Risky Schooling? K-12 funding over the business cycles.

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Abstract

Is school funding insured against business cycle shocks or are students attending school in booms advantaged over their peers that attend school in downturns? We study the sensitivity of funding to the economic conditions of the county and the state and we examine if states insure school districts against county-level income shocks. We find that there is perfect risk sharing between school districts within a given state, as state governments increase transfers to local school districts when a shock to local personal income generates a fall in locally raised revenue. However, local school districts are exposed to state income shocks. The sensitivity of school spending is heterogeneous according to the specific funding formula employed by the state.

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1 Introduction

We study the sensitivity of U.S. school funding to county- and state-level economic shocks. This issue is particularly important in light of the severe fiscal squeezes experienced by state and local governments during and after the recent Great Recession. School funding may be sensitive to economic fluctuations because restrictions on local government borrowing limit the ability of school districts to self-insure and most states are subject to balanced-budget rules. However, many maintain explicit stabilization funds and/or have some flexibility in adhering to the budget rules.

In the United States, there has been large upheavals in education funding following a number of lawsuits—starting with the *Serrano v. Priest* decision in California in 1971, which found that the state did not provide equal opportunity to students as required by the state constitution. The result has been a trend in favor of increased efforts by state governments to reduce cross-sectional disparities in education spending per student across school districts. This trend has manifested in a shift towards funding formulae that, in theory, place a greater emphasis on equalizing expenditures per student or providing a minimum level of spending, as documented by Jackson, Johnson, and Persico (2014). In practice, as shown by Hoxby (2001), not all attempts at expenditure equalization across districts in a state are equally effective, and, if they do equalize spending, may do so at a lower level than would have occurred without the reforms.[1] This is because different school finance equalization programs, even if they have the same objective, may have different effects on local tax prices (the increase in total revenue as a percent of locally raised revenue, when off-setting state grants are taken into account), which influence the incentives of local school districts to raise local revenue.

As reform efforts have been undertaken in almost all states, many studies have examined whether and how such school finance reforms have affected school spending and stu-

[1] Card and Payne (2002) find that school finance equalization reforms lower dispersion in spending across districts and boost achievement (measured via test scores) of students in low-income households.

dent achievement. See, for example, Downes and Figlio (1997), Nechyba (1997b), Nechyba (1997a), Epple and Platt (1998), and Lafortune, Rothstein, and Schanzenbach (2016). In general, most of the literature considers cross-sectional variation in spending per pupil and possible time variation in cross-sectional dispersion generated by the passage of school finance reforms. In this paper, we change the focus and analyze the dynamic adjustment of education finance and expenditures to local and state business cycle fluctuations. This is an important question, because if, in fact expenditures are an important determinant of student achievement and eventual adult outcomes (as several studies, such as Card and Krueger (1992), Jackson, Johnson, and Persico (2014), Jackson, Johnson, and Persico (2016), and Chetty and Hendren (2015) argue), then the sensitivity of these expenditures to shocks to local and state economies becomes an object of intense interest. Specifically, if a local recession leads to a transitory (or even persistent) decline in expenditures, then some cohorts of students will be exposed to a negative shock to the quality of their education, with potentially far-reaching consequences. On the other hand, as many reform programs have been aimed at reducing spending disparities across districts, it is important to know the extent to which state governments might act to offset an idiosyncratic income shock or how governments at either level react to an income shock at the state level.

We exploit data on spending, locally raised revenue, and state education transfers in a panel setting with large cross-sectional and time dimensions to characterize how school districts and state governments react to personal income shocks. We first perform a dynamic reduced form analysis, which shows that state governments do indeed act to insure local school districts against a local income shock. When a school district's county suffers an idiosyncratic decline in its home county's personal income, it raises less revenue locally, but in response, the state government increases transfers to the affected school district. The end result is a change in spending per student that is not statistically different from zero. There is a trade-off associated with this risk sharing mechanism, however. When the state economy is hit with an aggregate personal income shock, transfers to all districts are affected, and local school districts are not able to make up the loss with additional locally raised revenue. The effects that we describe play out over a span of several years, and the focus on the dynamic effects of income shocks on school finance variables is a novel contribution of our paper.

Hoxby (2001) demonstrates that different spending formulae adopted by state governments over the last forty years affect local tax prices in different ways, which alter the incentives of local areas to raise revenue to pay for education. This tax price channel influences whether a given school finance reform will ultimately level spending up or down as it equalizes spending across districts. This has implications for the dynamic response of school districts to local income shocks in that an inverted tax price (the amount a school district can spend for every dollar it raises) will not generally vary with the business cycle. With this in mind, we consider whether the dynamic responses of school districts and state governments to aggregate and idiosyncratic income shocks differ according to the funding plan in place. For two popular finance frameworks, Equalization Plans and Minimum Foundation Plans, we do find subtle differences in the reactions to income fluctuations, particularly as it regards relatively poor districts. In states with an Equalization Plan, expenditures in low-income districts comove slightly positively with local income, but in Minimum Foundation Plans, they react significantly negatively.

Informed by our reduced form regression results, our next objective is to develop a simple model which we use to interpret the interactions between state and local governments. We assume that local school districts derive utility from spending on education and from all other consumption at the local level, public and private. State government behavior is governed by inequality aversion with respect to spending levels across all school districts within a state and risk aversion with respect to all other private and public aggregate expenditure. When we take our model to the data, we find significant roles for these risk aversion factors.[2]

[2] In another attempt to gain insight into the fundamental factors behind governments' education funding decisions, but in a political economy context, see Kahn and Barron (2015), who evaluate why some states would devote more resources to education (specifically pre-K) than others.

In addition to the literature on the effects of school finance reform on expenditure per student, we see our paper as contributing also to two other literatures. First, we relate to the literature on inter-regional risk sharing, headlined by the work of Asdrubali, Sørensen, and Yosha (1996) who examine the channels through which U.S. state economies smooth their consumption in the face of idiosyncratic shocks. Other studies in this literature examine risk sharing at aggregate or regional levels, such as Sala-I-Martin and Sachs (1991), Bayoumi and Klein (1997), Hess and Shin (2000), and Crucini (1999). Second, our paper can be linked to the literature on intertemporal spending and revenue-raising behavior of local governments, as well as that on the consequences of annual balanced budget restrictions and possible interaction among different levels of government. Studies in this line include Wallis and Oates (1988), Holtz-Eakin, Newey, and Rosen (1989), Holtz-Eakin, Rosen, and Tilly (1993), Borge, Dahlberg, and Tovmo (2001), Schueler, Goodman, and Deming (2016), and Craig et al. (2016).

The rest of this paper proceeds as follows. Section 2 describes the school finance system in the United States, drawing heavily on the previous literature, especially Hoxby (2001) and Jackson, Johnson, and Persico (2014). Section 3 discusses the data that we use in our empirical analysis. Section 4.2 reports on our empirical findings. A conclusion follows in Section 5.

2 Education Funding in the United States

This section describes the current setting in which education financing occurs in the United States, with a special focus on the different sorts of funding plans employed by states. State governments set the funding plans that help directly determine state transfers to local school districts and may indirectly, via tax prices, influence the behavior of school districts, a phenomenon detailed in Hoxby (2001). Much of the information in this section derives from Hoxby (2001) and Card and Payne (2002), while the primary source of our information on the various funding schemes employed by states comes from Jackson, Johnson, and Persico (2014).[3]

Jackson, Johnson, and Persico (2014) identify five broad categories that education funding schemes could fall into: Minimum Foundation Plans, Flat Grants, Equalization Plans, "Reward-for-Effort" plans, and Spending Limit plans.[4] Minimum foundation plans aim to provide more funding to relatively poor school districts so that all students are able to enjoy a basic level of expenditure. Flat grants are distributed on a simple per-pupil basis to all school districts. Equalization plans allocate transfers based on wealth or income. Reward-for-effort plans encourage greater local revenue raising (especially in poor districts) by providing greater transfers if the school district applies a higher local property tax rate. Spending limit plans, true to their name, place caps on local expenditure.

These categories are a broad translation of the categories spelled out in Hoxby (2001), who lists pure local property tax finance (which is no longer used, although local property tax finance is still a big part of a given district's financing, as will be seen in Section 3), categorical aid (which overlaps with the flat grants and some equalization plans described by Jackson, Johnson, and Persico (2014)), foundation aid (analogous to the minimum foundation plans and some equalization plans), and power equalization plans, which align with the reward-for-effort schemes. These categories are not mutually exclusive, and any state's actual education transfer decisions can incorporate elements of more than one category.[5] Many states have changed their funding schemes, especially since the *Serrano v. Priest* decision; see Hoxby (2001), Card and Payne (2002), and Jackson, Johnson, and Persico (2014).

As the previous literature makes clear, a critical feature that distinguishes these funding

[3]Discussions of the various education funding programs employed across states can be found in Hightower, Mitani, and Swanson (2010) and Smith et al. (2013).

[4]A small number of district-year observations in our sample are in states with so-called "Full State" funding, in which the state government takes on the major share of the burden of education finance from local governments.

[5]Furthermore, state governments may occasionally act outside the bounds of their official funding formula. Consider the case of Houston Independent School District in Texas in 2016, where the mayor urged lawmakers to make adjustments to the state formula so that the inner city school district would not be obliged to make transfers to other areas in the state (http://www.chron.com/news/education/article/Mayor-Turners-calls-on-lawmakers-to-tackle-school-6860752.php).

schemes (and their multiple variants) from each other is their effect on the local tax price, or more specifically, the inverted local tax price. The tax price is the amount of revenue a government must raise in taxes so that it can spend an additional dollar. The inverted tax price, then, is the amount of extra spending that an extra dollar of revenue buys. The inverted tax price has a significant effect on the incentives of local school districts to raise greater amounts of revenue. While an inverted tax price of one can be considered to be roughly neutral, an inverted tax price less than one can, at the margin, give local governments the incentive to abstain from raising taxes on their residents, because the money available for spending on schools will be less than taxpayers give up in private consumption. On the other hand, an inverted tax price greater than one can encourage more local funding than would otherwise have been the case. Both Hoxby (2001) and Jackson, Johnson, and Persico (2014) emphasize the differing impacts on inverted tax prices inherent in the various funding plans.[6] While it is difficult to neatly pin down the effect of each plan, it appears that some, such as minimum foundation plans and flat grant programs, have little effect on the inverted tax price, whereas certain kinds of equalization plans push the inverted tax price below one and spending limit plans push it to zero. In contrast, reward-for-effort plans tend to have inverted tax prices greater than one.

Table 1 reports how the various forms of education finance plan are distributed across the district-year observations in our sample. The source for this information is Table D.1 in Jackson, Johnson, and Persico (2014). It is apparent from the table that many of the district-year observations in our sample are covered by what Jackson, Johnson, and Persico (2014) classify as Equalization Plans or Minimum Foundation Plans, with each accounting for approximately 75% of the total observations. These types of funding schemes have generally been gaining in popularity over the decades since *Serrano v. Priest.* Funding programs that can be described as Spending Limit plans, Flat Grant plans, and Reward-for-Effort plans each make up about one third of the overall sample, although it is worth pointing out that

[6] Indeed, Hoxby (2001) decries the apparent lack of awareness of these effects on the part of state governments.

the number of Flat Grant states has been declining over time, while the preponderance of the other two has been increasing, in line with the reform waves focused on greater equity and adequacy in education funding. Observations covered by Full State funding make up a very small part of the sample.

3 Data

We collect information on school district finance for the years 1992 to 2011 from the U.S. Census Bureau's Public Elementary-Secondary Education Finance Data. This includes school district enrollment, revenue in total and broken down by source, and current and capital expenditure, as well as information on short- and long-term debt and cash stocks. We collect county and state personal income from the Bureau of Economic Analysis. School districts are matched to counties by Federal Information Processing Standards (FIPS) codes. In most cases, school districts and counties occupy the same geographical space, but this is not always the case. When a district spans more than one county, we assign it to a particular county based on the FIPS code given it in the Census data.

