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Cash Flow and Agricultural Investments:
Evidence from a Natural Experiment

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Are farms credit constrained? Recent research answers 'yes' (Bierlen and Featherstone, 1998). However, criticism of the methods used (Kaplan and Zingales, 1997; Erickson and Whited, 2000; Gao, 2002) cast doubt on this answer. The U.S. Department of Agriculture (USDA) reports, "U.S. farms are likely to be financially stable and therefore an inability to take on more debt does not seem to be a concern." (USDA, 2003) This paper answers this important question by examining the responsiveness of farm investment to shocks in *exogenous* cash flow.

Several empirical papers demonstrate a relationship between farm investment and the availability of internal funds (Hart and Lence, 2004; Bierlen and Featherstone, 1998; Bierlen et al., 1998). A long-standing criticism of this line of empirical work is the endogeneity of internal funds, e.g., increased cash flow might simply signal "improvements in future profitability" (Poterba, 1988). More recently, researchers have presented alternative explanations of the "investment-cash flow" relationship, e.g., Abel and Eberly (2002) introduce monopoly power and Erikson and Whited (2000) highlight the role of measurement error.

This paper overcomes such criticism by using exogenous agricultural subsidy changes to identify the causal connection between a farm's cash flow and its investment decisions. Using nationally representative, farm-level data, I reveal the strength of cash flow in determining investment behavior. The nature of the data allows me to account for farm-level observable heterogeneity, further bolstering the finding that, similar to publicly traded corporations, the source of financing matters to farm investment.

Specifically, this paper exploits the sudden, exogenous cash flow received by farmers due to emergency legislation in 1998. This cash flow, uncorrelated with investment opportunity, provides a natural experiment with which to evaluate the "source-of-financing" hypothesis. Using data from the 1997 Census of Agriculture, the 1999 Agricultural Economics and Land Ownership

Survey (AELOS), a follow up to the census, and the 1998 Agricultural Resource Management Survey (ARMS), I create an extensive dataset of farms over the relevant period. The structure of the data allows me to construct the appropriate variables for the analysis and control for a rich set of farm-level characteristics.

I find that farm investment not only responds to exogenous changes in cash flow, but the estimated response magnitude coincides with ex-ante predictions. Further analysis indicates that credit constraints are the most likely explanation for failure of the perfect capital markets, optimal investment theory.

Much as the present paper does, recent empirical work in the corporate finance literature has established a causal connection between the level of a publicly traded firm's investment and its source of financing. Rauh (2006) demonstrated that external financing caused firms to invest less than they would if they could finance their investment internally (e.g., via cash flows). Fazzari at al. (1988) first observed a relationship between a firm's cash flow and it's investment. Some researchers interpreted this observation as evidence of a direct relationship between financing and investment, while others argued that the relationship was spurious, a result of myriad other factors, e.g., specification error (Erikson and Whited, 2000) or unobserved confounding effects (Gomes, 2001). Using a regression discontinuity approach, Rauh exploited the *exogenous* variation in a firm's pension funding requirements to demonstrate that the relationship was, in fact, causal.

In light of the findings presented by this paper and by Rauh (2006), an important new direction in the literature is investigating why the source of financing matters. Recent literature has looked more carefully at the relationship between the firm and the lender. For example, Roberts and Chava (2006) examine the influence of publicly traded firms' debt covenants on liquidity and investment. Likewise, this paper uses unique data from the 1999 AELOS and the 1998 ARMS surveys to observe the composition of each farm's debt portfolio in order to discern the driving mechanism of the observed cash-flow sensitivity.

A Model of Credit Constrained Agricultural Investment

Information asymmetries may play an important role in agricultural investment. The vicissitudes of Mother Nature make it difficult for outside investors to distinguish between negative shocks and farmer shirking. Under such circumstances costly state-verification models, such as those developed by Townsend (1979) and Gale and Hellwig (1985) show that the optimal contracts exactly resemble the contracts available to farmers, namely debt contracts with no outside equity financing.

