Private R&D Investment in the U.S. Food and Agricultural Sectors, 1950-2014

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Introduction

The relationship between a firm's financial position and its spending on research and development (R&D) has been studied for a number of manufacturing sectors. This topic has been little studied for the food and agricultural sectors, most likely a reflection of the substantive public R&D presence in these sectors, and, until recently, the paucity of firm-level data. However, since the 1950s, growth in inflation-adjusted spending on privately performed food and agricultural R&D in the United States has persistently outpaced the corresponding public-sector growth, such that by the mid-1970s the private sector began outspending the public sector (Figure 1). The private-public R&D gap continues to grow, and by 2013, for every dollar of public spending there was 2.2 dollars of private investment.

Over the past six decades, private food and agricultural R&D grew faster on average (4.8 percent per year from 1950-2014) than sales revenue (3.1 percent per year). Both rates of growth have slowed dramatically since 2000 (2.4 and 0.7 percent per year respectively), while the growth in sectoral profits has stalled (Figure 2).

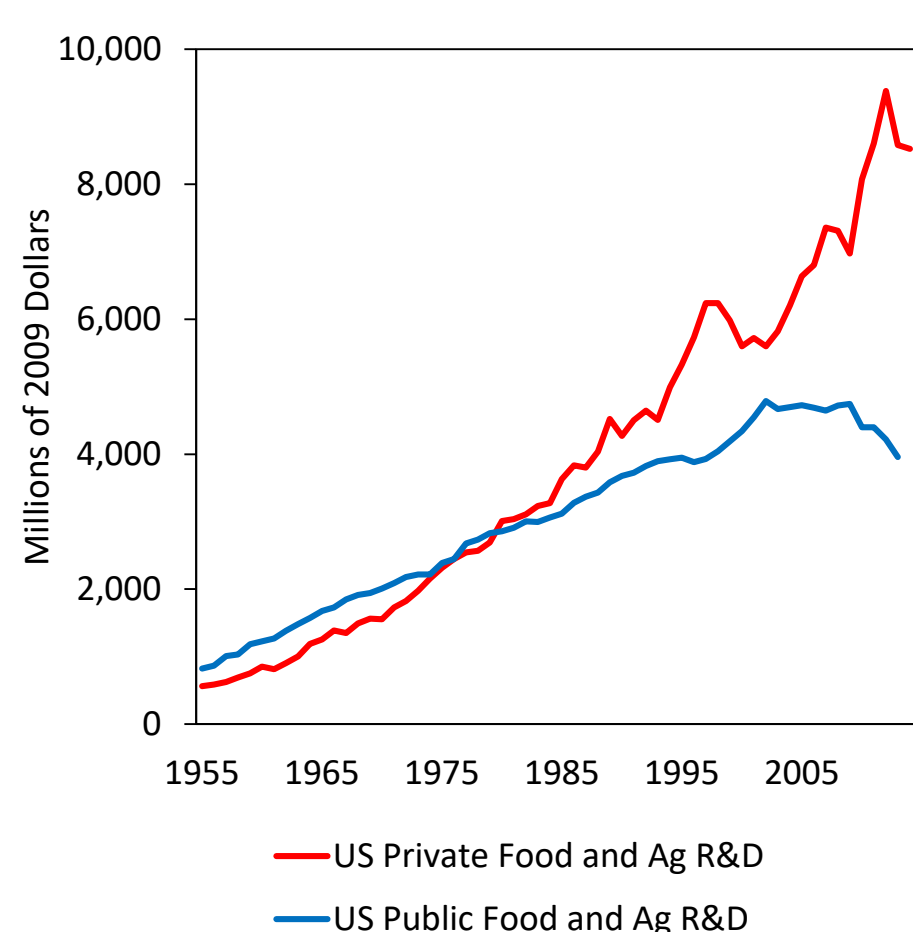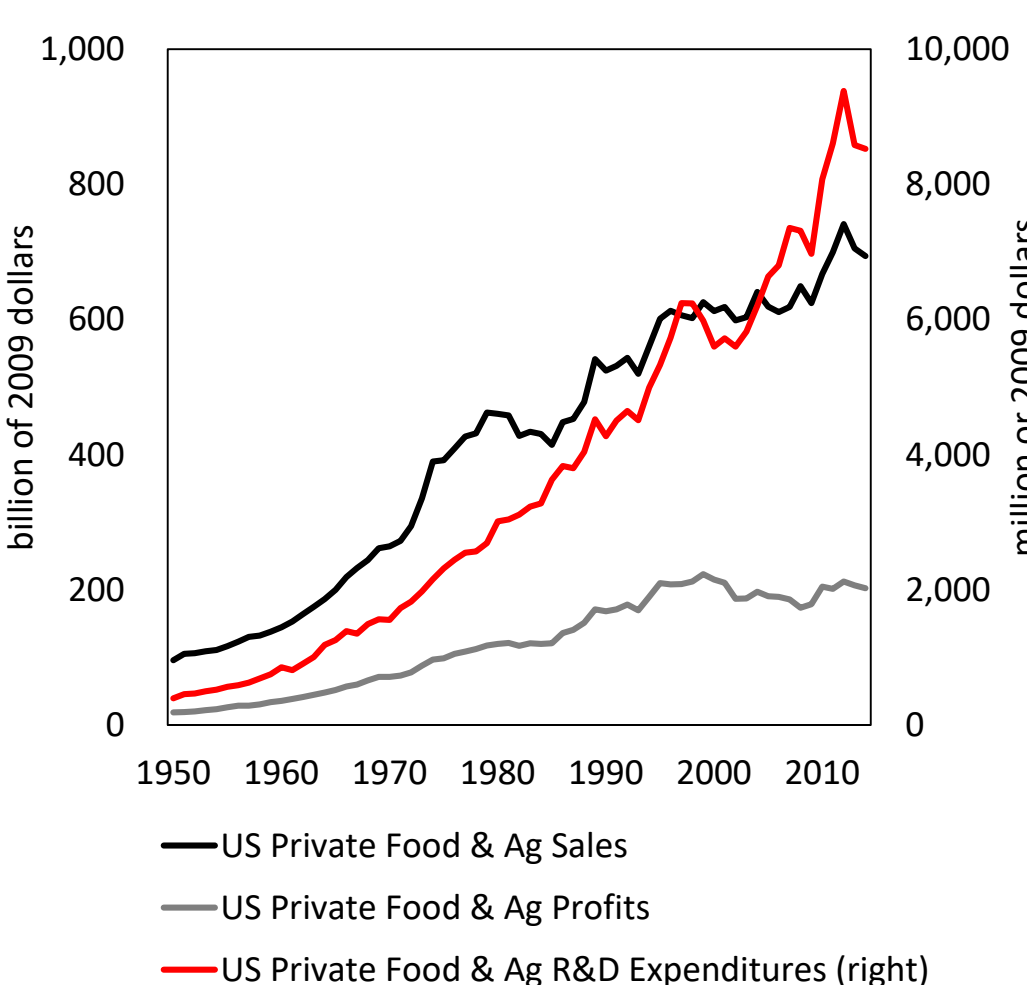**Figure 1. US Private and Public Food and Agricultural R&D Spending**