For our analysis, we want to consider only independent school districts, so we ignore any that are run by a parent government (such as New York City or the state of Hawaii).[7] This leads us to exclude all school districts from Alaska, Hawaii, Maryland, Virginia, and North Carolina, which have no school districts that were independent for the length of our sample period. We also ignore very small school districts, with the cutoff set at 100 students enrolled. Lastly, we want to consider a balanced panel, so we exclude any districts that are not present in the data for all twenty years of our sample. After these exclusions are imposed, we are left with a panel of 9,032 independent school districts observed at annual frequency over twenty years. This gives us a total of 180,640 district-year observations.

Table 2 gives summary statistics for the key variables in our analysis. Clearly, the

[7] "Independence" may be a difficult term to define in this context, as it means different things in different states. We rely on the indicator for independence that is encoded in the district identification variable for each school district by the Census Bureau.

role of the state government is a substantial one, as it supplies the funding for more than half of all current expenditure on average, although local governments also bear a high degree of responsibility for their own spending. Because so much of the burden of financing education expenditures falls on the state and local governments, we will primarily focus on their behavior at the expense of consideration of federal government behavior. The table also demonstrates the significance of balanced budget constraints for local school districts. On average, school districts do not spend more than they raise in revenue, a feature that we will exploit in our theoretical model.

Figure 1 shows the evolution over time of the cross-sectional average of the main variables of interest in our analysis, including total state transfers per student, total local revenue per student, and total current expenditure per student. Note that the relative importance of transfers from state governments has increased over time. The figures also include the 90th and the 10th percentiles of the cross-sectional distributions by year. From the figure, there is a noticeable leftward skew in the cross-sectional distribution of locally raised revenue, which feeds into the plot for total current expenditure per student as well. This suggests that some school districts are relatively unwilling or unable to obtain financing from local taxpayers, a problem exacerbated by economic downturns. Note in particular the persistent downward movement in locally raised revenue that begins during the Great Recession. In contrast, state transfers exhibit much greater equity, at least in terms of the relative differences from the cross-sectional mean for the district at the 90th quantile and that at the 10th quantile. It is also worth observing that total current expenditure is much smoother at all points in the yearly cross-sectional distributions than locally raised revenue. This implies that the state government may provide a mechanism through which risks to expenditures are mitigated.

It is also clear from the figure that there is an upward trend in each of these variables. This raises the question of how to specify the variables in our regression equations. We examine the persistence of our variables by running the simple regression $y_{i,t} = c + \alpha y_{i,t-1} + \mu * t + u_{i,t}$, where $y_{i,t}$ denotes the log of total state transfers per student, local revenue per student, or total current expenditure per student, t represents a linear time trend, and $u_{i,t}$ is an error term. A large value of the autoregressive coefficient, α, indicates high persistence in shocks and a value of one corresponds to a random walk with trend.[8] The results of these simple regressions can be found in Table 3. From the table, we observe that each of these series is highly persistent.

4 Empirical Analysis

4.1 Semi-Structural GMM-estimation

In this section, we develop a model to help us interpret the behavior of state and local governments with respect to education funding. Our model is simple (so much so that it can be solved analytically by hand) and not intended to replicate the complicated funding formulae used by different states. Rather, the purpose is to interpret the behavior that results from these formulae in terms of parameters which measure preferences for equalization and redistribution. In our reduced-form empirical work, we interpret education expenditures as a form of consumption on the part of governments, so our model takes the form of a consumption problem.

We start with consideration of the state government. We assume that it values equality in school spending, redistribution between rich and poor districts, and other consumption (which we are are not explicit about). These preferences can be captured with the following criterion function:

$$\max_{R_1^S, R_2^S, \ldots, R_D^S} \frac{1}{1-\eta} \left(\Sigma_{d=1}^{D} R_d^{S,1-\eta} R_d^{L,-\alpha} \right) + \chi_S \log(Y^S - \Sigma_d R_d^S) \ . \tag{1}$$

In words, the state government maximizes its utility by choosing transfers to all school districts in the state subject to the implicit constraint that total transfers cannot exceed

[8] We abstain from more formal unit root testing because our sample has a short time series dimension and a very large cross-sectional dimension, so standard asymptotical normality of our estimates obtains.

personal income in the state (expressed by Y^S). Here, η is a parameter that summarizes a state government's desire to smooth spending across districts, while the parameter α describes the extent to which the state government prefers to make transfer payments depend on local school district revenue efforts. A positive value of α implies that the state government obtains less utility per dollar transferred, the higher is the locally raised revenue. The second term of the criterion function captures the preferences for state residents over all other kinds of spending. We choose a logarithmic utility function for the residual state spending, corresponding to a curvature parameter of unity—an unrestricted curvature parameter would make the parameters unidentified.[9]

We take the first order condition of the criterion function with respect to transfers to district d (R_d^S) to find the best response of the state government, which is

$$R_d^{S,-\eta} R_d^{L,-\alpha} = \chi_S (Y^S - \Sigma_d R_d^S)^{-1} \ , \tag{2}$$

and by rearranging terms and taking logs, we arrive at the following expression:

$$\log R_d^S = -\frac{1}{\eta}\chi_S - \frac{\alpha}{\eta}\log R_d^L + \frac{1}{\eta}\log(Y^S - \Sigma_d R_d^S) \ . \tag{3}$$

This expression is very convenient for testing a number of possible hypotheses about state government behavior. For example, one might be interested in testing whether $\alpha = \eta$, which implies that state governments perfectly equalize expenditures across all school districts. Alternatively, the hypothesis that $\alpha = 0$ implies that transfers are constant across school districts and not dependent on local district resources or revenue-raising while a positive value of α implies that state governments lower state transfers when local governments increase spending—if $\eta = \alpha$, the state government will decrease transfers one-to-one corresponding

[9]It is not important for our purposes what this "other" spending is, although it could be other kinds of public expenditures, such as on highways or police, or private spending, in the form of lower state taxes. The essential role of this term is to provide a constraint for the state government's allocation problem. Also, we assume that each school district is small so that $\Sigma_d R_d^S$ is constant across school districts in each year.

to a tax price of one. Finally, if $\eta \approx \infty$, state governments require school districts to provide for their own school spending, at least on the margin (we do not focus on the state-specific constants).

Our model assumes that while state governments are choosing transfers to all of the local school districts, simultaneously, school districts are choosing locally raised revenue to maximize their own utility. Let local districts maximize the following criterion function:

$$\max_{R_d^L} \frac{1}{1-\xi} R_d^{L,1-\xi} R_d^{S,-\phi} + \chi_L \log(Y_d^L - R_d^L) \ . \tag{4}$$

Local governments are subject to laws that govern the state and the parameters for the local governments are not fully structural, but rather mongrel parameters which incorporates constraints imposed by state governments. For brevity, we will refer to the "utility" of local districts going forward.

The marginal utility derived by the districts from an extra dollar of revenue is a function of what they receive from the state government. Marginal utility from an extra dollar raised locally obviously declines as state transfers increase, and ϕ is the parameter that governs the extent to which marginal utility declines. In this way, ϕ reflects the incentivizing or disincentivizing effects of the local tax price. A higher value of ϕ, all else equal, makes school districts less inclined to raise further revenue, while a smaller value of ϕ has the opposite effect. The parameter ξ measures risk aversion on the part of local governments with respect to local revenues—a higher value of ξ indicates a stronger desire to smooth the path of local revenue. The last term implicitly incorporates the constraint on the school district's ability to raise further revenue from local source. The first order condition of the local school district's problem is:[10]

$$R_d^{L,-\xi} R_d^{S,-\phi} - \chi_L (Y_d^L - R_d^L)^{-1} = 0 \ , \tag{5}$$

[10] Analogously to the state government's problem, we assume that local revenue as a proportion of overall local income is reasonably small.

and, after taking logs and applying some algebra, we get:

$$\log R_d^L = \frac{1}{\xi}\log(Y_d^L - R_d^L) - \frac{\phi}{\xi}\log R_d^S + \log\chi_L \ . \tag{6}$$

Equations 3 and 6 offer two endogenous outcomes (state transfers and local revenue) as functions of two driving variables (state personal income and local personal income), and the parameters we are interested in are $\alpha,\ \eta,\ \xi,$ and ϕ .

In the next subsection, we show that adjustment is far from instantaneous and takes about 8 years, to fully play out. The year-by-year dynamic patterns are complicated and not of primary interest for us. However, we are interested in the typical speed of adjustment to the static equilibrium, so we estimate the four equations

$$\log R_{d,t}^S = \mu_s + \zeta_t + \frac{1}{\eta}\log(Y_t^S - \Sigma_d R_{d,t}^S) - \frac{\alpha}{\eta}\log R_{d,t}^L \ . \tag{7}$$

$$\log R_{d,t}^L = \nu_s + \upsilon_t + \frac{1}{\xi}\log(Y_{d,t}^L - R_{d,t}^L) - \frac{\phi}{\xi}\log R_{d,t}^S \ , \tag{8}$$

where μ_s, ν_s are state-specific constants and ζ_t,υ_t are time dummies. We further estimate the adjustment-to-equilibrium equilibrium equations:

$$\begin{aligned} d^4\log R_{d,t}^S =& a11 * d^4\log R_{d,t-4}^S + a12 * d^4\log R_{d,t-4}^L \\ &+ \gamma * (\mu_s + \zeta_t + \frac{1}{\eta}\log(Y_{t-4}^S - \Sigma_d R_{d,t-4}^S) - \frac{\alpha}{\eta}\log R_{d,t-4}^L - \log R_{d,t-4}^S) \ . \end{aligned} \tag{9}$$

$$\begin{aligned} d^4\log R_{d,t}^L =& a21 * d^4\log R_{d,t-4}^L + a22 * d^4\log R_{d,t}^L \\ &+ \delta * (\nu_s + \upsilon_t + \frac{\psi}{\xi}\log(Y_{d,t-4}^L - R_{d,t-4}^L) + \frac{\phi}{\xi}\log R_{d,t-4}^S - \log R_{d,t-4}^L) \ . \end{aligned} \tag{10}$$

We estimate the equation by Generalized Method of Moments using levels, lagged levels, and growth rates of state and county per capita income as instruments for the level equations and lagged levels and variables, including revenues, as instruments for the adjustment equations.

The estimated parameters are reported in Table 4 which report pooled results in the first column, results for EP plans in the second column, and for MFP plans in the third column. For the pooled results, state governments off-set local revenue as α is positive at 0.30, but not fully, as the aversion-to-inequality parameter ξ is significantly larger at 0.49. For local government, ϕ is negative with a value of $-.32$, which implies that higher transfers from the state government are associated with higher local revenue. This is somewhat surprising and this result like transpires because state governments influence how much revenue is raised locally. The χ parameter for risk aversion (or aversion to intertemporal variation) is highly significant with a value of 0.56, indicating that local school districts clearly prefers to avoid fluctuation in school spending. The adjustment parameters indicate that states have a more clearly defined "long-run" equilibrium as state transfers react quite strongly, with a coefficient of 0.41, to deviations from the stationary relations, while the corresponding parameter for local school districts is only 0.04. The autoregressive β parameters indicate significant dynamics (slow adjustment) with magnitudes for the state around 0.20 (for the 4-year lagged variables) while local districts show less lagged correlation with state revenue growth (a coefficient of 0.15) while there is more auto-correlation in the local revenue, implying a very slow adjustment.