Froot, Scharfstein, and Stein (1993) developed a simple two-period variant of the state-verification models that can be used to illustrate a farmer's total investment decision, looking at the total change in assets (ΔA), not just fixed capital. In period 1 the farm invests internal funds, *w*, and external funds, *D*, i.e., ΔA = w + D. In period 2 the firm receives a gross return of F(ΔA), where F is an increasing, concave function. A wedge between the cost of internal and external finance can be introduced as C(D,θ) where C(.) is an increasing, convex function and θ represents the firm specific wedge. Accordingly, the firm's problem is:

(1)
$$\max \frac{F(\Delta A)}{1+r} - \Delta A - C(D,\theta)$$

subject to the following constraints:

(2)
$$\Delta A \leq \left(\frac{\gamma}{r}+1\right)w + D$$

and

(3) $$D \leq \tau \Delta A,$$

where γ is the incidence rate, r is the real rate of return, and τ is the "collateral rate," i.e., the maximum portion of assets that can be used to secure debt. The first constraint establishes that the change in assets cannot be greater than the sum of the asset appreciation due to the cash flow, the cash flow itself, and the external debt financing. The second constraint integrates the notion that most debt financing in agriculture must be secured by collateral.

Using this framework and following Kaplan and Zingales (1997), one can show that the relationship between investment and internal resources is:

(4) $$\frac{d\Delta A}{dw} = \left(\frac{C_{11}}{C_{11} - F_{11}}\right)\left(\frac{\gamma + r}{r}\right)\left(\frac{1}{1-\tau}\right) \geq 0.$$

In other words, in the face of financial frictions, investment increases with the amount of internal resources. This result also gives a sense of the possible response magnitudes. Carpenter and Peterson (2002) suggest that in a perfectly competitive industry the first term in brackets approaches one as the slope of the supply of finance schedule (C_{11}) becomes large. The second and third terms reveal that the investment response can be quite large if the constraints bind and γ and τ are large.

Figure 1 illustrates the intuition embodied in equation 4. The flow of funds is measured along the horizontal axis and the vertical axis measures the rate of return. The firm's supply of finance schedule, labeled S in the figure, consists of three segments under imperfect financial markets. Initially, the farm can self-finance using cash flow at a constant shadow cost R. Once internal cash flow is exhausted, the farmer seeks external debt financing. This upward sloping segment of the supply of funds curve reflects two things. First, the likelihood and severity of financial distress increases with the farm's debt burden, requiring farmers to pay higher interest on increasingly large debt burdens. Second, the moral hazard problem increases as debt increases; farmers with greater debt have greater incentives to take risks that may lead to default. Ultimately, farmers reach the limit of debt financing. Because of asymmetric information the lender requires collateral to secure the loans. Here the collateral constraint is binding at some proportion, τ, of total assets. The marginal revenue product of investment curve, MRP_I, which has slope F_{11} in equation 4 above, illustrates the farm's demand for financing. The competitive nature of the agricultural sector ensures that this curve is relatively flat.

Figure 2 illustrates the effects of a positive shock to cash flow. The horizontal segment of the supply curve shifts right by the amount of the cash flow shock. Due to the capitalization effect, the collateral constraint shifts out by *more* than the cash flow shock. The increased asset value consequently affects the slope of the debt-finance section; a given level of debt is less risky for the lender.

Notice the theory predicts differential cash flow response according to the asset base of the farm. Farm operators who own all of the land they farm will experience the supply shift illustrated in figure 2. Tenant farmers, however, will see their supply curve shift by the amount of the cash-flow shock, but they won't experience the leverage effect and consequent decline in the slope of the debt finance portion of the curve.

Empirical Strategy

Beginning with Fazarri, Hubbard, and Peterson (1988) a large literature has estimated variations of the following linear investment equation:

(5)
$$\frac{I_{it}}{K_{i,t-1}} = \alpha_i + \alpha_t + \beta_1 Q_{i,t-1} + \beta_2 \frac{CF_{it}}{A_{i,t-1}} + \varepsilon_{it} .$$

The dependent variable is the ratio of capital expenditure to beginning of period capital stock. $Q_{i,t-1}$ is a measure of the present discounted value of profits due to capital investment, i.e., marginal Q.

Market-to-book value ratios are typically employed as a measure of average Q. CF_{it} is cash flow and $A_{I,t-1}$ is a measure of firm assets.

A standard model of optimal firm investment can be shown to be linear in marginal Q when the firm pays adjustment costs that are linearly homogeneous in investment and capital. If in addition the production function is linearly homogeneous, marginal Q equals average Q.

