THE IMPACT OF RISING ENERGY COSTS ON AGRICULTURAL PRODUCTION AND THE REGIONAL ECONOMY: A CASE STUDY OF SASKATCHEWAN

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Introduction

Higher energy prices, particularly those for crude oil, have been a worldwide reality since the creation of the Organization of Petroleum Exporting Countries (OPEC). Since many of the inputs in agriculture are either petroleum products or largely petroleum based, the agricultural industry has faced an unprecedented rise in input costs. Canada is no exception to this trend. By the third quarter of 1981, fertilizer prices had increased to 387.1 percent of their 1971 price level. Similarly, the price of fuel jumped to 279.3 percent of its 1971 level. Trends in the future may be even more dramatic. According to the Alberta Agreement,[2] the price of oil will increase from $21.25 per barrel in October 1981, to $57.75 by October 1986--an increase of 172 percent. For Saskatchewan, primarily because of the predominance of grains in the total agricultural production,[3] rising energy costs appear to be a threat to the future viability of the industry.

Energy Use in Agriculture

In 1978, the Canadian food system accounted for 15 percent of total energy use in Canada (Bray). Of that 15 percent, the production of farm commodities consumed only 18 percent. That energy is used directly as well as indirectly. Direct energy use is associated with fuel used for propulsion in machinery. Indirect energy use includes energy embodied in fertilizer, chemicals, buildings, and machinery. It is estimated that energy consumed through fuel, lubricants, and fertilizer constitutes roughly 82 percent of the total energy input in the farm production sector.

Rising Energy Costs and Effects on Agriculture

Grains and oilseeds consume more direct energy than livestock.[4] Carter and Youde argued that for U.S. agriculture in the 1970s, energy consumption is more related to price than supply.[5] They further argued that these price effects come from both direct price increases (increases in energy based based farm inputs) and indirect price increases (the impact of rising energy prices on the general price level).

The effects of higher prices of energy based farm inputs are felt by the agricultural industry in several ways. In the short run, an increase in farm input prices decreases net farm income (through a cost-price squeeze).[6] In subsequent periods, farmers will fertilize at lower levels and will search for other means of reducing the use of energy based inputs. Increases in the price of energy based inputs are also felt indirectly through increased transport costs, and, unless international prices increase, this translates into lower farmgate prices. The combined effect of changes in production and marketing costs is to change the competitive position of each region in producing crops and livestock.[7] As energy prices rise, agriculture undergoes adjustments through conservation measures, adoption of different production techniques (particularly in response to high irrigation costs), land use conflicts (particularly with energy related land use such as coal mining),[8] and, eventually, growing crops to produce energy within the farm sector.

This study is limited to the effects of direct and embodied energy price increases on the production sector. Since agriculture is an important contributor

to the regional economy,[9] any changes in its purchasing pattern will have an impact upon the output of other industries, and thereby upon the economic growth of the region.

Objectives and Scope of the Study

The potential vulnerability of food production to energy price increases raises two significant questions. First, what adjustments can be anticipated in Saskatchewan crop and livestock production activities and farm incomes as a result of increasing energy prices? Second, what implications do these changes in production activities have for regional development? This study was designed to answer these questions for Saskatchewan.

Saskatchewan is located in the heart of the crop production region of Canada. Since Canada is one of the major exporters of grains and oilseeds in the world, and since Saskatchewan contributes towards this export trade to a major extent, the results of the study of Saskatchewan agriculture under higher energy prices should have implications for Canada as a whole.

The study of production patterns was based on 1979 production costs, whereas the assessment of regional impacts was based upon a transaction matrix adjusted to reflect 1978 levels.

Model and Data

To meet the objectives of this study, a two part analysis was carried out. In part one, a quadratic programming (QP) model was developed to select the optimum mix of production (crop and livestock) activities under a set of demand relationships facing Saskatchewan producers. Results from this part were, in part two, fed into an input-output model developed by Johnson and Kulshreshtha. The QP model was designed on lines similar to that of Beaton, but with one major difference--the supply sector was represented by a number of activities for varying levels of fertilizer on crops grown on summerfallow as well as stubble cropping. It was hypothesized that as energy costs rise the profit maximizing farmer would make adjustments in (1) volume of crop produced, (2) crops grown on summerfallow versus stubble, (3) level of fertilizer, and (4) mixture of crops grown. The objective function in QP, however, is not profit maximization. The substitution of a price dependent product demand function and factor supply schedules transforms the objective function into a measure of consumers' plus producers' surplus, alternatively termed net social benefit. The objective function for the model is on lines suggested by Takayama and Judge, and is not presented here in order to conserve space.

