69 percent; Argentina, 1996, 47 percent). At the same time, IMF lending to individual countries varied substantially. Argentina and Mexico are two prominent examples: from 1984 to 2003, Argentina's 10 IMF loans ranged in size from 47 percent to 527 percent of its quota, and Mexico's five loans during the same period ranged in size from 120 percent of quota to 688 percent.

To explain this variation in the Fund's lending policies, I model IMF policymaking as a principal-agent relationship in which the "agent" (IMF staff) acts on behalf of a "collective principal" comprising the Fund's five largest shareholders, the United States, the United Kingdom, Germany, Japan, and France. These "G-5" countries exercise de facto control over the Fund's primary decision-making body, the Executive Board. At the same time, IMF staff members enjoy substantial autonomy over the negotiation, design, and proposal of Fund programs.

Using this framework, I argue that "agency slack," or the extent of staff autonomy in IMF lending, is conditional on the intensity and diversity of G-5 governments' interests. States and Fund bureaucrats exercise partial but incomplete authority over IMF lending. Staff autonomy is greatest in cases where G-5 interests are weak and divided; staff autonomy is weakest in cases where G-5 interests are strong and unified. Ultimately, the Fund is neither the servant of its member states nor its own master; rather, the relative influence of the IMF's largest shareholders and its bureaucrats varies over time and across cases.

Variation in IMF Lending

As the IMF makes lending decisions, it faces a central tradeoff. On the one hand, IMF loans help countries pay their international debt and help maintain international financial stability. On the other, IMF loans encourage countries (and their international creditors) to take financial risks by creating expectations that the Fund will provide "bailouts" if problems arise. As a result, IMF lending may exacerbate rather than lessen financial instability. This tradeoff presents the IMF with a difficult choice: lend freely at the risk of increasing demand for bailouts or limit lending at the risk of having a country default and triggering a broader financial crisis.

Political economists tend to explain how the IMF weighs this tradeoff and makes its lending decisions by considering whether the agency is "master" or "servant" — that is, whether the Fund is controlled by its bureaucrats acting autonomously or whether the IMF serves the interests of its most powerful member states. Scholars in the "master" camp argue that IMF

bureaucrats manipulate the loan process, exploiting agency slack to maximize their autonomy, budget, and/or the likelihood of program success. From this perspective, we should observe the staff consistently favoring larger loans with more conditions, since more lending and a larger role for the Fund in monitoring its borrowers' economic policies enhances the staff's influence. At the other extreme, those in the "servant" camp claim that the United States and other large IMF shareholders manipulate Fund lending to serve their domestic economic and geopolitical interests. In this view, American allies and/or countries of strategic importance receive more favorable treatment from the Fund. Along these lines, several studies find a relationship between IMF lending and countries' voting patterns in the United Nations General Assembly and/or levels of U.S. foreign and military aid to a given borrower country. In addition, several studies find evidence of a relationship between IMF lending and borrowers' economic ties with the G-5.

The IMF staff's autonomy — and therefore its ability to succeed at furthering its own interests — depends on G-5 interests. Ultimately, state interests and bureaucratic politics influence IMF decisions, but the Fund is neither the servant of its member states nor its own master.

Both political scenarios are plausible, but each presents certain problems. The disproportionate influence of the United States that enables it to veto some decisions within the IMF does not extend to lending decisions, since approval of loans formally requires the support of only a simple majority of the Executive Board's 24 directors. Moreover, lending decisions are generally made through informal consensus rather than voting. Other large shareholders, especially Japan, Germany, the United Kingdom, and France, also wield considerable influence because they, like the United States, hold permanent seats on the Executive Board. Likewise, while theories that ascribe power to the IMF bureaucracy generate clear predictions about variation in Fund lending over time, they do not explain variation within time periods. For example, the prediction that IMF staff members propose larger loans during quota reviews does not explain variation in loan size in years when a quota review is underway. Furthermore, the view that the IMF staff acts autonomously as its own "master" begs the question of when the IMF staff is able to "get away" with this type of behavior. Bureaucratic arguments drawing explicitly on principal-agent theory tend to leave unspecified both the identity and interests of the IMF staff's principal(s). As a result, they offer few predictions about the conditions under which member states' monitoring and enforcement will constrain staff behavior.

In short, while state-centric and bureaucratic-politics explanations of IMF behavior strongly suggest that political factors influence IMF lending decisions, they do not address the extent to which the IMF is the servant of the G-5, the conditions under which IMF staff act autonomously, and how and why IMF loan decisions vary over time and across countries.