The standard model of optimal firm investment, i.e., Q-theory, implies that the marginal return on investment is a sufficient statistic for firm investment. In other words, conditional on Q, nothing else should matter in the investment equation. Contrary to the predictions of Q-theory, most studies that estimate equation 5 find a positive, statistically significant coefficient on cash flow, indicating that contemporaneous cash flow influences investment. Stratifying the analysis by *ex ante* indicators of credit constraints typically reveals that the coefficient on cash flow increases with the likelihood of binding credit constraints. Researchers commonly interpret this relationship as being indicative of credit constraints.

This approach is not without criticism, however. Cash flow is jointly determined with investment, making statements of causality tenuous. Measurement error in Tobin's Q that is correlated with the *ex ante* predictors of credit constraints can lead one to erroneously attribute the observed responsiveness to credit constraints.

The strategy invoked by this paper relies on variation in exogenous cash flows, i.e., "decoupled" agricultural subsidies, to address these criticisms. Unlike contemporaneous cash flows, decoupled subsidies are unrelated to the profitability of the farm. Decoupled agricultural subsidies are factor subsidies to farmland. Farmers who own or rent subsidized land receive the subsidy regardless of price or production. The subsidy amount is known and unrelated to changing investment opportunities. Because decoupled subsidies are not jointly determined with investment opportunities they represent exogenous variation in farmer cash flow. Finding investment sensitivity to decoupled subsidies is indicative of a wedge between internal and external financing.

The analysis also employs a natural experiment induced by "surprise" subsidies in 1998. That these subsidies were a surprise is supported by the fact that farmers received their subsidy checks two months after legislation was *introduced*. The surprise subsidy was not conditioned on production. Rather, farmers who farmed subsidized land received a "bonus" equal to 50 percent of the subsidy already attached to that land.

A possible concern with this identification strategy is that the surprise subsidy represented more than just extra cash. Farmers who expected the government to take a "hands off" approach after the 1996 Freedom to Farm bill would have learned that subsidies would in fact increase if prices fell. In this case, attributing cash flow sensitivity to credit constraints would be spurious if this information differentially affected the investment decisions of farmers who appear to be credit constrained. The model in section two has sensitivity implications on multiple dimensions; the results are spurious if the information content of the surprise subsidy varied along those same dimension. This may be very unlikely, but should be kept in mind nonetheless.

The empirical model in this paper augments equation 5 to include decoupled subsidies (S^*), other agricultural subsidies (S), and a vector of beginning-of-period variables that might also explain investment ($X_{i,t-1}$):

(6) $$Y_{it} = \alpha + \beta_1 Q_{i,t-1} + \beta_2 \frac{S^*}{A_{i,t-1}} + \beta_3 \frac{S}{A_{i,t-1}} + \delta X_{i,t-1} + \varepsilon_{it}.$$

Y_{it} is the outcome variable of interest. In this paper I will examine two outcome variables, total farm asset growth ($\ln A_{it} - \ln A_{i,t-1}$) and capital expenditures ($I_{it}/K_{i,t-1}$).

Data

Few datasets contain sufficient information to effectively estimate equation 6. Other studies have used data from small, self-selected (i.e., nonrandom) samples of farms that belong to a business association within a particular state and have operated continuously for over 15 years (Bierelen and Featherstone, 1998; Hart and Lence, 2004). Conclusions drawn from such limited data are difficult to generalize to the entire agricultural industry.

In contrast, the analysis that follows uses farm-level data from a random sample of all agricultural producers, the 1998 Agricultural Resource Management Survey and the 1999 Agricultural and Land Ownership Survey, matched to farm-level data from the 1997 Agricultural Census. Results reported below relate primarily to 5,186 farms that were sampled in the 1998 ARMS data and received the "long form" of the 1997 Census of Agriculture. It is worth noting that there are roughly five times the number of entities in this study than the next largest study of firm credit constraints (in any industry). The data used in the following analysis has been Winsorized at the 1st and 99th percentile. Table 1 contains summary statistics.