Columns two and three compares MFP and EP states. The parameters estimated for the state static relation does not differ at all between these types of states. However, we do find significant differences for the school district parameters (the order of the parameters standard errors are so small that any formal test clearly rejects equality at normal levels of significance). The ϕ parameter is (negative) and numerically larger in EP states, implying that local governments move increase revenues significantly more in tandem with state transfers. The ξ parameter for curvature is smaller in EP states. Speeds of adjustment is higher for local districts in MFP states. These results are less than obvious to interpret and we therefore move on to a detailed mapping of the dynamic responses.

4.2 Dynamic Impulse Responses

We estimate the responses of a number of variables of interest with respect to both idiosyncratic and aggregate (state-level) shocks to personal income. Specifically, we run reduced form regressions of the following equation,

$$\Delta Z_{d,c,s,t} = \mu + \sum_{p=0}^{8} \alpha_p^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_p^S \Delta Y_{s,t-p} + \sum_{p=1}^{8} \gamma_{1,p} \Delta Z_{d,c,s,t-p} + \sum_{p=1}^{8} \gamma_{2,p} \Delta pop_{c,s,t-p} + \sum_{p=1}^{8} \gamma_{3,p} \Delta pop_{s,t-p} + \delta_t + \varepsilon_{d,c,s,t} \ , \tag{11}$$

where $\Delta Z_{d,c,s,t}$ is 100 times the change in the log of some particular outcome of interest, such as total locally raised revenue per student, total state transfers per student, or total current expenditure per student, for school district d in county c in state s in year t. The coefficients of interests are the accumulated sums of $\{\alpha_p^L\}_{p=0}^8$ and $\{\alpha_p^S\}_{p=0}^8$, which trace impulse responses to innovations in the annual growth rate of county personal income and state personal income, respectively.[11] We assume that the personal income processes at the county and state level are exogenous to the behavior of any individual school district, so we include the contemporaneous change in these series as well as lagged changes. Furthermore, by

[11] Hoxby (2001) criticizes the use of income to assess the ability of local school districts to finance education on the basis that in no case are local public schools funded via local taxes on income. She is correct, but for us, using income as our driving variable has a number of appealing characteristics. It is available at a higher frequency and at a lower level of geographic detail than any other indicator that we are aware of. Moreover, we are interested in the reactions of local and state governments to business cycle fluctuations, and income is more likely to capture such fluctuations than other county-level variables. Finally, as Hoxby (2001) notes, property value, which might also appear to be an appropriate variable for the right hand side of these regressions are endogenous to school financing. Although it is possible that increased education expenditures might raise incomes locally (via hiring more teachers in the local labor market, for example), we expect that such effects are small. Therefore, we believe it reasonable to assume that the personal income processes are exogenous to the education finance variables we study.

simultaneously including both county personal income and state personal income in the same regression, the series of coefficients $\{\alpha_p^L\}_{p=0}^8$ capture the response of our outcome variable to a local (county) income innovation that is orthogonal to the income process at the state level. Thus, we interpret these as idiosyncratic income shocks. Analogously, the series of coefficients $\{\alpha_p^S\}_{p=0}^8$ capture the response of the outcome variable to innovations in the state income process orthogonal to the local process.

Our income series are not specified in per capita terms, but we include population growth at the county and state levels on the right hand side of our regressions to account for per capita changes in a less restrictive way, making use of the large number of observations at our disposal. These are denoted as $\Delta pop_{c,s,t-p}$ and $\Delta pop_{s,t-p}$ in the above equation. We also include lags of the dependent variable to control for persistence in the main variables of interest, as well as time fixed effects (δ_t). $\varepsilon_{d,c,s,t}$ is an error term. We do not include individual district fixed effects, because we specify our dependent variables in first differences. In doing so, we are implicitly assuming that there are no district-specific time trends in our sample. Finally, we set our lag length to eight periods. Although our results are not sensitive to the specific lag length chosen, we find eight periods to be a reasonable compromise between the objective of measuring the response to income innovations over a sufficiently long period of time to observe if there are permanent changes, while not disposing of too much information.

Our regressions do not depict impulse response functions in the conventional sense of being iterations on a coefficient matrix estimated via a vector autoregression; however, this particular method of tracing out the dynamic effects of an innovation to a time series of interest has been employed before in other contexts. See, for example, Ramey and Shapiro (1998) and Sørensen, Wu, and Yosha (2001).

We evaluate the extent to which the dynamic responses to fluctuations in state and local personal income vary according to the education finance formula adopted by state governments. In particular, we focus on Minimum Foundation Plans (MFPs) and Equalization Plans (EPs), both because of their relative popularity and the different implications they have for local tax prices.[12] Our semi-structural estimations rejected pooling; however, pooled figures—-shown in the appendix—are fairly close to the figures for MPF and EP states discussed next.

There is one difficulty associated with estimating regressions based on Equation 11 for states with MFPs and EPs separately. This is the fact that the plans are not mutually exclusive, and although there are a considerable number of district-year observations in which only one of EP or MFP is in force, we are hesitant to dispose of too much information. It would not be satisfactory, however, to estimate Equation 11 only for district-year observations in which MFP or EP applies, because for observations where both are turned on, it would be difficult to disentangle the different behavior generated by following one funding plan or the other. We take, then, the following approach. For state s that makes use of an MFP funding scheme, for example, in year t, we estimate:

$$\begin{aligned}
\Delta Z_{d,c,s,t} &= \mu + \sum_{p=0}^{8} \alpha_p^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_p^S \Delta Y_{s,t-p} \\
&+ (I_{EP}) * (\sum_{p=0}^{8} \alpha_{p,EP}^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_{p,EP}^S \Delta Y_{s,t-p}) \\
&+ \sum_{p=1}^{8} \gamma_{1,p} \Delta Z_{d,c,s,t-p} + \sum_{p=1}^{8} \gamma_{2,p} \Delta pop_{c,s,t-p} \\
&+ \sum_{p=1}^{8} \gamma_{3,p} \Delta pop_{s,t-p} + \delta_t + \varepsilon_{d,c,s,t} \ ,
\end{aligned} \tag{12}$$

where all of the terms have the same interpretation as in Equation 11, but we now add interaction terms for the changes in local and state personal income that aim to capture the separate influence of district-year observations in which an EP funding scheme also applies. I_{EP} is a dummy variable that takes on a value of 1 when district i belongs to a state that has an EP type plan as well as an MFP type plan in year t. Similarly, for district-year

[12] Appendix Figure A1 contains the impulse responses for the main variables for all of the funding plans referenced in Jackson, Johnson, and Persico (2014), with the regressions stratified according to whether a school district is in a state with funding formula f in year t, for f = MFP, EP, FG (flat grants), RE (reward-for-effort), SL (spending limits), and FS (full state spending).

observations with an EP funding plan, we estimate:

$$
\begin{aligned}
\Delta Z_{d,c,s,t} = \mu &+ \sum_{p=0}^{8} \alpha_p^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_p^S \Delta Y_{s,t-p} \\
&+ (I_{MFP}) * (\sum_{p=0}^{8} \alpha_{p,MFP}^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_{p,MFP}^S \Delta Y_{s,t-p}) \\
&+ \sum_{p=1}^{8} \gamma_{1,p} \Delta Z_{d,c,s,t-p} + \sum_{p=1}^{8} \gamma_{2,p} \Delta pop_{c,s,t-p} \\
&+ \sum_{p=1}^{8} \gamma_{3,p} \Delta pop_{s,t-p} + \delta_t + \varepsilon_{d,c,s,t} \ .
\end{aligned}
\tag{13}
$$

We first consider districts in states with EP features in their transfers schemes. The left hand side panel of the top row of Figure 2 shows perfect risk sharing within because current expenditure per student does not respond significantly shocks to local personal income. On the other hand, from the right hand side, these districts are heavily exposed to shocks to aggregate (state-level) personal income, as expenditure responds significantly positively to such shocks. Eight years after a one percentage point decline in state personal income growth, the level of current expenditure per student is nearly 2% lower than it would have been had the shock not taken place, an economically meaningful quantity.

The bottom two rows of Figure 2 examine how these expenditure responses are manifested. The middle panel of the figure shows the reactions of locally raised revenue to local (left column) and state (right column) personal income shocks. The bottom panel shows how state transfers respond. The patterns in this figure largely match those seen in the pooled sample. Local revenue responds significantly positively to a local shock, and state transfers respond significantly negatively. When there is an innovation to state personal income, state transfers are affected positively, so local districts are exposed to aggregate income fluctuations orthogonal to their own income fluctuations. Locally raised revenue initially declines with a positive shock to personal income but increases steeply after a few years (consistent with the negative ϕ-parameter in the semi-structural estimation). Current expenditure per student increases steeply (and with narrow confidence bands) in response to state-level income shocks.

Looking at states with MFP features in their funding formulae in Figure 3, we see similar qualitative patterns with some slight differences in magnitudes and timing. Current expenditure per student actually sees a negative response to county personal income in the medium to long run, after several years of hovering around zero, as can be seen in the left column of the top row of the figure. This implies that in response to an adverse shock to local income, future expenditure will actually rise. This implies that the response of the state government (and the federal government) to a county income shock is more than adequate for restoring current expenditure to the level that would have obtained in the counterfactual case of no income shock. We observe, in particular, that the response of state transfers tends to increase in magnitude at a more or less constant rate once two years have elapsed from when the shock hit. In contrast, local revenue responds quickly at first to the income shock, but the response tends to flatten after the sixth year, so that state transfers continue to increase even after local revenue has been stabilized.

Like in the pooled sample, current expenditure in districts in MFP states moves significantly positively with an innovation to state personal income, though not as much as in EP states. Local districts do not raise more revenue locally after a shock at the state level, but, in the medium term, state governments do (briefly) increase transfers to local school districts some years later. Compared to EP states, MFP state governments do not allow their transfers to school districts to respond quite as much in the face of an aggregate shock.

4.3 Responses by Funding Plan and Income Level

The objective of MFPs is to establish a minimum level of expenditure per student and allocate transfers according to the expected ability of individual school districts to reach this level. In principle, then, states using MFPs as part of their education funding implicitly tend to distribute more funds to lower-income or lower-wealth districts. That said, districts who are able to maintain expenditure at or above the minimum level may not expect to receive any extra funding from their state government. In contrast, states that use EP funding place a greater weight on narrowing gaps between expenditure per student in wealthy districts and in poorer districts. To do so, they may distribute more funds to poorer districts and cut funding to wealthy districts.

States with different funding plans may therefore behave differently with respect to their distinct reactions to shocks in school districts that are relatively rich or poor. This section examines these prospective differences by stratifying the sample according to whether districts are relatively high- or low-income, in addition to whether they are in EP or MFP states.[13]

To undertake this analysis, of course, we need to define what makes a district rich or poor. We adopt the following method for distinguishing between "rich" and "poor" school districts. First, we compute the average level of real county personal income over time for each school district. We do the same for the real state personal income level. A school district is considered rich if its county's average personal income over the whole sample is greater than the average personal income for the state that it is located in (in per capita terms). We then estimate Equation 11 separately for districts defined as rich and those defined as poor. The results can be found in Figures 4, 5, 6, and 7.

We start by looking at EP states (Figures 4 and 5). In response to a county personal income shock, current expenditure in both rich and poor counties tends to move very little, but the point estimates on rich districts' responses is negative, while the effect on poor districts' expenditures is significantly positive at a horizon of one to four years (though it is quantitatively very small). It seems, then, that in EP states, rich school districts are better insured against local shocks than poor districts. This could be because local revenue in rich districts barely reacts in the first few years after the shock even as state transfers increase (if not in a statistically significant manner). In poor districts, local revenue positively

[13]Figures A2 and A3 in the appendix contain the results for rich and poor school districts separately with no division according to funding formula.

responds to the local income innovation in a statistically and economically significant way upon impact, and the effect grows over time. State transfers increase significantly so that, at the eight year time horizon, spending is unaffected, but they do not rise sufficiently in the interim to prevent a drop in expenditures.

