UNIVERSITY OF CALIFORNIA GIANNINI FOUNDATION

UPDATE

Agricultural and Resource Economics

VOL. 9 NO. 5 MAY/JUNE 2006

How Vulnerable is California Agriculture to Higher Energy Prices?

by

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Energy price risk is important to California agriculture. The degree of vulnerability varies substantially across product categories and most of it is indirect, arising from energy costs embodied in farm inputs and product distribution services. These findings indicate that changing energy prices could induce significant structural adjustment across the state's farm sector. Ê

Rising energy prices pose a renewed challenge to U.S. economic security. A long legacy of lower domestic fuel costs has sustained patterns of economic structure and technology adoption that may not be appropriate to future market conditions. This is particularly true in agriculture, where inputs rely on subsidized energy resources and the sales of outputs are highly dependent on energy-intensive distribution services. In farming and elsewhere, significant and sustained increases in energy costs could induce far-reaching adjustments, yet the basis of evidence for understanding our energy-price vulnerability is relatively weak. Here we provide a snapshot of the energy-price dependence of California agriculture, using a new dataset to estimate how energy costs pass through to agricultural and food producer prices. Our results indicate that vulnerability of California farmers is high relative to other sectors, and there is wide variation in the level of energy dependence across the state's diverse portfolio of farm products. Both these findings imply that farm policy needs to better anticipate energy price impacts on agriculture.

Thanks to the energy shock three decades ago, most sectors of the U.S. economy know their direct energy needs relatively well, yet all are woven together in a web of indirect energy use via supply chains. The total amount of energy embodied in upstream inputs and downstream services may significantly exceed that used within an individual industry. The cost of such indirect energy use can still affect farm balance sheets, yet firms may have limited control over this. The goal of this article is to elucidate this network of energy interdependence, with California agriculture as an important, but by no means unique, case study. To the extent that this vulnerability to increased energy prices varies between agricultural activities, pressure will arise for structural adjustment in this sector. To the extent that the vulnerability arises from indirect sources, farms and agro-enterprises must alter their supply chain relationships. Finally, to the extent that own-energy costs are a source of vulnerability, energy security for agricultural producers must come from new commitments to process innovation and technology adoption.

Measuring Energy-Price Vulnerability

To better understand cost-price linkages across the California economy, we use the Social Accounting Matrix (SAM) framework, as applied in the price domain by Roland-Holst and Sancho (1995). The approach used here is a straightforward generalization of multiplier analysis,

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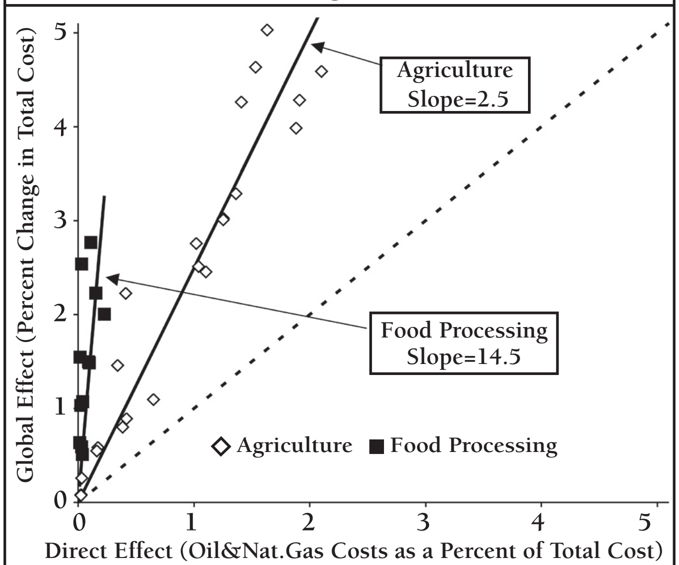
Figure 1. Direct and Global Cost-Price Pass Through: Oil & Gas



assuming for convenience that costs pass through to prices in a linear fashion. Each production activity uses energy in the form of either oil/gas or electricity, with a coefficient that represents its share in total cost of production. Labor, as one factor of production, might represent 20 percent of the direct cost of producing a crop, and thus a 50 percent increase in the cost of labor would result in a 10 percent increase in the direct cost of producing this crop. The SAM approach emphasizes the distinction between the direct and indirect cost effects arising from price changes among factors (e.g. labor) and inputs (energy). The direct effect of energy price increases on the production of cotton arises from direct energy use in production, for example to power processing machinery. The indirect effect can be decomposed into upstream and downstream effects. The upstream effect includes energy-induced cost increases among inputs, such as fertilizers, pesticides, and water (which embodies conveyance costs). The downstream effect represents the indirect cost increase imposed on the sales of cotton by virtue of increased transportation and distribution costs. In assessing the impact of changes in major factors like energy on the economy, the SAM will divide the economy into several sectors, some of which are interdependent. Thus, prices to consumers are influenced at every stage of long supply and value chains, starting with the production of farm inputs, moving through farm production itself, and onward through to downstream transport, processing, marketing, and concluding with the distribution and retailing of finished goods.