Empirical Results

I begin by investigating the response of the exogenous cash flow shock on total agricultural investment, measured as the growth rate of asset values. The assets considered in this construction are land, physical capital, inventories (both crop and livetock), and accounts receivable. Table 2 contains the results of estimating equation 6 on the full sample, using the asset growth rate as the dependent variable. The top row reports the estimate of β_3, the response of asset growth to an extra dollar of decoupled payments. The statistically significant, positive coefficients reported in this row indicate the excess sensitivity of agricultural investment to cash flow shocks. Column 1 reports the simple augmented Q equation without any other covariates. In this specification an extra dollar of decoupled subsidy results in increased asset values of $1.21. Accounting for county level unobserved heterogeneity in column 2 raises the response to $3.05. Including county level fixed effects effectively reduces the sample size considerably since many counties contain only one farm. Including instead detailed covariates from the 1997 Census that control for the proportion of revenue from 16 different groups, yields of major crops, type of farm organization, and the presence of irrigation results in a similarly sized effect, $2.98 in column 4. Including both covariates and county fixed effects brings the coefficient, reported in column 5, to 3.47, signifying a nearly three and a half dollar growth in total farm assets from the marginal decoupled subsidy dollar.

Table 3 begins to explore whether credit constraints cause the observed sensitivity to cash-flow shocks. At this point, the analysis proceeds by stratifying the sample into groups according to their *ex ante* likelihood of facing credit constraints. This is done in two ways. First, columns 1-3 report the coefficients when the sample is stratified by interest coverage ratio. The interest coverage ratio is the ratio of the amount of interest payments made to the amount of cash available to make the interest payments. Farms with an interest coverage ratio close to one are likely to be credit constrained; the estimates from this group are reported in column 1. An interest coverage ratio close to zero signifies farms with the capacity to take on more debt. This estimates for this group are reported in column 3. Column 2 contains an intermediate group of farms. The progression of coefficients across these three columns illustrates the potential role played by credit constraints. The most likely to be constrained have a $3.71 response to cash flow, while those least likely to be constrained experience a $2.41 response. Grouping farms based on another measure of possible credit constraints, the debt-asset ratio, reveals a less compelling picture. Columns 4-6 report the coefficients from most- to least-likely to be constrained. Under this grouping the coefficients are nearly identical across the different groups, $3.12 for the constrained group and $3.64 for the unconstrained.

As indicated in equation 4, the degree of responsiveness is larger the greater the capitalization effect. The role played by the capitalization effect can be seen when the sample is separated according to land tenure. Farmers who own all of the land they farm should experience a much greater relaxing of the credit constraint than tenant farmers who do not own the land they farm. In other words, owner/operators should experience a financing supply curve shift analogous to that seen in figure 2, while tenants would simply see their curve shift out by the amount of the subsidy without a change in the slope. Tables 4 and 5 illustrate these effects.

Table 4 reports the cash-flow sensitivities of three groups of farmers: full owners, partial owners, and full tenants. Consistent with the explanation above, full owners have nearly three times the asset growth of tenant farmers. Full owners' assets grow by $9.67 for each extra dollar of decoupled subsidy. Tenant's assets grow by $3.48.

Table 5 provides the best evidence that credit constraints affect real agricultural investment. In this analysis farmers are grouped according to their likelihood of being credit constrained (according to the interest coverage ratio) *and* their land ownership characteristics. Equation 6 is estimated for each of the nine resulting groups. The theory introduced in section two predicts that highly credit constrained landowners should be most responsive to the surprise subsidy and the responsiveness should decrease as asset ownership decreases and credit constraints become less binding. Ultimately, unconstrained tenant farmers should respond the least. The coefficients in table 5 bear out the theory. In response to the exogenous subsidy shock, highly constrained owner/operators' assets grow by $15.38 while highly constrained tenant's assets grow by $4.80. Looking down the 'Full Owner' column reveals that owner/operators' responsiveness decreases as credit constraints loosen; ultimately, unconstrained owner/operators' assets grow by $4.82, about the same as constrained tenants. Tenants' responsiveness, on the other hand, remains relatively stable across credit constraint groups, dropping only to 3.86 for unconstrained tenants.

Investment

The literature generally focuses exclusively on a single component of total asset growth, namely investment in physical capital. I reflect that analysis in tables 6 and 7. Table 6 demonstrates relatively little change in the responsiveness of capital expenditures to cash flow shocks as covariates are included in the model. Again, the coefficient on decoupled subsidies is positive and statistically significant in every specification, providing further evidence of a wedge between internal and external financing. According the preferred specification in column 3, about 55 cents of the marginal subsidy dollar is invested in physical capital.

Table 7 explores how the positive response to cash flow shocks changes with the likelihood of binding credit constraints. Unlike the results for total asset growth, the responsiveness of capital expenditures does not appear to be related to credit constraints. Constrained farmers spend 45 cents of the subsidy dollar on physical capital, while unconstrained farmers spend 63 cents. If anything, unconstrained farmers are more responsive to cash flow shocks.