I address these issues by drawing on insights from principal-agent theory. I argue that an exclusive focus on American interests overlooks the importance of other powerful states, as well as the effects of disagreements among these states on Fund decisions. My collective-principal model of IMF lending illustrates how G-5 countries exercise de facto control over IMF lending decisions. I also argue that the IMF staff's autonomy — and therefore its ability to succeed at furthering its own interests — depends on G-5 interests. Using an original dataset of IMF lending to 47 countries from 1984-2003, I find strong support for this model and its hypotheses.

A Collective-Principal Model of IMF Lending

The IMF lending process begins when a country formally requests a loan and begins negotiations with Fund staff over its terms. Once a country signs a formal letter of intent, the staff presents the program for approval to the Executive Board, whose 24 executive directors represent the Fund's member states. If the loan is approved, the Fund disburses the first payment and monitors compliance with the conditions. Future disbursements require a staff review and subsequent Executive Board approval. The board is a "collective principal" that comprises multiple members designing a single contract for a single agent.

G-5 Governments as the "Collective Principal"

Although the IMF is technically responsible to all of its member states, in reality a small group of powerful countries — the G-5 — exercise de facto control of IMF policymaking: their permanent seats on the Executive Board give them 39.22 percent of the votes. Furthermore, the common practice is for loan decisions to be made by a consensus process that reflects

states' relative voting power, rather than by formal Executive Board votes. It is almost inconceivable that the IMF will approve a loan without the support — or at least consent — of its five largest shareholders. As the dominant players in international trade and finance, G-5 governments have a strong interest in utilizing Fund liquidity to maintain international financial stability. However, because they provide the largest share of the Fund's lending quotas, they have a vested interest in conserving these resources and risky loans. Economic factors such as country size, external debt levels, and foreign exchange reserves do influence loan decisions; however, the strong influence of political factors suggests that G-5 governments will favor larger loans for countries that they deem economically or geopolitically important. In these cases, G-5 executive directors should be relatively less concerned with the risks associated with IMF lending and more inclined to pursue their geopolitical and economic interests by providing larger loans. In contrast, when the G-5 countries have little or no economic or geopolitical interest in a given country, they should be relatively more concerned with preventing risky loans and less willing to approve large-scale Fund lending. As a result, IMF loans should be smaller in these cases.

The IMF Staff as Agent

While the G-5 countries exercise ultimate control over lending decisions, the Fund's professional staff enjoys substantial autonomy over the IMF's day-to-day operations. The approximately 2,700 staff members from 165 countries act as the member states' agent in executing the IMF's day-to-day operations. The staff negotiates loans directly with borrower governments and sets the agenda: the Executive Board cannot approve a loan without an initial staff proposal. Moreover, the board can only vote up or down (i.e., without amendment) on staff proposals. These delegated responsibilities give the staff significant influence over IMF lending. Nonetheless, as the staff operates "in the shadow" of an Executive Board vote, it finds that the member states' final authority circumscribes its autonomy.

As economists and civil servants interested in achieving the Fund's policy objectives, staff members generally consider macroeconomic factors when making lending decisions. At the same time, staff members, like all bureaucratic agents, have incentives to maximize their budget, autonomy, and influence. The staff also will figure in the preferences of the G-5 countries while designing loan proposals for Executive Board consideration. Thus, while the staff enjoys agenda-setting power, they will not want to put forth a proposal unless they are confident that the board will approve the program.

Agency Slack in IMF Policymaking

To predict IMF loan decisions and the degree to which loans reflect the interests of the Fund's member states and its bureaucrats, we need to identify how much autonomy IMF staff has — agency slack — in recommending loans. I expect that staff autonomy and influence over Fund lending decisions should be conditional on the intensity and heterogeneity of G-5 governments' preferences. All else equal, IMF lending should more closely reflect G-5 preferences when these countries have a strong and unified economic or geopolitical interest in a given country. Conversely, staff influence and autonomy should be greatest in cases where G-5 interests are weak and divided. Figure 1 illustrates this. When G-5 aggregate interests are high (the top row), we should observe larger IMF loans, since the borrowing countries in question are economic and/or strategically important to the United States and its G-5 partners. On the other hand, when G-5 aggregate interests are low (the bottom row), we should generally observe smaller loans, since the Executive Board is less likely to approve large programs for countries of lesser importance to its key members. The staff, knowing that this is the case, should propose relatively smaller loans in order to ensure approval.