Figure 2. US Private Food & Agricultural R&D Spending, Sales, and Profits

Objectives

The purpose of this research was to investigate stylized associations between firm-level sales, profits and R&D spending in the food and agricultural sectors. Our specific objectives are to:

- Construct a replicable and comprehensive set of firm-level data related to food and agricultural R&D for the period 1950-2014.
- Examine the relationship between firm sales and profitability on past and present commitments to R&D.
- Assess if these sales, profitability and R&D relationships vary between sectors (i.e., food versus agriculture) and by size of firm.

Method

Our estimation is based on the error correction model (ECM) used by Bond et al. (1999) and Mulkay et al. (2001). For estimation, we used a system GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998). This allows us to control for unobserved firm-specific effects and address the endogeneity problem. Our estimation equation is:

$$\Delta r_{it} = \delta_t + \sum_{n=1}^{n} \omega_n \Delta r_{it-n} + \sum_{n=0}^{n} \theta_n \Delta y_{it-n}$$

$$+ \mu_1 r_{it-1} + \mu_2 y_{it-1} + \sum_{n=1}^{n} \rho_n \Delta \Pi_{it-n} + \tau_{it}$$

where r_{it} is the log of R&D expenditure firm i in period t, y denotes the log of output, Π is the log of profit, and $\tau_{it} = \delta_i + \varepsilon_{it}$ where δ_i and δ_t are firm- and time-specific effects respectively.

Data

Our data are an unpublished series developed by the International Science and Technology Practice and Policy (InSTePP) at the University of Minnesota. This series was largely compiled from data on publicly-traded firms operating in the United States obtained from Standard & Poor's Compustat North America (NA) database, supplemented with data drawn from the published annual reports or financial statements of the larger firms. We used SIC codes to identify and classify food- and agriculturally-related firms, and for the purposes of this particular analysis set aside firms with no reported R&D spending.