Discussion and Conclusion

A voluminous literature in corporate finance explores the relationship between investment and cash flow. A concern with nearly all of this literature is the endogeneity of cash flow. This paper addresses the endogeneity issue by relying on decoupled subsidies, which are predetermined and independent of changing investment opportunities, as exogenous cash flow. I employ several unique datasets to exploit an innovation in decoupled subsidies in 1998, when decoupled subsidies were surprisingly increased by fifty percent. Using this exogenous cash flow variation and the traditional reduced form Q-theory approach, I estimate the responsiveness of farmers to cash flow. The analysis indicates overwhelmingly that a wedge exists between internal and external financing. According to a model I develop in the paper, owners of durable assets, such as land, should be much more responsive than tenant farmers if credit constraints are binding. The empirical analysis bears this out, demonstrating that credit constrained owner/operators are about three times more responsive than tenant farmers to cash flow shocks.

These findings have significant policy implications. Market failures in farm financing suggest a role for the government to ensure financing for the most profitable ventures, even if there is little collateral available. In addition, the presence of cash-flow constraints “decoupled” subsidies have substantial production effects. Such effects might jeopardize this subsidy instrument in the context of global trade negotiations.

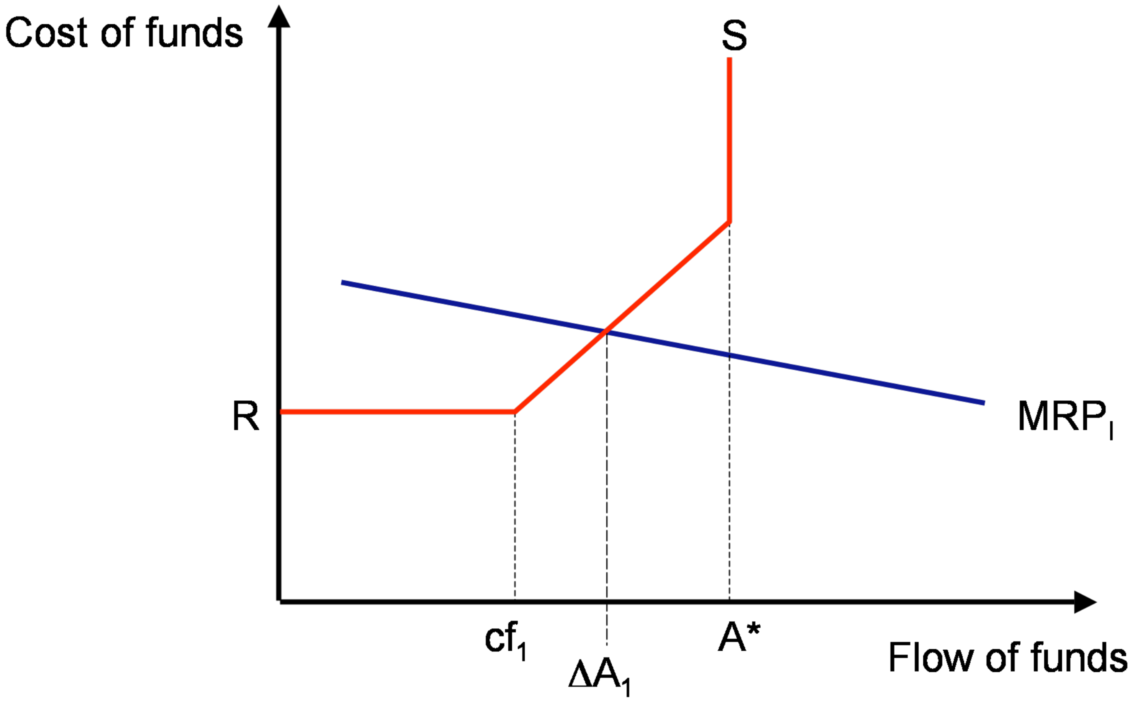

Figure 1

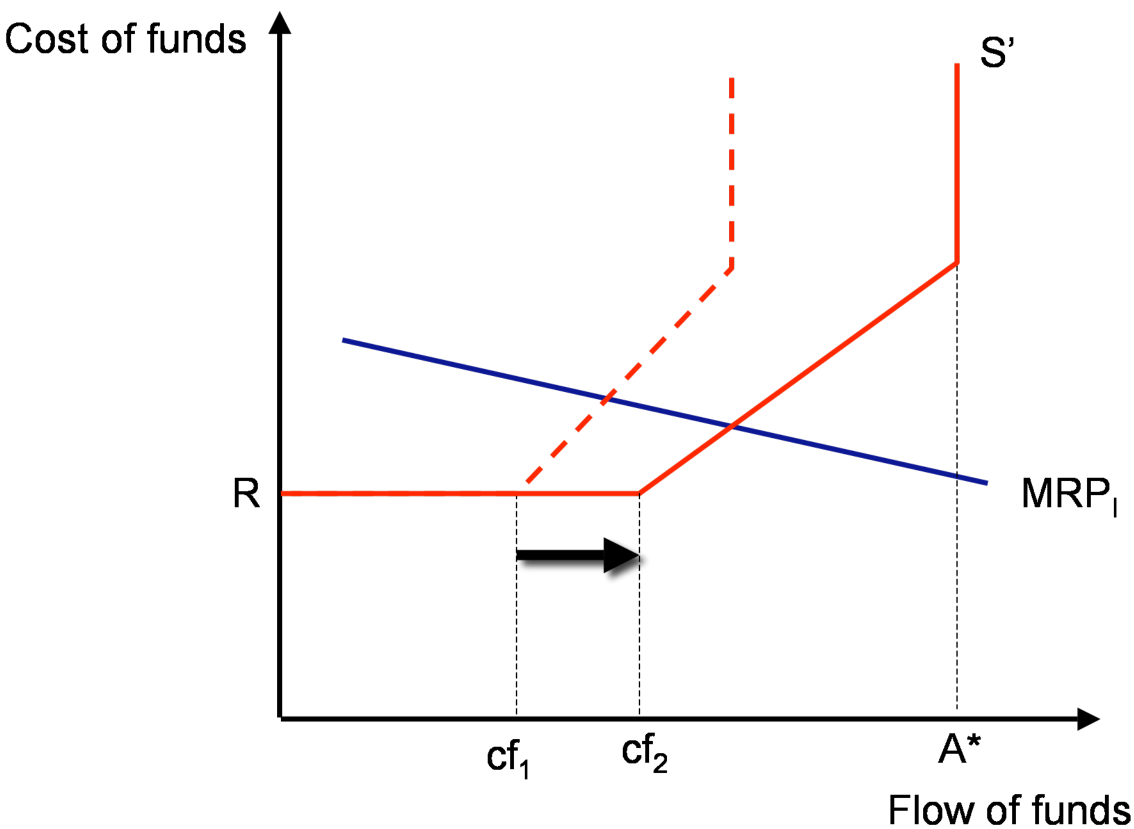

Figure 2

Table 1

Table 2

Cross Sectional Regression of Total Asset Growth on Agricultural Subsidies

	Dependent Variable: 1997-98 Growth Rate of Total Assets			
	(1)	(2)	(3)	(4)
Decoupled Subsidy_t	1.213	3.053	2.976	3.468
	(0.388)	(0.580)	(0.407)	(0.577)
Other Subsidies_t	1.200	2.654	2.962	3.282
	(0.582)	(0.818)	(0.589)	(0.829)
Q_{t-1}	0.398	0.396	0.392	0.405
	(0.034)	(0.051)	(0.037)	(0.052)
R^2	0.063	0.094	0.117	0.126
Obs	5186	5186	5186	5186
Covariates	N	N	Y	Y
County Effects	N	Y	N	Y

Notes: See paper for detailed description of data and covariates. Standard errors reported in parenthesis.

Table 3

Cross Sectional Regression of Total Asset Growth on Agricultural Subsidies

	Dependent Variable: 1998 Growth Rate of Total Assets					
	Interest Coverage			Debt/Asset		
	Highly Constrained	Constrained	Unconstrained	Highly Constrained	Constrained	Unconstrained
Decoupled $Subsidy_t$	3.714	2.550	2.413	3.124	3.964	3.614
	(0.792)	(0.644)	(0.681)	(0.570)	(0.647)	(0.949)
Other $Subsidies_t$	2.669	2.401	2.971	3.338	2.874	2.818
	(1.109)	(0.987)	(0.960)	(0.909)	(0.844)	(1.211)
Q_{t-1}	0.340	0.639	0.374	0.409	0.425	0.380
	(0.154)	(0.066)	(0.052)	(0.061)	(0.058)	(0.066)
R^2	0.082	0.164	0.140	0.188	0.162	0.109
Obs	1735	1736	1715	1728	1734	1724
Covariates	Y	Y	Y	Y	Y	Y
County Effects	N	N	N	N	N	N

Notes: Interest coverage ratio is the ratio of interest payments to gross cash flow. Standard errors in parenthesis.