At the same time, we should observe variation in IMF loan size as a result of differences in the heterogeneity of G-5 interests (i.e., within each row of Figure 1). The

Figure 1
Impact of G-5 Preference Intensity and Heterogeneity on IMF Lending

Intensity of G-5 Interests	Heterogeneity of G-5 Interests: Low	Heterogeneity of G-5 Interests: High
High	◆ G-5 consensus ◆ Largest loans	◆ G-5 conflict ◆ Large loans, but logrolling cost
Low	◆ G-5 consensus ◆ Smallest loans	◆ G-5 conflict ◆ Small loans, but prime opportunity to maximize staff budget, autonomy, and influence

effect of this diversity depends on the aggregate level of G-5 interest intensity. At high levels of interest, greater heterogeneity of G-5 interests should translate into conflict within the Executive Board over the size of Fund programs. Thus, while we should still observe large IMF loans in these cases (the top right cell of Figure 1), these loans should be smaller than those provided when G-5 interests are both strong and unified (the top left cell). In these situations, the G-5 countries still have a strong collective interest in large-scale IMF lending, but those G-5 governments with less at stake will demand a "logrolling cost" (a reduction in loan size) in exchange for supporting their more heavily invested counterparts' demands. Put simply, the conflict among G-5 countries about the merits of providing an IMF "bailout" results in approval of a somewhat smaller (though still large) loan. The G-5 governments with less at stake will "go along" reluctantly with their counterparts, in the hopes that they themselves will receive such support ("logrolling") in future cases where they are heavily invested.

Testing the Collective Principal Model

To test these hypotheses, I analyze 197 short-term IMF loans to 47 "emerging market" countries from 1984-2003. These countries are middle-income developing countries that typically borrow internationally on private markets. Data on each loan are taken from the IMF's online lending arrangements database, as well as from IMF documents. The goal is to see which factors — macroeconomics, plus G-5 geopolitical and economic interests — affect the size of a loan, measured in terms of a country's IMF quota.

I consider geopolitical and economic interests in gauging G-5 intensity. I use three variables as proxies for G-5 interests in a particular borrower country: bilateral foreign aid commitments; voting affinity (the degree to which countries vote the same way on an issue) within the United Nations General Assembly; and commercial bank exposure, the amount of money commercial banks in the G-5 countries provide to a particular IMF borrower. These variables, combined with the relative voting power of the United States, France, Japan, Germany, and the United Kingdom, serve as measures of the intensity of G-5 interests. The more aid a G-5 country commits to give to another nation, the more often a G-5 country votes the same as an IMF loan recipient, and the more exposed G-5 commercial banks are to a given country, the greater the G-5's geopolitical and/or economic interest in provid-

Table 1
Changes in Size of IMF Loans as Predicted by G-5 Geopolitical and Economic Interests

G-5 Economic Interests as Measured by Bank Exposure

	Predicted change in loan size	Interpretation of one standard deviation change
Time period of loan	45.77%	20 to 30 months
Quota gap	27.61%	67.4 to 127.74 times quota
Ratio of debt to gross domestic product	24.30%	58.49% to 94.3%
Ratio of external debt service to exports	34.35%	23.55% to 42.26%
Ratio of short-term debt to reserves	14.39%	0.79 to 3.09 times reserves
Year in which quota is under review	-12.30%	0 to 1
Low heterogeneity of interests	11.16%	115.53 to 162.10
Medium heterogeneity of interests	-10.18%	115.53 to 162.10
High heterogeneity of interests	-12.29%	115.53 to 162.10