The QP model included five major crops--wheat, barley, oats, flaxseed, and rapeseed--along with cattle and pig feeding. For wheat, barley, flaxseed, and rapeseed, separate demand functions were included for exports and domestic use. Saskatchewan was divided into three regions based on soil type. For each soil type, yield functions and production costs were estimated for representative farms under alternative levels of fertilizer application--both N_20 and P_20_5.[10] The production activities were constrained only by the availability of land of a given soil type. The cost of production included, in addition to fertilizer cost, the cost of fuel, fixed and variable capital costs, and the cost of labour. The feeding of cattle and pigs included both wheat and barley rations. The cost of feed was excluded since its production costs were taken into account. Other costs included fuel, labour, and capital costs. The solution of the QP was obtained using the MINOS computer program.[11]

For the purposes of this study, it was assumed that the price of energy (which is to include the price of fertilizer and fuel) increases by 50 percent, 100 percent, and 300 percent. These costs are well within the realms of possibilities based on predictions of oil prices.[12]

The second part of the study employed a rectangular input-output model of the Saskatchewan economy, with the agricultural sector exogenous.[13] Treating agriculture exogenously makes the estimation of the effects of changes in the agricultural sector on the rest of the economy more consistent. The transaction matrix has a total of 80 commodities and 59 industries. Although the basis for the industrial coefficients was 1974, the household and agricultural sectors were updated to reflect 1978 levels. Results were obtained for the benchmark solution and for three energy price increase scenarios--50 percent, 100 percent, and 300 percent.

Empirical Results

Impact on Farm Production Sector

The impacts of increased energy prices on Saskatchewan agriculture were as postulated. In general, the demand (use) for energy based inputs decreased, net social payoff declined, and producers' surplus decreased, resulting from a decreased level of production, prices, or both. These are described in detail in the following sections.

Production Mix and Prices

With a moderate (50 percent) increase in energy cost, grain and livestock activities were not altered to any large extent. In most cases, the changes were within 2 or 3 percent of the benchmark solution. With a more dramatic increase in the energy price (300 percent), however, changes in production levels were more significant. The largest decrease was noticed in the production of coarse grains (barley and oats), and their export levels. Livestock activities were also affected, as pig and cattle activities decreased by 6 and 8 percent respectively. These decreases are also consistent on a priori grounds, since as feedgrains become more expensive, the supply function for these products should shift to the left.

The prices for barley and livestock products increased in each scenario, whereas for wheat and rapeseed a positive change in price was observed only for the largest increase in energy costs. These results can perhaps best be explained in terms of differences in demand elasticities and responsiveness to nitrogen fertilizer. The total producers' surplus declined by 4.3 percent under a 50-percent increase in energy cost, and by 18.7 percent under a 300-percent increase.

Energy Input Expenditures

Although the quantity of fertilizer purchased falls as energy costs increase, the monetary expenditures increase to 298 percent of the benchmark solution levels. As a result, the share of fertilizer and fuel in total expenditures increased from 12.9 percent in the benchmark run to 28.8 percent in the 300-percent energy increase scenario.

Impact on the Regional Economy

Since the value of agricultural production does not rise in proportion to energy input cost, the income of the household sector is reduced substantially. As the agricultural households change their purchasing patterns, a different level of output is generated by other industries. As increases in energy prices are experienced, the decline in the regional activity becomes more noticeable. With a 50-percent increase, the loss is about $265 million in nonagricultural output, which increases to $1,335 million under a 300-percent increase in energy cost.

Gains are, however, recorded in the output of sectors such as crude mineral oil, petroleum refining, and in finance and insurance. Most other sectors register a decline. In particular, declines are registered in agricultural processing, farm machinery, and wholesale and retail trade sectors.

Summary and Implications of the Results

This study was undertaken to determine the effects of energy price increases on the agricultural industry in Saskatchewan. Because of its scope, it is necessarily a partial analysis. The study assumes, first, that energy supplies are adequate to meet the buyer demands. Secondly, the study assumes that the prices of nonenergy based commodities are constant. Finally, the analysis of regional impacts considers only the effects of changes in agriculture, ignoring the impact of changes in industries other than agriculture.

The results of this study suggest that, in the short run, increases in energy based input prices in the agricultural and other (especially transport) sectors will have a substantial influence upon application of energy based inputs, their share of total production expenditures, and upon producers' surplus (or income of the household sector). The decline in the income of the household sector, then, has a virtually devastating effect on the remaining sectors.

One of the major implications of results here can be in terms of the Green Revolution technology. Producers using this technology would feel a substantial reduction in their incomes and purchasing power. Unless domestic policies are designed to augment these effects, serious income transfer will take place from energy consuming to energy producing regions.

In terms of the role played by Canada in international markets, results indicate that this role will continue, except under very dramatic increases. The target of increased international trade set by the Canadian Wheat board will be difficult to attain, particularly under a threefold increase in energy prices. Farmers facing these dramatic increases in energy costs will look for methods of conserving energy on farms. A number of such methods have been identified: zero tillage, solar drying of grain, purchase of more energy efficient machinery, construction of energy efficient buildings for livestock, and soil management such as more organic farming and less summerfallowing. The use of crops or residues to produce energy on farms also remains a potentially viable alternative provided that commodity prices are more favourable to this type of processing.