To illustrate the approach, consider that producers and households are undertaking an economic activity. Producers pay for raw materials and factors which are combined to generate output; factors make use of household endowments to provide firms with labor and capital services. Households purchase output from producers for their own consumption. The government is an additional sector, to which each group may be liable to pay taxes and import duties. The system has to adjust to taxation in order to be realistic. The system of taxation has several elements. The government collects indirect production taxes from firms, taxes on the use of labor and capital from factors, and indirect consumption taxes and income taxes from households. Thus, each of these activities has an implicit cost or price index, which is linked to the rest of the price indices through the coefficients of the SAM.

To examine cost-price linkages in California agriculture, we use a new and detailed California SAM estimated for the year 2003. This framework can provide good estimates regarding the vulnerability of California agricultural producers to changes in energy prices. Figure 1 summarizes the relation between direct and global (includes direct and indirect) cost-price vulnerabilities in California. The horizontal axis of Figure 1 shows, for selected sectors, the share of total direct cost represented by Oil & Gas (LNG). On the vertical axis is the corresponding global multiplier, incorporating both the direct effect and all indirect cost-price linkages that extend over upstream and downstream supply chains. Because direct effects are included, all the points on these scatter diagrams are above the diagonal. Lastly, a trend line has been added in each case to indicate average ratios of global/direct effects. The slope of this line can be thought of as an average ratio of global to direct effects. We separate agricultural products and food processing, since the latter represent very different technologies and different stakeholders. Table 1 gives the exact product categories and also includes estimates for other sectors of the state economy for comparison.

To illustrate how the figure works, consider the cotton sector. Our estimates suggest that a 50 percent increase in the price of energy fuel will increase the direct cost of producing cotton by one percent because oil is two percent of the direct cost of cotton and, when all linkage effects are taken into account, cotton prices will rise by twice as much (two percent). A two to three percent increase in total cost of producing cotton because of a 50 percent increase in the price of energy

Table 1: Global and Relative Cost-Price Pass Through

Agriculture			Food Processing			Other Sectors		
Activities	Direct	Global	Activities	Direct	Global	Activities	Direct	Global
Cattle	1.6	5.0	Milk	0.1	2.8	AirTransport	5.7	9.7
OtherLivestock	1.5	4.6	Coffee/Tea	0.0	2.5	ChemFertilizer	3.9	7.6
OtherCrops	2.1	4.6	FoodMfg	0.2	2.2	TruckTransport	2.5	5.2
Hay	1.9	4.3	SnackFood	0.2	2.0	PublicTransport	2.8	5.0
AquaCulture	1.4	4.3	Meat	0.0	1.5	WaterTransport	1.4	3.8
Cotton	1.9	4.0	OtherProcFood	0.1	1.5	VehicleTransport	1.3	3.7
Citrus	1.4	3.3	FoodProcess	0.0	1.5	HouseHold	1.0	2.9
Grapes	1.3	3.0	OtherBeverage	0.0	1.1	OtherTransport	1.4	2.9
TreeNuts	1.3	3.0	Wine	0.0	1.0	Labor	0.0	2.8
OtherVegetable	1.0	2.8	PoultryProd	0.0	0.6	Capital	0.0	2.1
Berries	1.0	2.5	Baking	0.0	0.6	Chemical	0.7	2.1
Rice	1.1	2.5	SeaFood	0.0	0.5	WholsalRetlTrade	0.2	1.8
Poultry	0.4	2.2				OtherServices	0.1	1.4
Forest	0.3	1.5				ChemPesticides	0.4	1.1
Fishery	0.6	1.1				OtherMfg	0.1	1.1
OilseedGrain	0.4	0.9				Metal	0.1	0.8
OtherPrimary	0.4	0.8				Electron	0.0	0.7
Floral	0.2	0.6				Vehicle	0.1	0.6
Nursery	0.2	0.6				TextilesApparel	0.1	0.6
Mushroom	0.0	0.1				Machinery	0.1	0.5

Direct = Oil & Natural Gas Costs as a Percent in Total Costs   *Global = Percent Change in Total Cost*

may not seem like a lot, but it must be recalled that this effect goes straight to the farmer's bottom line. Considering the relatively low profit margin in farming (e.g. five percent), the share of profit effect could be much higher (e.g. 20 percent), and this cost increase may tip the balance sheet of a farm from the black to the red.

Returning to the general results, at least three arresting features are immediately apparent in Figure1. First, the impact of energy prices on agriculture is far from uniform. The heterogeneity of cost-price vulnerability across agricultural activities (representing variations in both direct and indirect energy dependence) indicates that rising energy prices will affect different sectors in very different ways. Second, detailed results in Table 1 show that farm-product vulnerability is high relative to other state activities and generally higher (in some cases significantly) than the food sector.