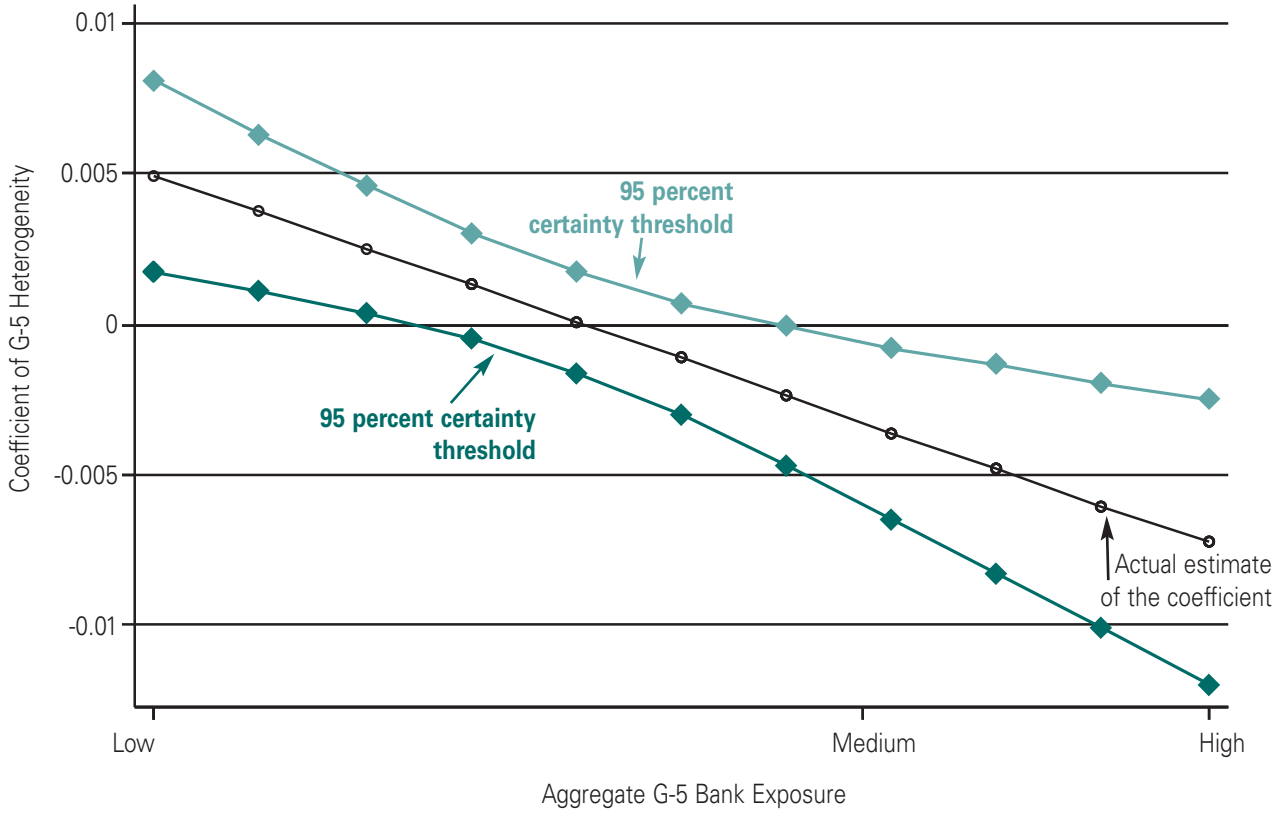
G-5 Geopolitical Interests as Measured by Foreign Aid Commitments

	Predicted change in loan size	Interpretation of one standard deviation change
Time period of loan	48.64%	20 to 30 months
Ratio of debt to gross domestic product	17.60%	58.49% to 94.3%
Ratio of external debt service to exports	28.89%	23.55% to 42.26%
Currency crash	32.82%	0 to 1
Year in which quota is under review	-14.23%	0 to 1
Low heterogeneity of interests	48.35%	134.14 to 178.36
Medium heterogeneity of interests	20.89%	134.14 to 178.36
High heterogeneity of interests	8.97%*	134.14 to 178.36

*Not statistically significant at 95 percent confidence

Note: Values of heterogeneity of interests correspond to values at the mean and ±1.5 standard deviations.

Figure 2
Effect of G-5 Interest Heterogeneity on Loan Size at Different Levels of G-5 Interest Intensity, as Measured by Bank Exposure



The values below the 0 line mean "negative effect on loan size," and values above the 0 line mean "positive effect on loan size." When G-5 interest intensity is low, greater heterogeneity leads to large loans (i.e., the staff exploits agency slack), whereas the opposite is the case when G-5 interest intensity is high (i.e., the G-5 care a lot, and conflict among them has a large negative impact on IMF loan size.

ing large IMF loans. A second set of variables measures the diversity of G-5 interests by considering the distribution of bank exposure, foreign aid commitments, and voting affinity among the G-5 countries.

In my research, several statistical analyses show that bank exposure and foreign aid commitments — but not voting affinity — affect the size of an IMF loan to a country. In addition, my analysis shows that consideration of the G-5 interest is a much better predictor of a loan outcome than just the interests of the United States. As for macroeconomic factors, longer loans tend to be larger in relation to quota; and loan size correlates to the ratios of external debt to gross domestic product, debt services to exports, and short-term debt to reserves.