With respect to a shock at the aggregate level, rich and poor school districts in EP states see similar dynamics in all of the main variables that we consider. Expenditures per student move positively with an innovation in state personal income, as state transfers follow a broadly hump-shaped pattern and local revenues initially move in the opposite direction (implying attempts to self-insure in both types of school district), but eventually move positively with the change in income.

We turn next to the potentially differential reactions across rich and poor school districts in MFP states, starting with the effects of changes in county personal income. In relatively rich school districts, expenditures per student do not change in a statistically significant manner when local personal income growth experiences a negative shock. Locally raised revenue responds positively to the shock, but not significantly so for a couple of years, while state transfers are not much affected. The responses in poor districts are quite different. Current expenditure per student actually rises when local income experiences a decline. We note that we observed this pattern in MFP states overall, and here we can see that such dynamics are driven entirely by the behavior of relatively poor school districts. Locally raised revenue per student falls significantly with a negative income shock, implying a need for an insurance mechanism, which arises in the form of a statistically significant increase in state transfers. It is worthwhile to take a moment to emphasize the differences here relative to higher-income districts. Relatively rich districts experience a noisier response of local revenue per student and a much more muted response of state transfers per student compared to poor districts. In turn, expenditures do not change as much, whereas in poor districts, they change significantly and in short order after the impact of the income innovation. This accords with what one might expect for states with MFP plans, where the risk sharing mechanism that we observe is a more important feature of the school finance system in areas where expenditures per student are in danger of falling below the minimum foundational level of expenditures.

Looking next at the effects of a state personal income shock, we note that current expenditures and locally raised revenue respond positively in both rich and poor school districts. The magnitude of the expenditure reaction is about the same in both types, while local revenues respond more in rich school districts. Notably, state transfers do not change much for relatively poor school districts, while they exhibit the same positive change for rich districts that we have observed in other contexts. This again is what one might expect. If a poor school district is already spending close to the minimum that the state formula mandates, the state government may be less inclined to cut transfers to that district than to a relatively well-off district when it experiences an aggregate shock. We also point out that state transfers to rich districts eventually turn significantly negative (after about four years), such that after eight years, transfers to richer districts have returned close to their pre-shock levels, suggesting that states with MFP features tend to restore lost transfers to such school districts.

5 Conclusion

In this paper, we examine state and local governments' behavior with respect to the financing of the primary and secondary education system. In particular, we study this issue from the perspective of how state governments and local school districts insure each other against shocks to income. The previous literature (e.g., Hoxby (2001), Card and Payne (2002), Downes and Figlio (1997)) has demonstrated that reforms to school finance systems have been effective in altering how schools are funded. Additionally, other studies, such as Jackson, Johnson, and Persico (2014), Jackson, Johnson, and Persico (2016), Chetty et al. (2014), and Chetty and Hendren (2015), have described how education spending has helped shape student outcomes as adults. We see our paper as providing a dynamic complement to these papers, by describing how school spending allocations react to business cycle fluctuations and building a simple model to interpret the observed behavior.

Our estimations of reduced form dynamic relations and model-based static long-difference relations reveal that state governments provide substantial risk sharing to local school districts in the face of local income shocks. When county personal income growth declines by one percentage point (orthogonal to the state personal income path), expenditure per student does not significantly change. This is because, even though locally raised revenue declines after a negative income shock, state transfers to the school district correspondingly rise. However, if the state as a whole suffers a negative income shock, current expenditure per student declines even in school districts where the local economy is doing relatively well.

The literature has devoted a great deal of attention to the reforms to education systems enacted over the last few decades, and we contribute to this literature by examining the differential behavior of state and local governments according to what kind of funding scheme they have in place. We look closely at two kinds of funding formulae that have proven especially popular, Equalization Plans (EPs) and Minimum Foundation Plans (MFPs). We find that school spending actually increases with negative local shocks in relatively poor MFP districts, although we do not explore whether this is intended or indeed optimal.

Our most important finding is that while local education expenditure is perfectly insured against local shocks, it is left heavily exposed to statewide income shocks. If school funding is important for children's schooling outcomes, as many authors believe, the federal government could play an important role in setting up an insurance scheme for school funding. Craig et al. (2016) show that the U.S. state-federal unemployment system perform well in general and we suggest that a similar insurance scheme for school funding could lower the risk of disadvantaged students being further disadvantaged from having to attend schools when the state economy is weak.

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Table 1: Proportion of District-Year Observations with Each Funding Plan

Plan	% of District-Year Observations
Equalization Plan	76.9%
Minimum Foundation Plan	74.8%
Spending Limits	37.8%
Flat Grants	32.3%
Reward-for-Effort Plans	33.9%
Full State Funding	3.9%

Notes: This table reports the proportion of district-year observations that have the school financing plan given in each row. The source of these figures is Jackson, Johnson, and Persico (2014).

Table 2: Summary Statistics of Key Variables

Variable	Mean	Std Dev 1	Std Dev 2
Total Revenue	10.47	3.57	1.94
Revenue from State Govt	5.01	2.33	1.18
Local Revenue	4.76	3.65	1.06
Total Current Expenditure	8.85	2.63	1.46
Total Revenue from Federal Govt	0.70	0.34	0.80
Total Capital Outlay	1.06	1.38	1.87
County Personal Income	29.56	6.61	3.92
State Personal Income	34.56	4.95	4.10

Notes: Values expressed in thousands of 2009 dollars per student (for the education variables) or 2009 dollars per capita (for the income variables). "Std Dev 1" is defined as the time average of $[(1/n)\sum_i (X_{it} - \bar{X}_t)^2]^{1/2}$. "Std Dev 2" is defined as the cross sectional average of $[(1/T)\sum_t (X_{it} - \bar{X}_i)^2]^{1/2}$.

Table 3: AR Coefficient Regressions

Variable	(1)	(2)	(3)
Revenue from State Govt	0.889***	0.733***	0.889***
	(0.001)	(0.001)	(0.001)
Local Revenue	0.962***	0.759***	0.961***
	(0.001)	(0.002)	(0.001)
Total Current Expenditure	0.965***	0.902***	0.966***
	(0.001)	(0.001)	(0.001)
State Personal Income	0.971***	0.941***	0.989***
	(0.005)	(0.007)	(0.006)
County Personal Income	0.979***	0.936***	0.975***
	(0.001)	(0.002)	(0.001)
Time Trend	No	No	Yes
Fixed Effects	No	Yes	No

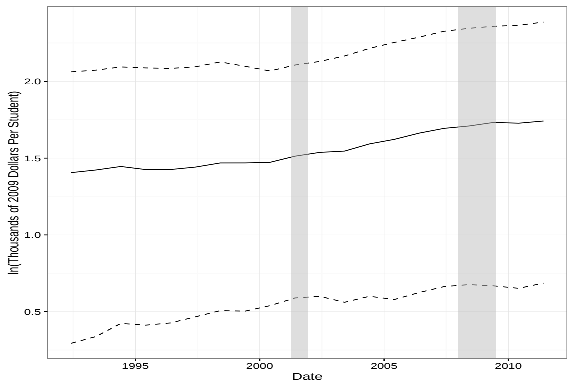
Notes: The table reports the coefficient estimate on the autoregressive term from a regression of an AR(1) in each of the variables listed. Each regression includes a constant and a time trend. Standard errors are in parentheses.

Table 4: Model Estimation Results

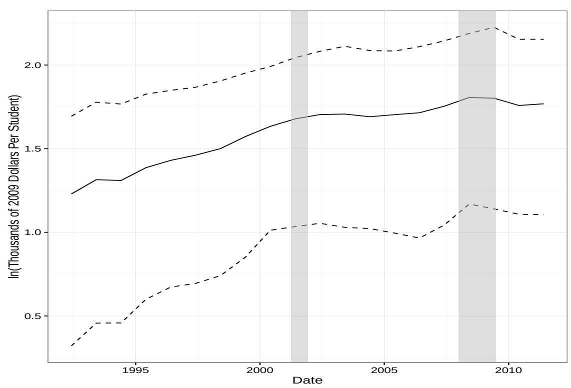
Parameter	Pooled	EP	MFP
State:			
α	0.30***	0.27***	0.27***
	(0.005)	(0.005)	(0.005)
η	0.49***	0.44***	0.44***
	(0.010)	(0.009)	(0.009)
District:			
ϕ	−0.32***	−0.43***	−0.30***
	(0.018)	(0.017)	(0.017)
ξ	0.56***	0.46***	0.54***
	(0.011)	(0.010)	(0.010)
Speed of Adjustment:			
State:			
Error Correction	0.41***	0.46***	0.48***
	(0.017)	(0.018)	(0.020)
β_{11}	0.22***	0.24***	0.28***
	(0.008)	(0.011)	(0.011)
β_{12}	0.24***	0.25***	0.16***
	(0.010)	(0.010)	(0.011)
District:			
Error Correction	0.04***	0.04***	0.08***
	(0.004)	(0.003)	(0.005)
β_{21}	0.15***	0.26***	0.18***
	(0.009)	(0.010)	(0.010)
β_{22}	0.35***	0.36***	0.36***
	(0.008)	(0.009)	(0.009)

Notes: The table reports estimates from the equations $\log R^S_{d,t} = \mu_s + \zeta_t + \frac{1}{\eta}\log(Y^S_t - \Sigma_d R^S_{d,t}) - \frac{\alpha}{\eta}\log R^L_{d,t} + u_{state,t}$ (state level), $\log R^L_{d,t} = \nu_s + \upsilon_t + \frac{1}{\xi}\log(Y^L_{d,t} - R^L_{d,t}) - \frac{\phi}{\xi}\log R^S_{d,t} + u_{district,t}$ (county level), $d^4 \log R^S_{d,t} = \beta_{11} * d^4 \log R^S_{d,t-4} + \beta_{12} * d^4 \log R^L_{d,t-4} + \gamma * \hat{u}_{state,t} + error$ (state adjustment), $d^4 \log R^L_{d,t} = \beta_{21} * d^4 \log R^S_{d,t-4} + \beta_{22} * d^4 \log R^L_{d,t-4} + \delta * \hat{u}_{district,t} + error$ (country adjustment). $R^S_{d,t}$ is transfers for state (of district d to school district d in real per student dollars, $R^L_{d,t}$ is locally raised revenue of school district d in real per student units, Y^S_t is the real per student personal income of state S, and $Y^L_{d,t}$ is real per student income of the county in which school district d is located. Variables are specified in log levels or long differences as indicated by the column headers and estimation includes year fixed effects (and state dummies for the specification in log levels). α is calculated as $\frac{a_1}{a_2}$, η is calculated as $\frac{1}{a_2}$, ϕ is calculated as $\frac{b_2}{b_1}$, and ξ is calculated as $\frac{1}{b_1}$. Delta method standard errors are in parentheses. $^{***}, ^{**}, ^{*}$ represent statistical significance at the 1%,5%, and 10% levels, respectively.