We designated agricultural firms to be those involved in the manufacture of farm machinery, seed production and agricultural chemicals. Food related firms include those engaged in the processing and production of food, beverage and tobacco products. Given the business segments of some firms are only partially associated with food and agriculture, we parsed each firm's total R&D spending in line with the share of sales associated with that firm's agricultural or food-related business segments. To do this, we used historical business segment sales data reported in 10-k filings (collected from either the Security and Exchange Commission's EDGAR database or the Orbis database). For some of the larger firms we also used data obtained from the firms for this purpose. The result was an unbalanced panel of 468 firms operating within the U.S. jurisdiction for the period of 1950-2014.

Results

Table 1 reports summary statistics for all 468 firms. On average, agricultural firms invest more in R&D than do food firms ($33 million per firm for agricultural firms, versus $27 million per firm for food firms). On the other hand, food firms report higher sales and profits on average than do agricultural firms. Thus the intensity of R&D—R&D expenditures divided by sales—is markedly higher on average for agricultural versus food firms.

Table 1. Descriptive Statistics

	Agricultural Sector				Food Sector			
	Number of Firms	Mean	Median	Std. Dev	Number of Firms	Mean	Median	Std. Dev
R&D Expenditures	255	33.2	5.1	86.5	214	27.6	4.2	63.5
Sales	255	1,745	420	3,613	214	3,608	1,027	6,968
Profits	255	466	134	885	214	1,146	257	2,673
R&D Intensities (ratio)	255	0.96	0.01	24.80	214	0.10	0.00	3.56

Note: All units are millions of 2009 dollars except for R&D intensities which are a ratio or R&D spending to sales. The sales, profits and R&D estimates pertain only to US jurisdictional data.

Table 2 reports our econometric results. For this analysis, we settled on a lag length of two years for the agricultural sector and one year for the food sector based on the results of a VAR model. We find that R&D growth in the current year is negatively correlated with R&D growth in the previous year for both the agricultural and food sectors. However, for the agricultural sector this negative relationship does not persist (the coefficient on R&D growth lagged two years, $\Delta R\&D_{t-2}$, is not statistically significant. In contrast, contemporaneous and previous year's sales growth are both positively related to R&D growth, with the magnitude of the sales to R&D effect generally declining over time. The estimated R&D-profit relationship is more complex and somewhat more confounding, and subject to on-going study.

Conclusion

This entirely new series of R&D related data for US food and agricultural firms reveals a diverse and complex pattern of R&D spending. For those firms that conducted any R&D over the 65 year period beginning in 1950, the range in spending is remarkable. There were 175 firms (37 percent of the combined food and agricultural firm sample) that annually spent less than $1.0 million per firm on R&D conducted in the US, 46 firms spent more than $50 million per firm, on average, and three firms spent in excess of $300 million per year. Our findings suggest that prior year(s) R&D spending in terms of amounts and growth rates have limited influence on current R&D spending. However, there appears to be a systematic and positive relationship between sales revenues and R&D spending for both food and agricultural companies alike. The estimated profit-R&D relationship is less stable, and profits seem to have less influence on R&D spending decisions, a result that is in line with the findings of Bond et al. (1999) and Mulkay et al. (2001) for the manufacturing sector.

Results

Table 2. Estimation Results

	Agricultural		Food	
	(1)	(2)	(3)	(4)
$\Delta R\&D_{t-1}$	-0.16**	-0.17**	-0.08**	-0.05**
$\Delta R\&D_{t-2}$	-0.01	-0.02		
$\Delta Sales_t$	0.44**	0.69**	0.53**	0.68**
$\Delta Sales_{t-1}$	0.15**	0.19**	0.14**	0.04
$\Delta Sales_{t-2}$	0.04**	0.11**		
$\Delta Profit_t$		-0.05		-0.06**
$\Delta Profit_{t-1}$		-0.03		0.11**
$\Delta Profit_{t-2}$		0.03		
$R\&D_{t-1}$	-0.30**	-0.28**	-0.31**	-0.32**
$Sales_{t-1}$	0.23**	0.24**	0.22**	0.27**
Year	-0.001**	-0.001**	-0.001**	-0.001**
Chi-square	2,980.4	2,846.9	3,201.2	3,002.0
p-value	0.000	0.000	0.000	0.000
Observations	3,023	2,834	3,010	2,904
# of Firms	188	174	179	173

Note: Standard errors in parentheses
* p<0.10, ** p<0.05

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