As Table 1 illustrates, the effect of G-5 diversity of interests depends on interest intensity and vice versa. Affinity of United Nations votes does not have a significant effect on IMF loan size. However, diversity of economic interests among the G-5 countries has different effects at different levels of "aggregate" G-5 interest intensity. Figure 2 shows how the effect of G-5 interest heterogeneity (the coefficient of G-5 bank exposure) on IMF loan size varies as it interacts with different levels of G-5 interest intensity (aggregate bank exposure). For example, when G-5 bank exposure is high but unevenly dispersed, these countries care strongly about the IMF's lending policies but cannot agree on loan size. As a result, IMF loans in these cases tend to be smaller than in those cases where G-5 bank exposure is high and evenly distributed. In contrast, when G-5 bank exposure is low but unevenly dispersed, IMF loans tend to be larger than in cases where G-5 bank exposure is low and evenly distributed. Similarly, countries receiving large amounts of G-5 foreign aid (and which are therefore

geopolitically important) always receive larger loans from the IMF, but those loans are less large when G-5 foreign aid is both high and unevenly dispersed.

This result suggests that the IMF does indeed suffer from a principal-agent problem. When the Fund's collective principal has weak and divided interests in a given lending case, the IMF staff exploits its autonomy by proposing larger loans. Without strong collective incentives to monitor staff behavior in these cases, the G-5 countries approve these loans within the Executive Board, rather than sanctioning IMF staff members for attaching benefits for themselves to the loan. In contrast, when the G-5 countries have more intense interests in a borrower country — as measured by bank exposure and foreign aid commitments weighted by their Executive Board voting power — their incentives to monitor staff behavior increase. As a result, greater divisions (i.e., more interest heterogeneity) among the G-5 countries have a negative effect on loans in these latter cases; those G-5 countries without strong interests in an IMF bailout demand a logrolling cost from their more intensely interested G-5 counterparts in exchange for supporting loan approval in the Executive Board.

IMF staff members, like all bureaucratic agents, have incentives to maximize their budget, autonomy, and influence. The staff also will figure in the preferences of the G-5 countries while designing loan proposals for Executive Board consideration.

We see that IMF agency slack — the autonomy that enables staff to "get away with" proposing larger loans to maximize their budget, autonomy, and influence — depends on the intensity and heterogeneity of G-5 member states' interests. When G-5 interests are weak and divided, IMF loans tend to be larger. In contrast, when G-5 interests are strong and divided, IMF loans tend to be smaller, all else equal. This finding suggests that divisions among the G-5 countries translate into conflict within the Executive Board in "important" cases, while divisions result in greater staff autonomy and when the borrower country is less important to the Fund's largest shareholders.

These findings provide clear evidence that supports the predictions of the collective principal framework. More importantly, these results confirm that powerful states' domestic interests and the IMF bureaucrats' behavior play a role in shaping Fund loan decisions — and each of these effects is conditional on the other. Thus, while politics does play a key role in shaping IMF lending, it does so in different ways at different times, depending on the importance of a loan recipient to the G-5 countries and the extent to which these powerful states disagree about the relative merits of large-scale IMF lending in a given case.

Conclusions

These results have important implications for our understanding of the politics of IMF lending. Above all, they clearly illustrate that no single actor "controls" the IMF. While powerful states exert great influence over Fund decisions, this influence does not lie unilaterally with the United States. In addition, the staff's substantial autonomy partially constrains powerful states' ability to control IMF decisions. Likewise, the Executive Board's authority circumscribes staff influence over Fund policies, particularly in cases where G-5 interests are strong and unified. Ultimately, the relative influence of states and IMF bureaucrats varies over time, and effective "control" over Fund lending policies depends on what is at stake in a particular case.

Furthermore, these results cast doubt on the merits of proposals to alter the distribution of votes within the Executive Board to give developing countries a greater say in Fund decisions by removing "politics" from IMF lending. In contrast, my findings suggest that this outcome is highly unlikely to occur. Indeed, replacing G-5 votes with ballots from other countries would not necessarily result in a more technocratic or independent IMF; rather, other large countries' political interests would simply replace those of the G-5. Moreover, spreading voting power more evenly among more states would likely increase the scope for agency slack by increasing the diversity of interests among Executive Board members. Thus, eliminating the influence of G-5 politics through voting reform might, paradoxically, increase the problem of agency slack and efforts by the IMF staff to increase its influence.