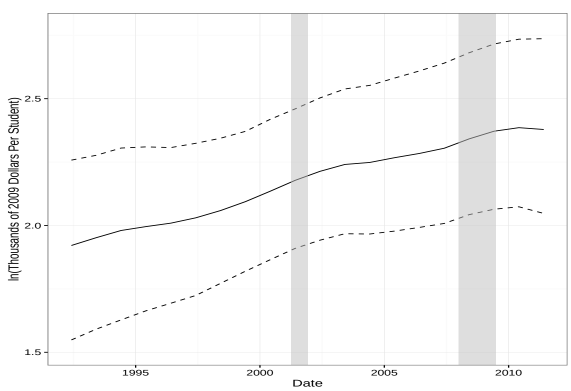
Figure 1: Evolution of Main Variables over Time



(a) Locally Raised Revenue per Student



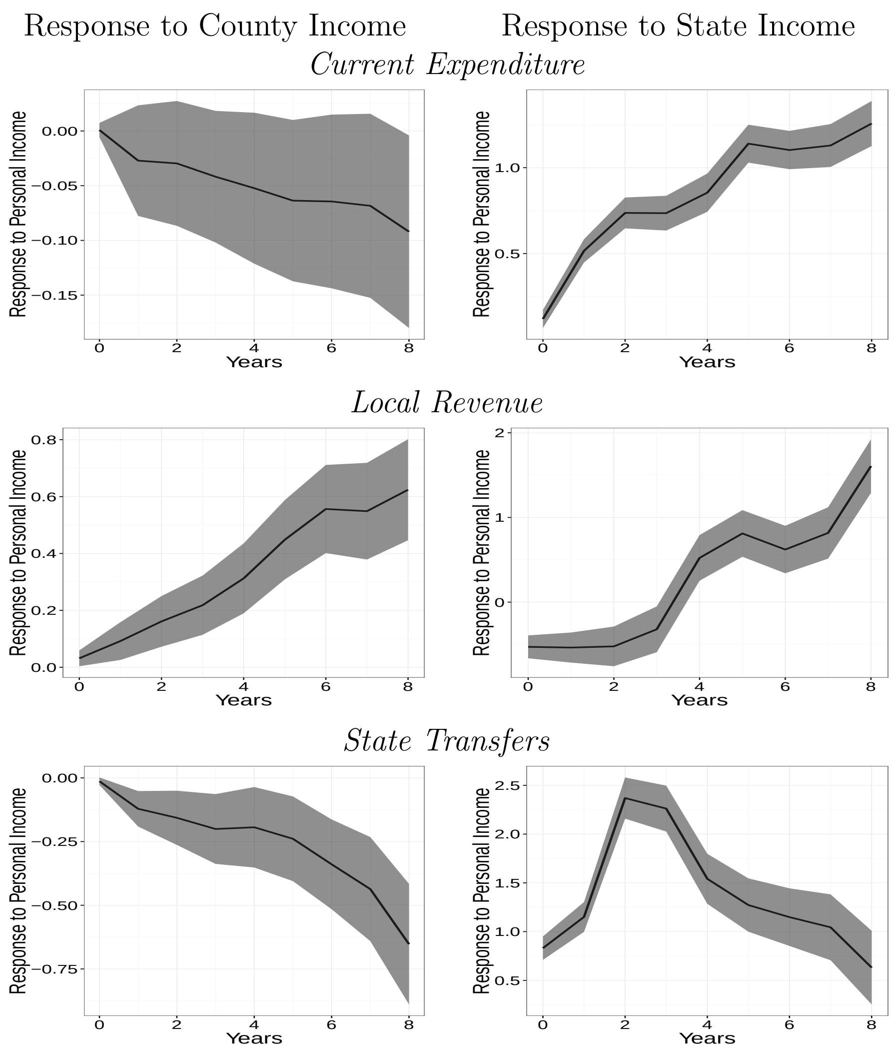
(b) State Transfers per Student



(c) Total Current Expenditure per Student

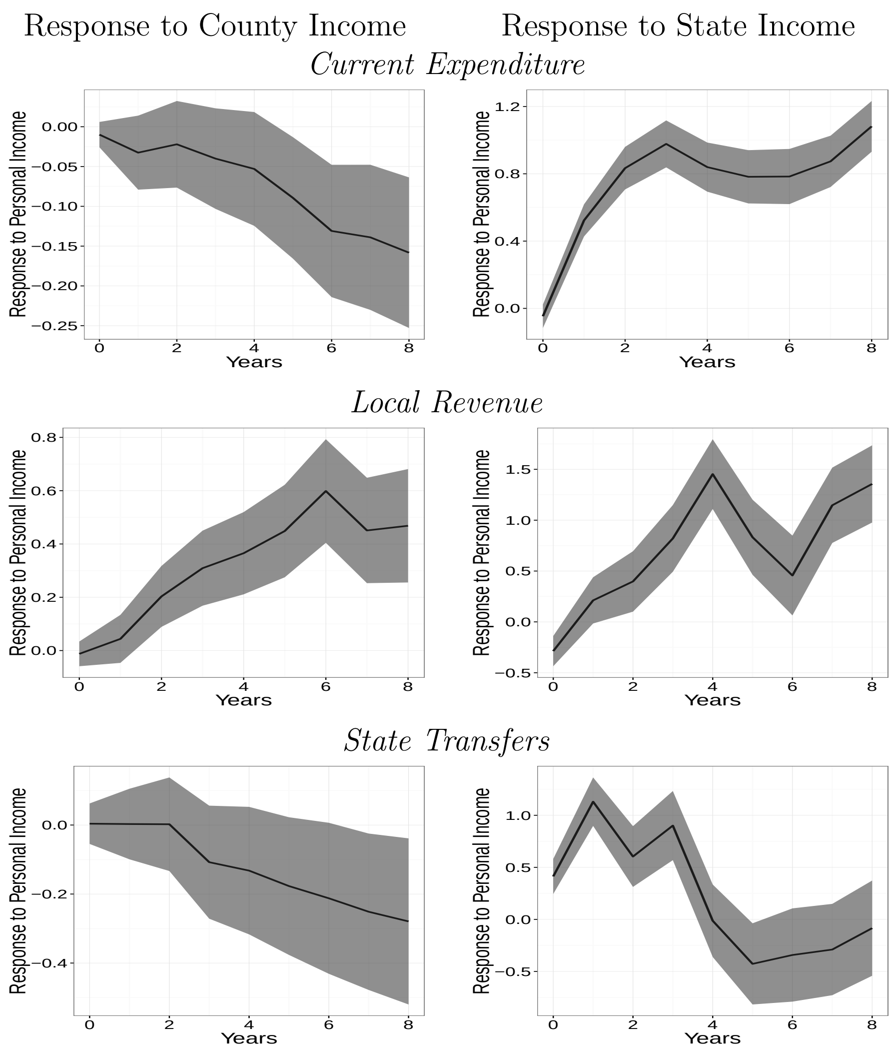
The figure shows the time series evolution of total current expenditures per student, locally sourced revenue per student, and total state transfers per student, measured in the natural log of thousands of 2009 dollars. The solid lines give the cross-sectional average across all school districts in the sample for each year, while the dashed lines give the 90th and 10th percentiles of the cross-sectional distributions in each year. Shaded bars indicate NBER recession dates.

Figure 2: Responses to Income Innovations in EP States



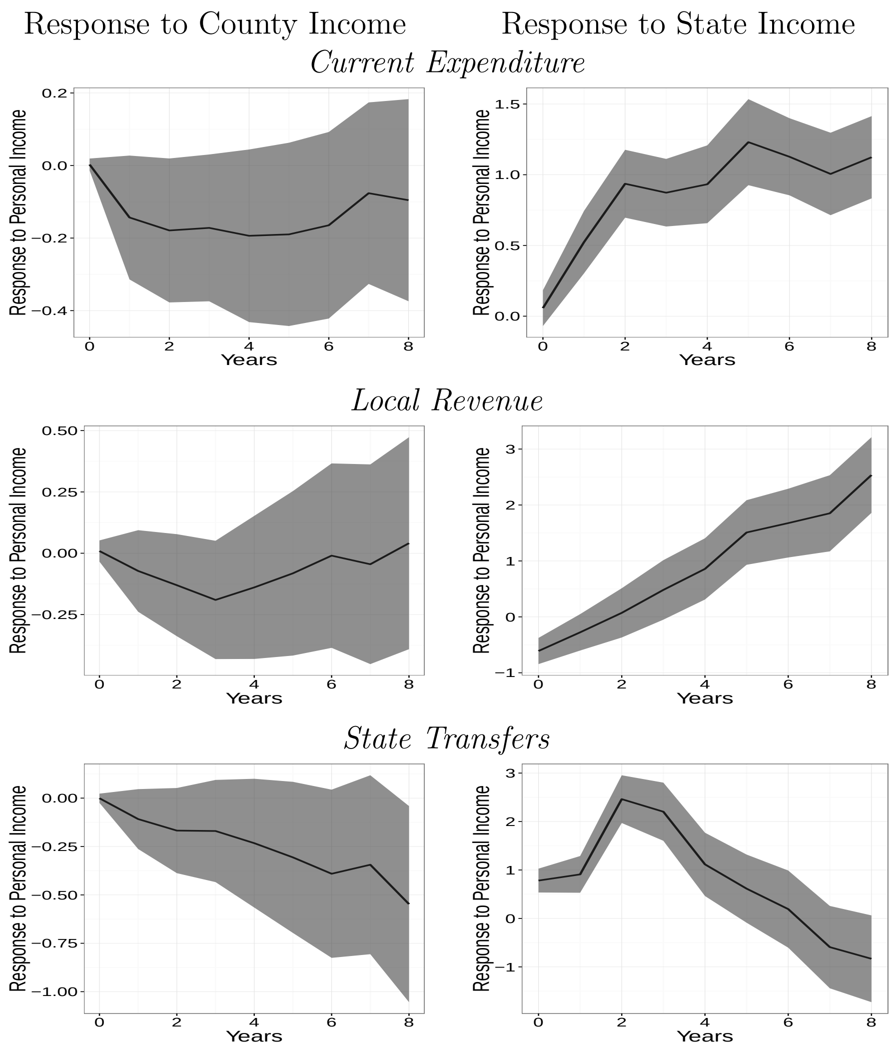
Notes: This figure displays the results from estimating $\Delta Z_{d,c,s,t} = \mu + \sum_{p=0}^{8} \alpha_p^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_p^S \Delta Y_{s,t-p} + (I_{MFP}) * (\sum_{p=0}^{8} \alpha_{p,MFP}^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_{p,MFP}^S \Delta Y_{s,t-p}) + \sum_{p=1}^{8} \gamma_{1,p} \Delta Z_{d,c,s,t-p} + \sum_{p=1}^{8} \gamma_{2,p} \Delta pop_{c,s,t-p} + \sum_{p=1}^{8} \gamma_{3,p} \Delta pop_{s,t-p} + \delta_t + \varepsilon_{d,c,s,t}$, where the left hand side gives the accumulated sums of α_p^L and the right hand side gives the accumulated sums of α_p^S (that is, the main effects in the regression) with 95% confidence bands. $\Delta Y_{c,s,t}$ denotes the change in the log of real personal income in county c in state s in time t and $\Delta Y_{s,t}$ denotes the change in the log of real personal income growth in state s in time t. The regressions include eights lags of the dependent variable and eight lags of county and state population growth, as well as year fixed effects.