Table 4

Cross Sectional Regression of
Total Asset Growth on Agricultural Subsidies

Dependent Variable: 1998 Growth Rate of Total Assets			
	Full Owner	Part Owner	Full Tenant
Decoupled $Subsidy_t$	9.669	5.329	3.488
	(1.915)	(0.463)	(0.589)
Other $Subsidies_t$	11.320	3.990	4.664
	(2.839)	(0.703)	(0.971)
Q_{t-1}	0.340	0.445	0.490
	(0.070)	(0.050)	(0.070)
R^2	0.140	0.172	0.314
Obs	1150	3349	687
Covariates	Y	Y	Y
County Effects	N	N	N

Notes: Standard errors in parenthesis.

Table 5

Dependent Variable: 1998 Growth Rate of Total Assets

	Full Owner	Part Owner	Full Tenant
	Highly Constrained		
Decoupled Subsidy$_t$	15.383	5.678	4.797
	(2.950)	(0.852)	(1.301)
Other Subsidies$_t$	9.826	3.480	5.362
	(4.511)	(1.188)	(2.278)
Q_{t-1}	0.399	0.360	0.511
	(0.303)	(0.181)	(0.439)
	Constrained		
Decoupled Subsidy$_t$	9.348	5.037	2.308
	(6.386)	(0.804)	(0.934)
Other Subsidies$_t$	11.734	3.508	3.537
	(8.366)	(1.135)	(1.758)
Q_{t-1}	0.680	0.679	0.738
	(0.142)	(0.090)	(0.126)
	Unconstrained		
Decoupled Subsidy$_t$	4.823	4.928	3.864
	(2.683)	(0.723)	(0.972)
Other Subsidies$_t$	12.679	4.401	4.537
	(3.378)	(1.231)	(1.487)
Q_{t-1}	0.306	0.420	0.432
	(0.096)	(0.070)	(0.102)
Covariates	Y	Y	Y
County Effects	N	N	N

Notes: Constraint classification based on the interest coverage ratio. Standard errors in parenthesis.

Table 6

Cross Sectional Regression of Capital Expenditures on Agricultural Subsidies

	Dependent Variable: 1998 Capital Expenditures			
	(1)	(2)	(3)	(4)
Decoupled Subsidy_t	0.447	0.615	0.549	0.632
	(0.085)	(0.112)	(0.089)	(0.110)
Other Subsidies_t	0.593	0.675	0.642	0.667
	(0.129)	(0.163)	(0.129)	(0.161)
Q_{t-1}	0.023	0.019	0.023	0.020
	(0.003)	(0.004)	(0.003)	(0.004)
R^2	0.133	0.156	0.161	0.178
Obs	5185	5185	5185	5186
Covariates	N	N	Y	Y
County Effects	N	Y	N	Y

Notes: See paper for detailed description of data and covariates. Standard errors reported in parenthesis.

Table 7

Cross Sectional Regression of Capital Expenditures on Agricultural Subsidies

	Dependent Variable: 1998 Capital Expenditures					
	Interest Coverage			Debt/Asset		
	Highly Constrained	Constrained	Unconstrained	Highly Constrained	Constrained	Unconstrained
Decoupled $Subsidy_t$	0.424	0.552	0.615	0.534	0.559	0.508
	(0.150)	(0.159)	(0.144)	(0.148)	(0.146)	(0.154)
Other $Subsidies_t$	0.415	0.862	0.609	0.631	0.687	0.571
	(0.194)	(0.232)	(0.224)	(0.210)	(0.229)	(0.229)
Q_{t-1}	0.016	0.026	0.023	0.025	0.022	0.019
	(0.009)	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)
R^2	0.085	0.217	0.200	0.200	0.186	0.117
Obs	1737	1739	1709	1731	1733	1721
Covariates	Y	Y	Y	Y	Y	Y
County Effects	N	N	N	N	N	N

Notes: Interest coverage ratio is the ratio of interest payments to gross cash flow. Standard errors in parenthesis.

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