More broadly, the results suggest that both academics and policymakers can learn much about international organizations by focusing on the actual policies they make, rather than solely on the reasons behind their creation. In the end, international organizations are neither masters of their own fate, nor servants of their member states. Rather, both actors play critical roles in shaping policies within global governance institutions. ◆

Does Learning By Doing Improve Energy Technology?

Gregory F. Nemet

Gregory F. Nemet joined the La Follette School of Public Affairs in fall 2007 as an assistant professor with a joint appointment at the Nelson Institute for Environmental Studies. His research and teaching focus on improving understanding of the social, technical, political, and economic dynamics of the global energy system. He also conducts research on the ways in which science and technology policy affect the rate and direction of technological change. His work is motivated by a more general interest in issues related to energy and the environment, including how government actions can enhance energy availability and environmental outcomes.

The rate and direction of improvements in energy technologies are highly uncertain. This uncertainty hinders efforts to assess the costs of policies and technologies to combat global warming. A standard means for evaluating the costs of climate policy is through large-scale energy-economic models. While these models have become increasingly sophisticated, their treatment of improvements in technologies remains highly stylized, especially as compared to our rich understanding of the economics behind the process of innovation.

This gap between research on the economics of innovation and on modeling the economics of energy technology development may be due to basic incompatibilities in the approaches of the two fields. Research on innovation tends to emphasize uncertainty and the cumulative nature of effects. These lines of inquiry have led to an emphasis on empirical and case studies rather than development of a broader theory. On the other hand, large-scale energy models require quantitative estimation with manageable uncertainties. The notion of the learning curve provides one of the few methods that bridge this gap.

The learning curve is an important tool for modeling technological change and informing policy decisions related to energy politics because it treats technologies as dynamic. The concept originates from observations that workers in manufacturing plants become more efficient as they produce more units. This process of learning by doing provides opportunities for cost reductions and quality improvements. In terms of innovation, the more a new technology is manufactured and used, the greater the efficiency of production and the larger the savings. The learning curve model can evaluate the cost effectiveness of public policies to support new technologies and weigh public investments in these technologies against the costs of environmental damage. Policy models that characterize future energy supply now use learning curves in predicting technology improvements.

This article explores the validity of the learning curve as it relates to a specific energy technology, photovoltaics. Sometimes referred to as solar cells, photovoltaics consist of silicon-based semiconductors that convert sunlight directly into electricity. Photovoltaics offer a clean alternative to coal and natural gas. However, while the cost of photovoltaics has declined rapidly and while markets are expanding at more than 40 percent a year, photovoltaics compete only in niche markets and do not yet vie economically with conventional electricity sources. The extent to which photovoltaics challenge coal, gas, and other energy sources will depend on how quickly the technology underlying it improves and costs fall.

The learning curve has been used to predict this rate of improvement. However, recent work has suggested that use of the learning curve to evaluate public policies may be inappropriate. In this article, I assess the validity of using learning curves to inform public policies related to photovoltaics by constructing a cost model and comparing its results to the assumptions behind the learning curve. I find that the predictive power of learning curves is misleading because important variables are omitted. While learning by doing has played a small role, policymakers need to pay greater attention to expectations of future demand, research and development, and knowledge spillovers; each of these elements played an important role in the impressive cost reductions achieved to date. With these results in mind, the practice of governments subsidizing demand for a technology until it becomes inexpensive appears to be a rather blunt, and expensive, tool.

Changes in Photovoltaics Technology

Technical improvements in photovoltaics technology have been explained as the result of learning from experiences acquired during production. The process of learning by doing provides opportunities for cost reductions and quality improvements. The learning curve represents the relationship between experience (using a measure of cumulative production or use) and the costs of a technology; typically the learning

curve appears as a downward sloping curve in which production costs fall as experience is gained. The steeper the slope, the more quickly costs fall as manufacturers acquire experience.