Figure 3: Responses to Income Innovations in MFP States



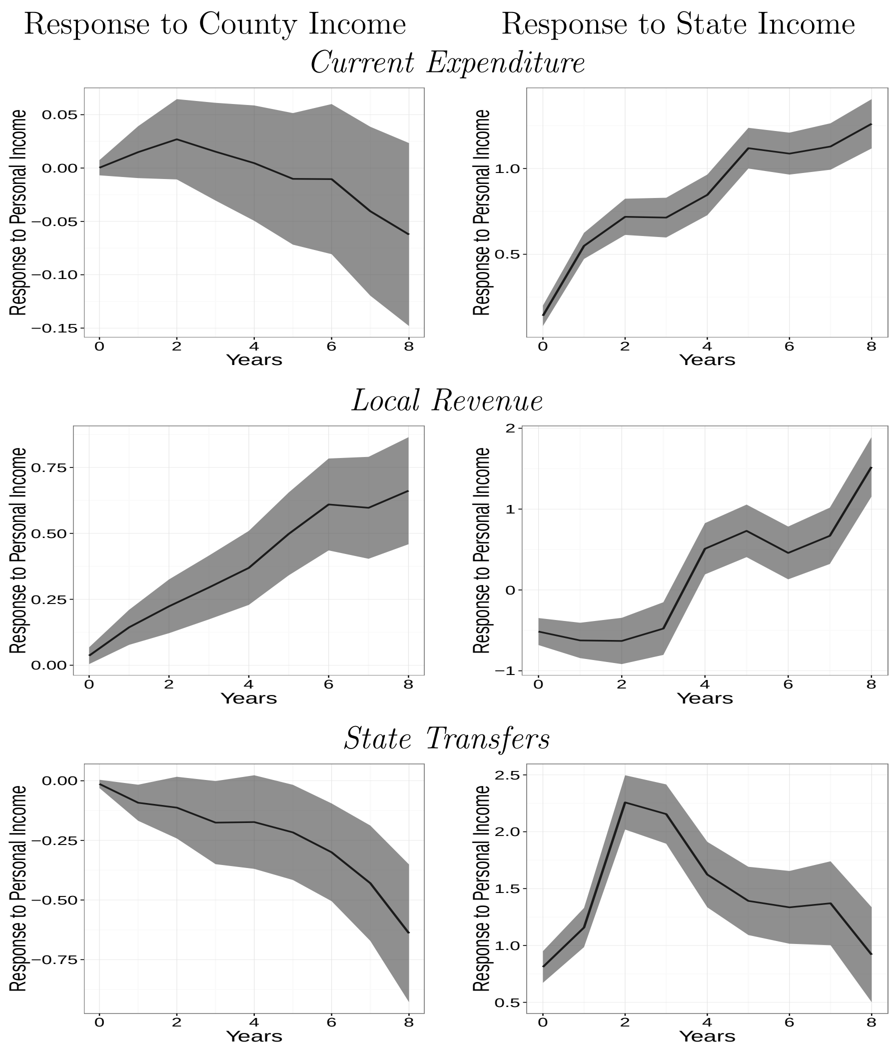
Notes: This figure displays the results from estimating $\Delta Z_{d,c,s,t} = \mu + \sum_{p=0}^{8} \alpha_p^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_p^S \Delta Y_{s,t-p} + (I_{EP}) * (\sum_{p=0}^{8} \alpha_{p,EP}^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_{p,EP}^S \Delta Y_{s,t-p}) + \sum_{p=1}^{8} \gamma_{1,p} \Delta Z_{d,c,s,t-p} + \sum_{p=1}^{8} \gamma_{2,p} \Delta pop_{c,s,t-p} + \sum_{p=1}^{8} \gamma_{3,p} \Delta pop_{s,t-p} + \delta_t + \varepsilon_{d,c,s,t}$, where the left hand side gives the accumulated sums of α_p^L and the right hand side gives the accumulated sums of α_p^S (that is, the main effects in the regression) with 95% confidence bands. $\Delta Y_{c,s,t}$ denotes the change in the log of real personal income in county c in state s in time t and $\Delta Y_{s,t}$ denotes the change in the log of real personal income growth in state s in time t. The regressions include eights lags of the dependent variable and eight lags of county and state population growth, as well as year fixed effects.

Figure 4: Responses to Income Innovations in Rich Districts in EP States



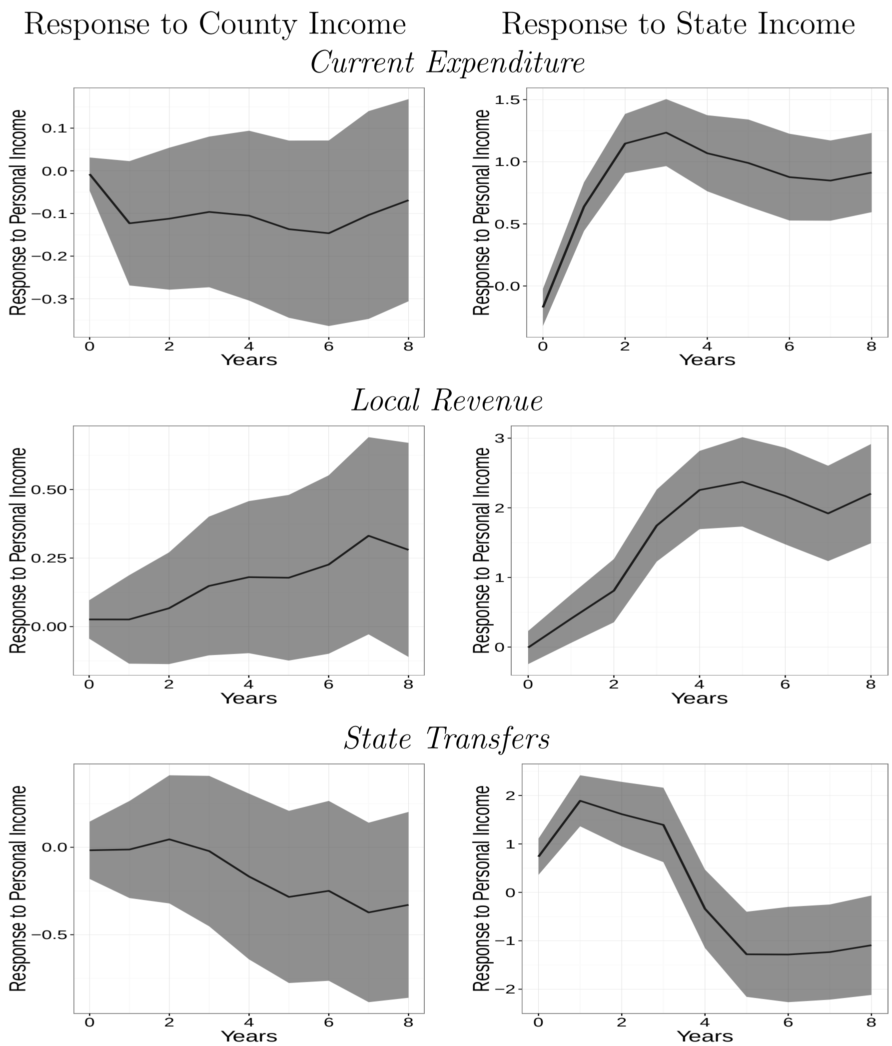
Notes: This figure displays the results from estimation on a sample consisting only of district-year observations categorized as "rich" (defined in the text) of $\Delta Z_{d,c,s,t} = \mu + \sum_{p=0}^{8} \alpha_p^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_p^S \Delta Y_{s,t-p} + (I_{MFP}) * (\sum_{p=0}^{8} \alpha_{p,MFP}^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_{p,MFP}^S \Delta Y_{s,t-p}) + \sum_{p=1}^{8} \gamma_{1,p} \Delta Z_{d,c,s,t-p} + \sum_{p=1}^{8} \gamma_{2,p} \Delta pop_{c,s,t-p} + \sum_{p=1}^{8} \gamma_{3,p} \Delta pop_{s,t-p} + \delta_t + \varepsilon_{d,c,s,t}$, where the left hand side gives the accumulated sums of α_p^L and the right hand side gives the accumulated sums of α_p^S (that is, the main effects in the regression) with 95% confidence bands. $\Delta Y_{c,s,t}$ denotes the change in the log of real personal income in county c in state s in time t and $\Delta Y_{s,t}$ denotes the change in the log of real personal income growth in state s in time t. The regressions include eights lags of the dependent variable and eight lags of county and state population growth, as well as year fixed effects.

Figure 5: Responses to Income Innovations in Poor Districts in EP States



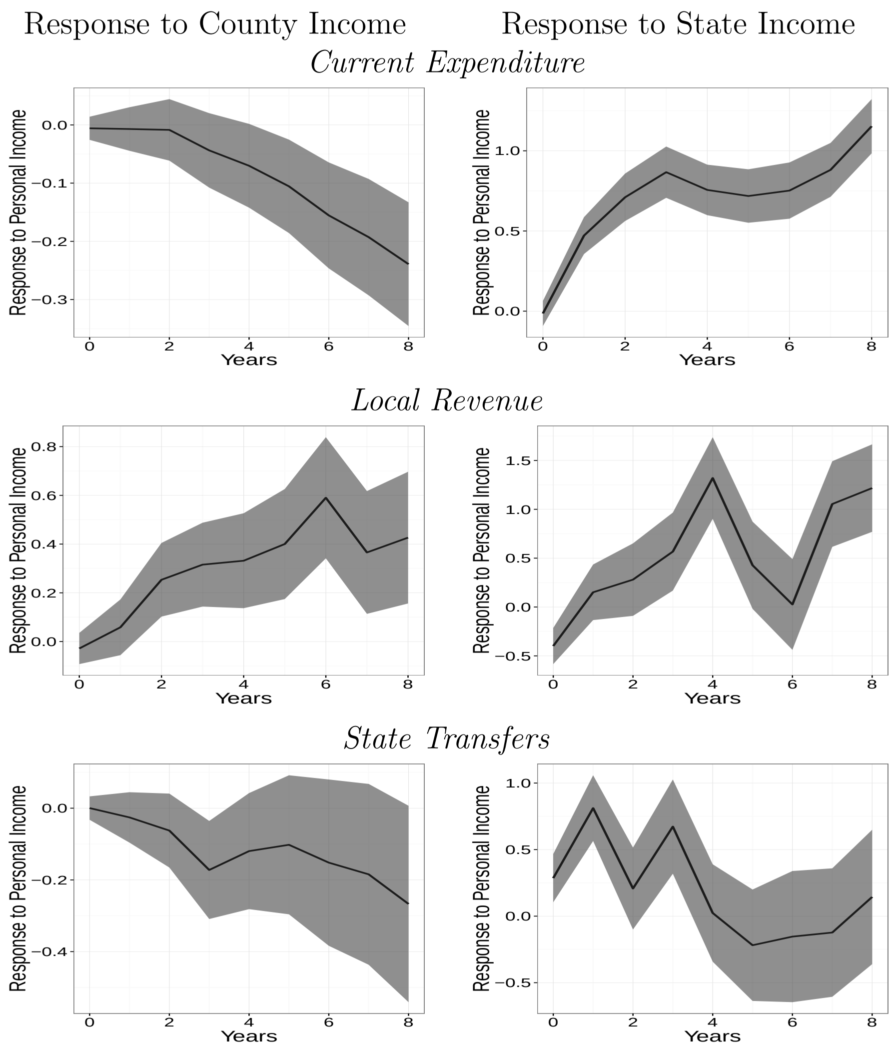
Notes: This figure displays the results from estimation on a sample consisting only of district-year observations categorized as "poor" (defined in the text) of $\Delta Z_{d,c,s,t} = \mu + \sum_{p=0}^{8} \alpha_p^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_p^S \Delta Y_{s,t-p} + (I_{MFP}) * (\sum_{p=0}^{8} \alpha_{p,MFP}^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_{p,MFP}^S \Delta Y_{s,t-p}) + \sum_{p=1}^{8} \gamma_{1,p} \Delta Z_{d,c,s,t-p} + \sum_{p=1}^{8} \gamma_{2,p} \Delta pop_{c,s,t-p} + \sum_{p=1}^{8} \gamma_{3,p} \Delta pop_{s,t-p} + \delta_t + \varepsilon_{d,c,s,t}$, where the left hand side gives the accumulated sums of α_p^L and the right hand side gives the accumulated sums of α_p^S (that is, the main effects in the regression) with 95% confidence bands. $\Delta Y_{c,s,t}$ denotes the change in the log of real personal income in county c in state s in time t and $\Delta Y_{s,t}$ denotes the change in the log of real personal income growth in state s in time t. The regressions include eights lags of the dependent variable and eight lags of county and state population growth, as well as year fixed effects.