In the rest of the economy, transport service sectors (Table 1) and agro-chemicals are more vulnerable than farming. This is to be expected given their energy intensity, but otherwise it is noteworthy that some farming activities are among the most energy dependent in the economy.

Closer inspection of Table 1 indicates that fully two-thirds of the agricultural products considered are above the median global value (2.2) for the economy as a whole. Third, the slope of estimated global-direct ratios suggest that indirect effects generally exceed direct effects, in both agriculture and food processing. Agriculture's direct cost-price vulnerability is relatively modest, but indirect cost-price effects make many farm activities much more vulnerable to energy prices. The average global/direct ratio for agriculture is 2.5, against 14.5 for food processing.

Components of Energy-Price Vulnerability

Ordering economic activities by energy-cost vulnerability is a simplistic beginning for policies and practices to address this challenge. To respond effectively, policymakers and enterprises need to identify the structural sources of energy-cost risks. In the present context, this can be done using the cost-price multiplier decomposition methods. This approach is relatively technical, yet the intuition is clear. To elucidate the paths of energy dependence, we decompose the agricultural supply chain and search for linkages that carry significant energy costs between economic factors. Rather than publishing elaborate network tables, for the present discussion we provide a few inductive examples.

Cattle is the agricultural activity with the highest overall oil and gas dependency coefficient (Table1), yet it has a modest direct effect coefficient (1.6). However, this sector is heavily dependent on hay and other crops (fodder) and on truck transportation. All these in turn have high global oil and gas coefficients. Hay is dependent on chemical fertilizers, which has a very high global oil and gas coefficient (7.6). Thus, for example, policies that will increase energy efficiency of transportation, or the introduction of nitrogen-fixation technologies to reduce dependency on natural gas in producing fertilizers, will make important indirect contributions to reducing energy-price vulnerability. The results in Figure 1 and Table 1 suggest that we can distinguish among three groups of crops in terms of vulnerability to increased energy prices. Livestock and field crops that produce low value per unit of volume are most vulnerable and have a global coefficient between 4.0 and 5.0. Fruits and vegetables, as well as poultry, produce more value per volume and have coefficients between 2.2 and 3.3, and high-value crops like nursery products and flowers are least vulnerable with global coefficients that are less than 1.0.

Our results do not imply, however, that the cattle and dairy industries will emigrate from California. It needs to be recognized that production technologies do not vary significantly between states in this sense. Thus, savings can be made by producing these products closer to the final market. For example, importation of some dairy products from New Mexico might become less profitable, increasing investment in dairy activities closer to California urban areas. On the other hand, some of the fruits and vegetables that are exported to the East Coast may be vulnerable to substitution by local producers. It is also noteworthy that the growing nursery sector does not seem to be very vulnerable to increases in energy prices.

As indicated in Figure 1, food processing activities have much higher rates of indirect energy-cost exposure. Although direct and total cost-price risk is lower than for most agriculture, indirect exposure represents 98 percent of the total for meat and 96 percent for wine. For meat, the primary source is energy services embodied in livestock inputs, while in wine it is a factor cost pass through from energy in the Consumer Price Index. Other important inputs, such as wine, fruits, distribution, and transport services, also play important roles.

Conclusions

Agriculture faces a variety of important challenges in the new energy era, and our results point to significant vulnerability if energy costs continue their ascent. Direct (own process) energy-price vulnerability will prompt a new search for technology and efficiency measures, while indirect (supply chain) vulnerability will induce substitution and complex market adjustments. These challenges need to be better anticipated by farmers and farm-technology companies, but also by agricultural policymakers. We cannot accurately predict the course of energy prices, but upside risks are ever more apparent and our results indicate California agriculture could face significant challenges.

In the absence of perfect foresight, policymakers can still improve this sector's ability to adapt effectively. In particular, incentives to develop technologies that reduce vulnerability to energy-price changes need to be introduced proactively, before energy shocks impose irreversible adjustment costs on producers. Just as importantly, the capacity of the marketplace to provide solutions should not be undermined by unnecessary barriers to technology introduction and, especially, adoption. California farmers have proven themselves again and again to be among the nation's most technologically savvy. Their capacity as a laboratory of innovation in process efficiency and product quality already sets global standards. With enabling policies in the present context, they can also serve a global agenda for improved food security and more sustainable energy use. We also expect insurance schemes against energy-price vulnerability to emerge for some sectors of agriculture. Without a coherent approach to public and private interest in this area, California agriculture could face disruptive structural adjustments with adverse spillovers to the state economy.

For additional information, the authors recommend:

Roland-Holst, D. and Sancho, F. (1995). "Modeling Prices in a SAM Structure," *The Review of Economics and Statistics*, 77: 361-371, 1995.

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