The use of learning to explain technological improvement has drawn a few criticisms. Among them is that the model provides no means with which to predict discontinuities in the learning rate. Industrywide learning curves require assumptions about firms sharing their production experience; disregard the effect of knowledge from other sources, including research and development or other industries; and ignore changes in quality beyond the single dimension being analyzed. Despite such critiques, the application of the learning curve model has persisted without major modifications as a basis for predicting technical change, informing public policy, and guiding firm strategy. These omissions need to be incorporated into decisions about public policy, given the billions of dollars of public funds being used to pay for technology learning. For example, if important variables such as research and development are ignored, then publicly subsidized programs may generate substantially fewer benefits than models predict. Alternatively, a broader public technology strategy that addresses the market imperfections involved in each omitted factor likely would have a stronger chance of success.

For the moment, I set aside the learning curve model and explore the factors that lie behind technical change in photovoltaics by studying the history of cost reductions and relating observable technical factors. I focus on 1980 to 2001 when enormous reductions in the cost of photovoltaics occurred. The beginning of this period included large government sponsored research and development efforts in the United States, Japan, and, to a lesser extent, in Europe. Energy efficiency of a photovoltaics module nearly doubled in that time, while growing demand prompted manufacturers to build larger facilities. The cost of silicon, the primary material for photovoltaics, and the amount needed for a photovoltaics module declined. In addition, wafers cut from silicon ingots that comprise multiple crystals accounted for a larger share of the world's silicon production. Photovoltaics modules that use this poly-crystalline silicon cost 10 percent less than monocrystalline modules. Increases in wafer size led to additional savings. Improved cell and module processing techniques increased yield, the proportion of functioning units available at the end of manufacturing. Based on changes to these seven factors, I estimate a model that quantifies the impact of each factor change on the cost (in constant 2002 dollars) of a photovoltaics module. Table 1 outlines the seven factors and their changes, while Figure 1 shows the portion of cost reduction accounted for by each factor.

Table 1
Changes Leading to Cost Reductions for Photovoltaics, 1980-2001

Factor	Change			Effect on Module Cost (dollars per watt)
Energy efficiency of module	8.0%	→	13.5%	–6.50
Manufacturing plant size	125 kilowatts per year	→	14 megawatts per year	–9.22
Silicon cost	131 dollars per kilogram	→	25 dollars per kilogram	–2.67
Silicon consumption	28 grams per watt	→	18 grams per watt	–0.62
Proportion of poly-crystalline silicon used to manufacture wafers	0%	→	50%	–0.38
Wafer size	48 square centimeters	→	180 square centimeters	–0.64
Yield	88%	→	92%	–0.43
Sum of factors				–20.46
Actual change				–21.62
Residual				–1.16

Note: Dollars are in 2002 constant dollars

From 1980 to 2001, the cost of photovoltaics declined by a factor of 7. The model explains 95 percent of this change, with two reasons predominant: plant size accounts for 43 percent and efficiency accounts for 30 percent of the reductions in the cost of photovoltaics. Module efficiency and plant size were the most important contributors to cost reduction, while the cost of silicon was moderately important, its decline accounted for 12 percent of the change. The other factors — yield, silicon consumption, wafer size and proportion of poly-crystalline silicon used — were of minor importance.