Figure 6: Responses to Income Innovations in Rich Districts in MFP States



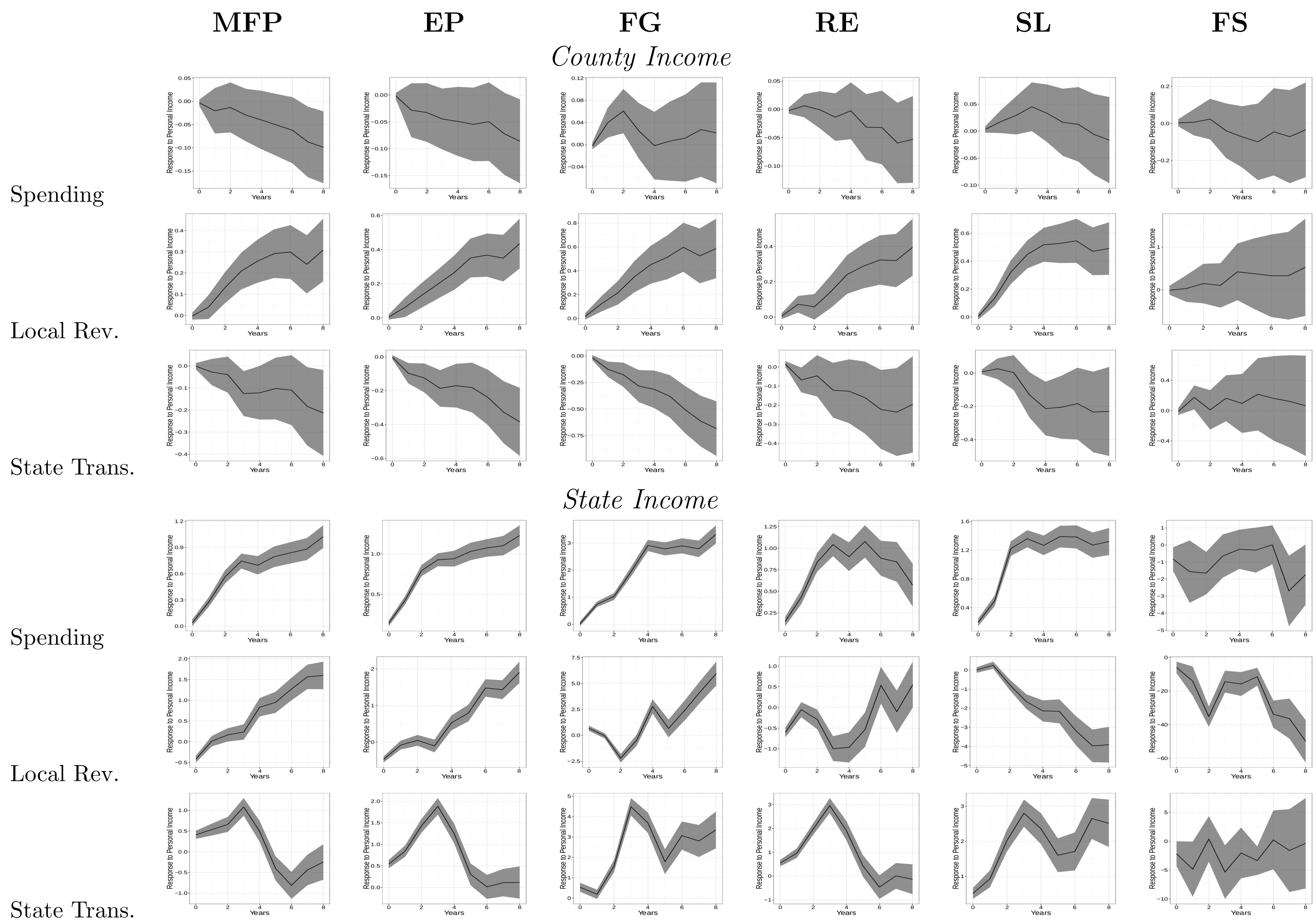
Notes: This figure displays the results from estimation on a sample consisting only of district-year observations categorized as "rich" (defined in the text) of $\Delta Z_{d,c,s,t} = \mu + \sum_{p=0}^{8} \alpha_p^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_p^S \Delta Y_{s,t-p} + (I_{EP}) * (\sum_{p=0}^{8} \alpha_{p,EP}^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_{p,EP}^S \Delta Y_{s,t-p}) + \sum_{p=1}^{8} \gamma_{1,p} \Delta Z_{d,c,s,t-p} + \sum_{p=1}^{8} \gamma_{2,p} \Delta pop_{c,s,t-p} + \sum_{p=1}^{8} \gamma_{3,p} \Delta pop_{s,t-p} + \delta_t + \varepsilon_{d,c,s,t}$, where the left hand side gives the accumulated sums of α_p^L and the right hand side gives the accumulated sums of α_p^S (that is, the main effects in the regression) with 95% confidence bands. $\Delta Y_{c,s,t}$ denotes the change in the log of real personal income in county c in state s in time t and $\Delta Y_{s,t}$ denotes the change in the log of real personal income growth in state s in time t. The regressions include eights lags of the dependent variable and eight lags of county and state population growth, as well as year fixed effects.

Figure 7: Responses to Income Innovations in Poor Districts in MFP States



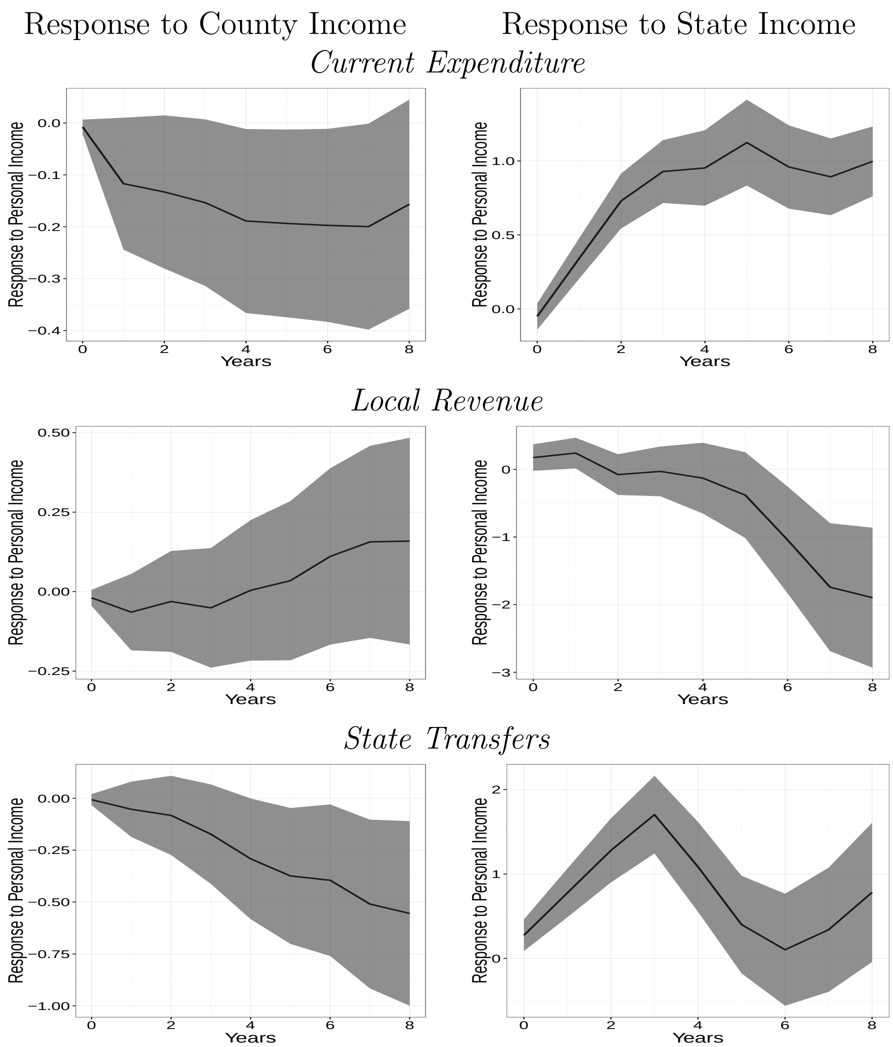
Notes: This figure displays the results from estimation on a sample consisting only of district-year observations categorized as "poor" (defined in the text) of $\Delta Z_{d,c,s,t} = \mu + \sum_{p=0}^{8} \alpha_p^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_p^S \Delta Y_{s,t-p} + (I_{EP}) * (\sum_{p=0}^{8} \alpha_{p,EP}^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_{p,EP}^S \Delta Y_{s,t-p}) + \sum_{p=1}^{8} \gamma_{1,p} \Delta Z_{d,c,s,t-p} + \sum_{p=1}^{8} \gamma_{2,p} \Delta pop_{c,s,t-p} + \sum_{p=1}^{8} \gamma_{3,p} \Delta pop_{s,t-p} + \delta_t + \varepsilon_{d,c,s,t}$, where the left hand side gives the accumulated sums of α_p^L and the right hand side gives the accumulated sums of α_p^S (that is, the main effects in the regression) with 95% confidence bands. $\Delta Y_{c,s,t}$ denotes the change in the log of real personal income in county c in state s in time t and $\Delta Y_{s,t}$ denotes the change in the log of real personal income growth in state s in time t. The regressions include eights lags of the dependent variable and eight lags of county and state population growth, as well as year fixed effects.

Figure A1: Responses to Innovations in Personal Income



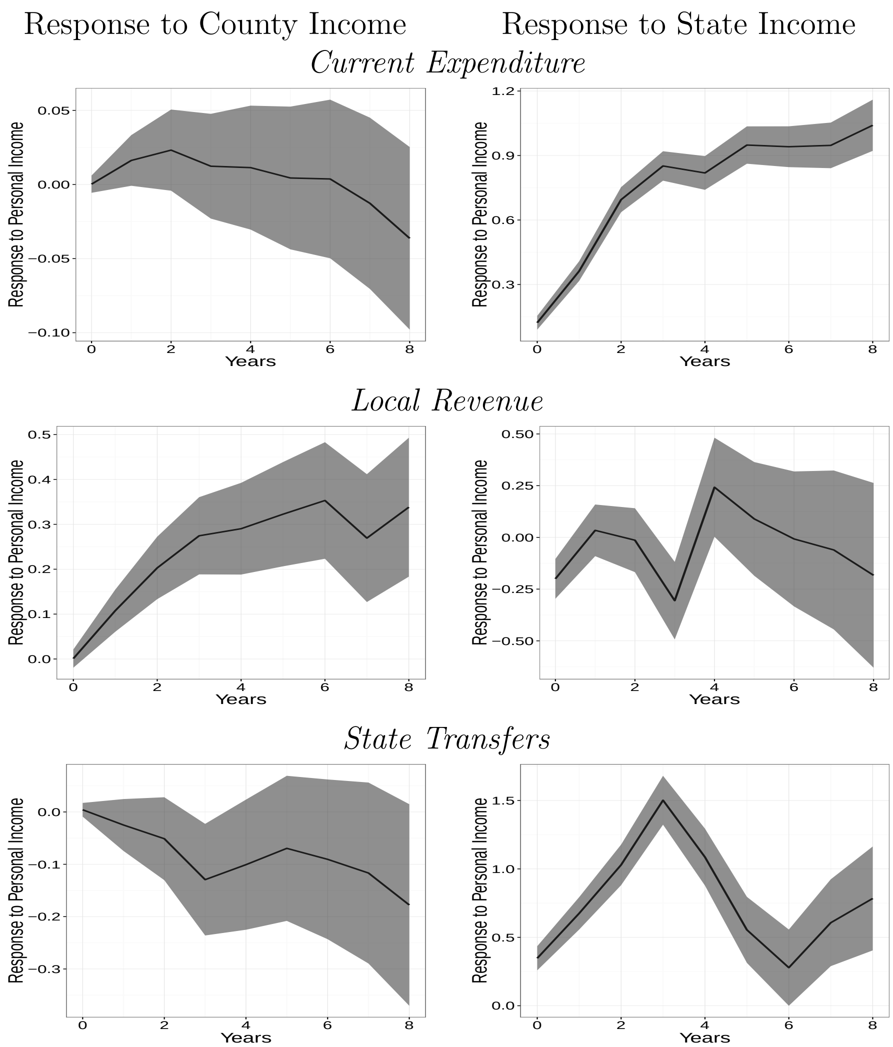
Notes: This figure displays the results from estimating $\Delta Z_{d,c,s,t} = \mu + \sum_{p=0}^{8} \alpha_p^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_p^S \Delta Y_{s,t-p} + \sum_{p=1}^{8} \gamma_{1,p} \Delta Z_{d,c,s,t-p} + \sum_{p=1}^{8} \gamma_{2,p} \Delta pop_{c,s,t-p} + \sum_{p=1}^{8} \gamma_{3,p} \Delta pop_{s,t-p} + \delta_t + \varepsilon_{d,c,s,t}$, for total current expenditure (Rows 1 and 4), total local revenue (Rows 2 and 5), and total state transfers (Rows 3 and 6), where the top panel gives the accumulated sums of α_p^L and the bottom panel gives the accumulated sums of α_p^S, with 95% confidence bands. $\Delta Y_{c,s,t}$ denotes the change in the log of real county personal income and $\Delta Y_{s,t}$ denotes the change in the log of real state personal income. The regressions are run separately according to whether a district-year observation is in a state with a given school funding formula. MFP indicates minimum foundation plans, EP indicates equalization plans, FG indicates flat grants, RE indicates Reward-for-Effort plans, SL indicates spending limit plans, and FS indicates full state funding.