Limits to the Explanatory Power of Experience

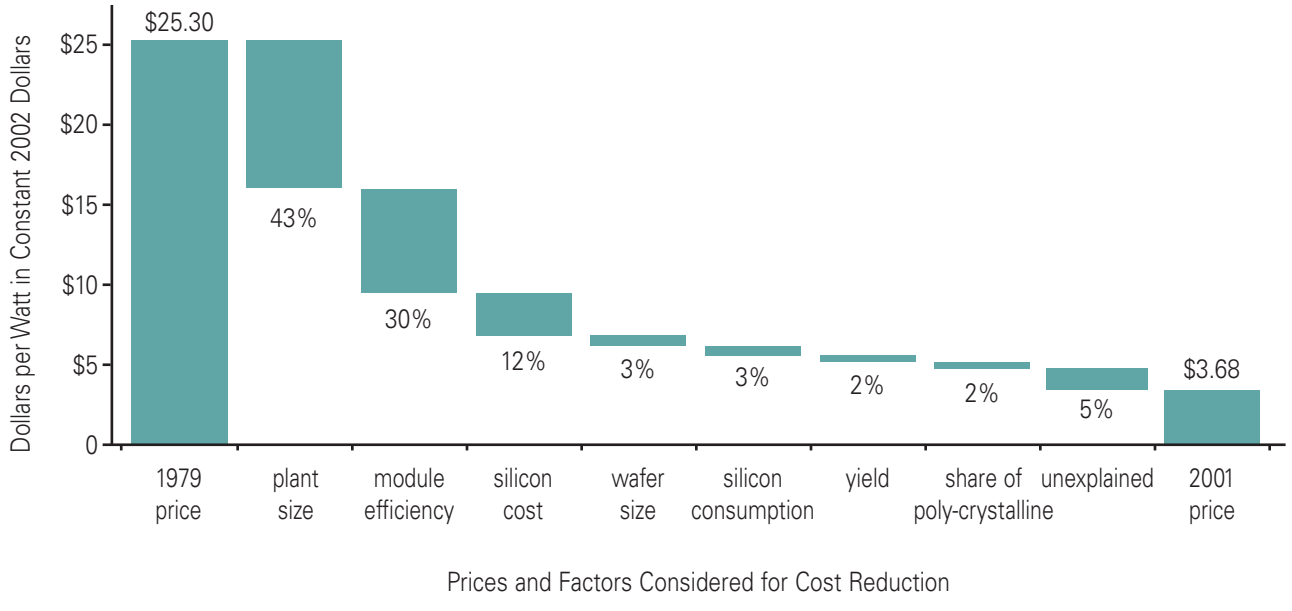
Having identified which factors contribute most to reductions in the costs of producing photovoltaics, I turn back to the learning curve. In my analysis, I use cumulative manufacturing production to measure experience. I find that learning by doing only weakly explains the most important factors in reducing the cost of photovoltaics — growth in plant size and improved energy efficiency of the module. Overall, the "learning" from "experience" gained from cumulative production does not appear to be a major factor in enabling firms to reduce the cost of photovoltaics, which is the assumption underlying the learning curve model.

Rather, growth in expected demand and the ability to manage investment risk were the main drivers of the change in plant size. Increased module efficiency is only partly attributable to learning by doing. Most of the technical improvements in module efficiency are not due to efforts by manufacturers, but to government and university research and development efforts, which were the result of large publicly sponsored investment in the late 1970s and early 1980s. Reductions in the cost of silicon were a spillover benefit from microprocessor manufacturing, itself subsidized by a government-sponsored program. Learning by doing did heavily influence four factors — yield, wafer size, silicon consumption, and the share of poly-crystalline silicon in manufacturing — but together these account for only 10 percent of the change in the case of photovoltaics. The more manufacturers worked with these factors, the more efficient they became, thus reducing costs.

Conclusion

Learning by doing is only one of several explanations for the large cost reductions in photovoltaics. Its role in enabling changes in the two most important factors identified in this study — plant size and module efficiency — is small compared to those of expected demand, risk management, research and development, and knowledge spillovers. Moreover, further analysis confirms that rates of reductions in the costs consumers face are sensitive to industry structure and profit margins. The weak relationship between

Figure 1
Portion of Photovoltaics Cost Reductions Accounted for by Each Factor, 1980-2001



learning by doing and cost reductions suggests careful consideration should be given before policymakers rely on learning curves to predict technical change.

The results do indicate that the confidence with which we use learning curves to predict technological change might be enhanced with analysis of the underlying technical and market dynamics. This type of approach is suggested by other studies that recommend multiple, complementary methods to inform policy decisions related to energy technology. In addition, policymakers would benefit from more explicit treatment of the uncertainties that are inherent in learning curves.

The inclusion of learning curves in models that assess the costs of climate policy has enhanced the realism of models. Given the vast set of results showing that energy technologies improve over time, incorporation of learning curves represents a substantial improvement over omitting them (and implicitly assuming a learning rate of zero). But the results of this study indicate that, at least for the case of photovoltaics, a broader set of influences than experience alone contributed to the rapid cost reductions. One implication is that learning curves overestimate the technical improvements that should be expected to accrue from experience alone.

To avoid expensive disappointments associated with large public investments in subsidizing demand, policymakers need to consider the effects of public and private research and development, knowledge spillovers, technological opportunity, and market dynamics to more realistically inform decisions about large investments in energy technologies. The public sector may need to play a role as well in advancing some of these factors.

The practice of governments subsidizing demand for a technology until it becomes inexpensive appears to be a rather blunt, and expensive, tool.

If innovation is central to making the cost of climate policy affordable and market failures require government support for innovation, then these results suggest that efficient policy requires more than simply "riding down the learning curve." Policymakers may want to create incentives for firms to invest in cost-reducing activities and require thorough program evaluation, especially when benefits will be uncertain and will take several years to be realized. ◆

La Follette
Policy Report

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