Figure A2: Responses to Income Innovations in Rich Counties



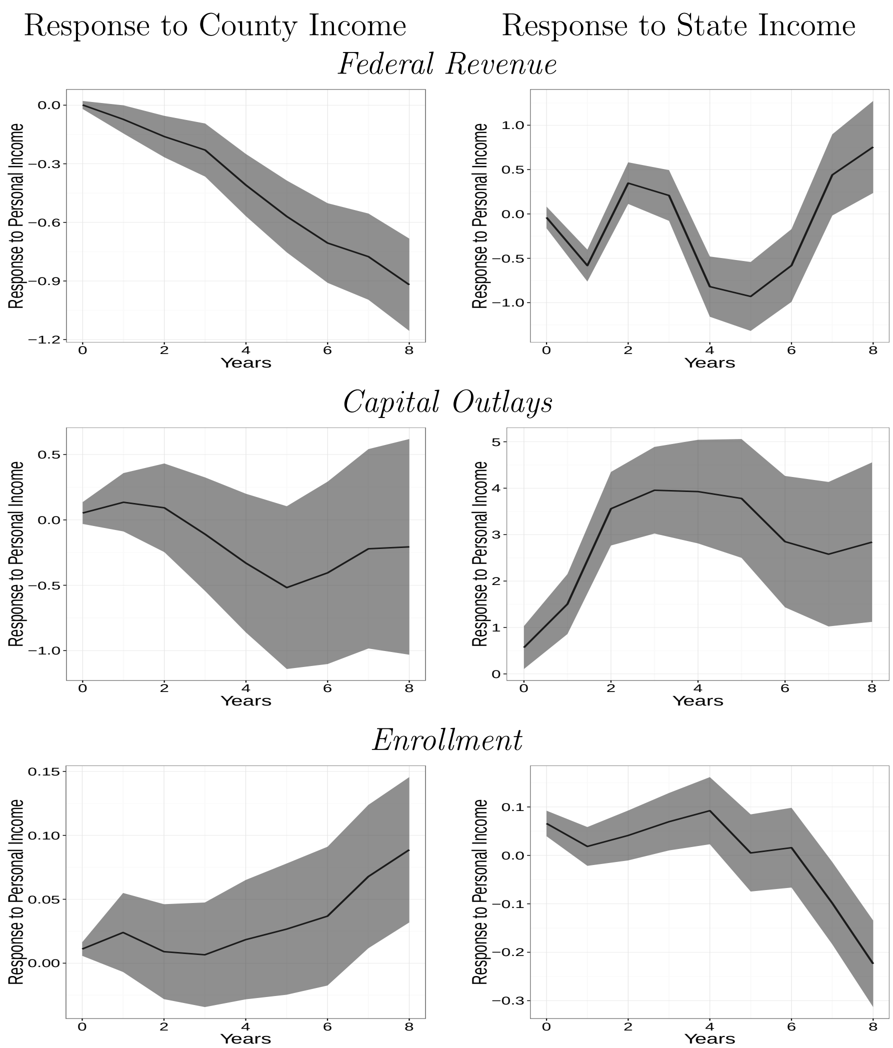
Notes: This figure displays the results from estimation on a sample consisting only of district-year observations categorized as "rich" (defined in the text) of $\Delta Z_{d,c,s,t} = \mu + \sum_{p=0}^{8} \alpha_p^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_p^S \Delta Y_{s,t-p} + \sum_{p=1}^{8} \gamma_{1,p} \Delta Z_{d,c,s,t-p} + \sum_{p=1}^{8} \gamma_{2,p} \Delta pop_{c,s,t-p} + \sum_{p=1}^{8} \gamma_{3,p} \Delta pop_{s,t-p} + \delta_t + \varepsilon_{d,c,s,t}$, where the left hand side gives the accumulated sums of α_p^L and the right hand side gives the accumulated sums of α_p^S, with 95% confidence bands. $\Delta Y_{c,s,t}$ denotes the change in the log of real personal income in county c in state s in time t and $\Delta Y_{s,t}$ denotes the change in the log of real personal income growth in state s in time t. The regressions include eights lags of the dependent variable and eight lags of county and state population growth, as well as year fixed effects.

Figure A3: Responses to Income Innovations in Poor Counties



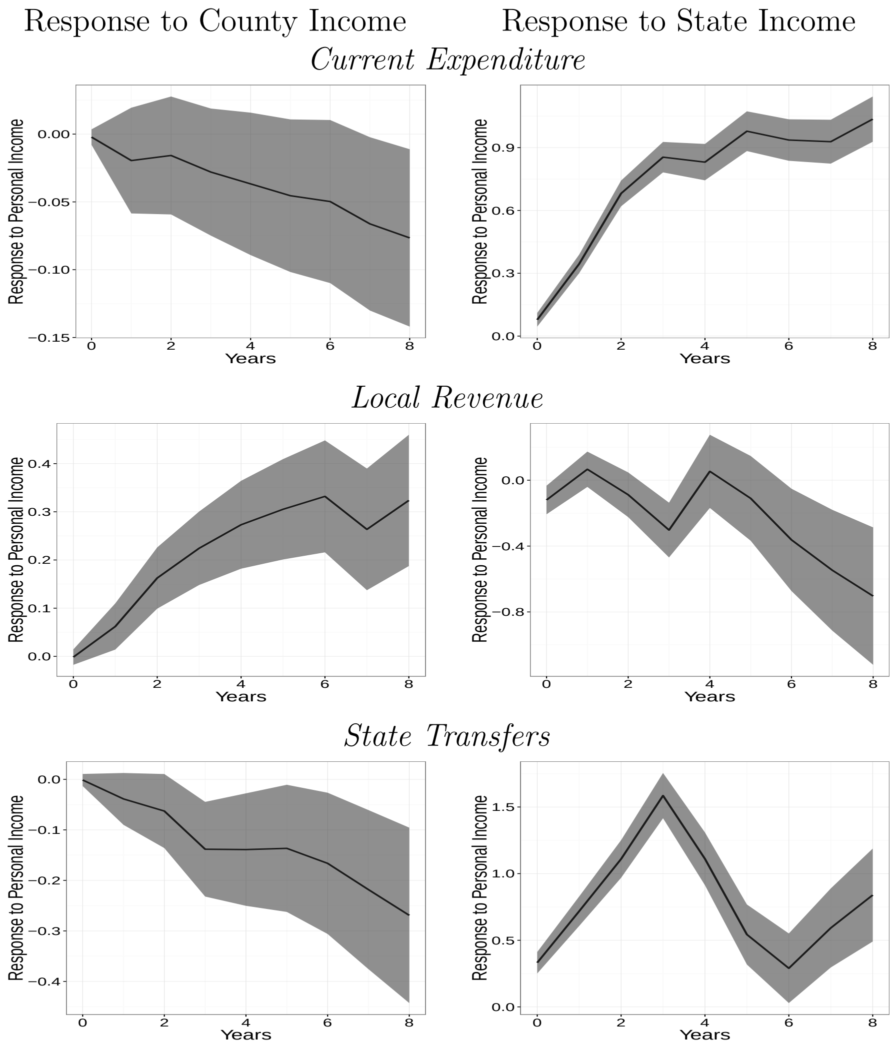
Notes: This figure displays the results from estimation on a sample consisting only of district-year observations categorized as "poor" (defined in the text) of $\Delta Z_{d,c,s,t} = \mu + \sum_{p=0}^{8} \alpha_p^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_p^S \Delta Y_{s,t-p} + \sum_{p=1}^{8} \gamma_{1,p} \Delta Z_{d,c,s,t-p} + \sum_{p=1}^{8} \gamma_{2,p} \Delta pop_{c,s,t-p} + \sum_{p=1}^{8} \gamma_{3,p} \Delta pop_{s,t-p} + \delta_t + \varepsilon_{d,c,s,t}$, where the left hand side gives the accumulated sums of α_p^L and the right hand side gives the accumulated sums of α_p^S, with 95% confidence bands. $\Delta Y_{c,s,t}$ denotes the change in the log of real personal income in county c in state s in time t and $\Delta Y_{s,t}$ denotes the change in the log of real personal income growth in state s in time t. The regressions include eights lags of the dependent variable and eight lags of county and state population growth, as well as year fixed effects.

Figure A4: Responses to Innovations in Personal Income



Notes: This figure displays the results from estimating $\Delta Z_{d,c,s,t} = \mu + \sum_{p=0}^{8} \alpha_p^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_p^S \Delta Y_{s,t-p} + \sum_{p=1}^{8} \gamma_{1,p} \Delta Z_{d,c,s,t-p} + \sum_{p=1}^{8} \gamma_{2,p} \Delta pop_{c,s,t-p} + \sum_{p=1}^{8} \gamma_{3,p} \Delta pop_{s,t-p} + \delta_t + \varepsilon_{d,c,s,t}$, where the top panel gives the accumulated sums of α_p^L and the bottom panel gives the accumulated sums of α_p^S, with 95% confidence bands. $\Delta Y_{c,s,t}$ denotes the change in the log of real personal income in county c in state s in time t and $\Delta Y_{s,t}$ denotes the change in the log of real personal income growth in state s in time t. The regressions include eights lags of the dependent variable and eight lags of county and state population growth, as well as year fixed effects.

Figure A5: Responses to Innovations in Personal Income



Notes: This figure displays the results from estimating $\Delta Z_{d,c,s,t} = \mu + \sum_{p=0}^{8} \alpha_p^L \Delta Y_{c,s,t-p} + \sum_{p=0}^{8} \alpha_p^S \Delta Y_{s,t-p} + \sum_{p=1}^{8} \gamma_{1,p} \Delta Z_{d,c,s,t-p} + \sum_{p=1}^{8} \gamma_{2,p} \Delta pop_{c,s,t-p} + \sum_{p=1}^{8} \gamma_{3,p} \Delta pop_{s,t-p} + \delta_t + \varepsilon_{d,c,s,t}$, where the top panel gives the accumulated sums of α_p^L and the bottom panel gives the accumulated sums of α_p^S, with 95% confidence bands. $\Delta Y_{c,s,t}$ denotes the change in the log of real personal income in county c in state s in time t and $\Delta Y_{s,t}$ denotes the change in the log of real personal income growth in state s in time t. The regressions include eights lags of the dependent variable and eight lags of county and state population growth, as well as year fixed effects.