Notes

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[2]Signed between the Province of Alberta and the Government of Canada.

[3]During 1980, grain and its products constituted 77 percent of the total cash receipts from farm products in the region.

[4]At least Yanagida and Conway have argued that they do. But since livestock production uses energy through products of crop origin, that assertion should be interpreted with caution.

[5]The implicit assumption here is that that statement applies with equal force to Canada.

[6]Holland (p. 974) has argued that energy will be allowed to continue to rise in price, while simultaneously the price of wage goods will be held down to the lowest degree consistent with a cheap food policy.

[7]The issue of competitive position has been discussed by Casavant and Whittlesey, and Dhillon (p. 78). However, one should recognize that a host of

other factors plays an important role in determining the location of an industry. Dvoskin, Heady, and English; and Debertin and Pagoulatos have addressed those issues.

[8]Murdock and Leistritz (pp. 155-164) have discussed those effects.

[9]Agriculture in Saskatchewan during 1979 contributed 40 percent of the total value added by the goods producing industries.

[10]For each soil zone, there were 16 combinations of N_20 and P_20_5 for summerfallow, and 20 combinations for stubble cropping.

[11]For details, see Murtagh and Saunders.

[12]Miranowski (p. 6) has argued that a doubling of energy prices is not unexpected, and a fivefold increase is typically the maximum predicted.

[13]For the reasons for treating agriculture exogenously, see Johnson and Kulshreshtha (p. 15).

References

Beaton, E. J., "Quadratic Programming Model of Saskatchewan Agriculture," M.Sc. thesis, Department of Agricultural Economics, University of Saskatchewan, 1980.

Bray, N., Consultants, Inc., *Energy and Saskatchewan Agriculture,* study prepared for Saskatchewan Federation of Agriculture, 1980.

Carter, H. O. and Youde, J. G., "Some Impacts of the Changing Energy Situation on U.S. Agriculture," *American Journal of Agricultural Economics,* Vol. 56, No. 4, Nov. 1974.

Casavant, K. and Whittlesey, N. K., "Increasing Energy Prices: The Impact on Transportation Costs and the Regional Location of Agricultural Production," paper presented at the Western Agricultural Economics Association meeting, July 1974.

Debertin, D. L. and Pagoulatos, A., "Energy Problems and Alternatives: Implications for the South," *Southern Journal of Agricultural Economics,* Vol. 12, No. 1, July 1980.

Dhillon, P. S., "Impact of Increased Energy Costs on Greenhouse Tomato Production," *Journal of the Northeastern Agricultural Economics Council,* Vol. X, No. 2, Oct. 1981.

Dvoskin, D., Heady, E. O., and English, B. C., *Energy Use in U.S. Agriculture: An Evaluation of National and Regional Impacts from Alternative Energy Policies,* Report No. 78, Center for Agricultural and Rural Development, Iowa State University, March 1978.

Holland, D., "Energy and the Structure of Agriculture: A Political Economic Analysis," *American Journal of Agricultural Economics,* Vol. 62, No. 2, Dec. 1980.

Johnson, T. G. and Kulshreshtha, S. N., *Nature of Intersectoral Relations of Saskatchewan Agriculture: An Input-Output Analysis,* Econ. TB 81-06, Department of Agricultural Economics, University of Saskatchewan, Nov. 1981.

Miranowski, J. A., "Effects of Energy Price Rises, Energy Constraints, and Energy Minimization on Crop and Livestock Production Activities," *North Central Journal of Agricultural Economics,* Vol. 1, No. 1, Jan. 1979.

Murdock, S. H. and Leistritz, F. L., *Energy Development in the Western United States,* Praeger, New York, 1979.

Murtagh, B. A., and Saunders, M. A., *MINOS/Augmented Users Manual,* Technical Report No. 80-14, Department of Operations Research, Stanford University, 1980.

Takayama, T. and Judge, G. G., *Spatial and Temporal Price and Allocation Model,* North-Holland Publishing Co., Amsterdam, 1971.

Yanagida, J. F. and Conway, R. K., "The Effect of Energy Price Increases on the U.S. Livestock Sectors," *Canadian Journal of Agricultural Economics,* Vol. 29, No. 3, Nov. 1981.

OPENER'S REMARKS—H. L. Chawla

The facts highlighted in Tyner and Hrabovszky's paper are highly useful for analysis of the energy question. However, one aspect of energy production is not mentioned. Scientists have established the possibility of producing methanol from materials like cow manure, farm residues, and water hyacinths, etc. Countries like India are giving close attention to setting up biogas plants. Would it not be desirable to stress this source of energy generation, particularly for non-oil-producing developing countries?

Equity is a genuine concern of mankind. References have been made to equity aspects of using agricultural production for generating energy. However, when FAO is putting so much stress on problems of world hunger and when 800 million people are stated to be undernourished, how does one reconcile equity for farmers growing energy crops in certain regions and food security for the poor in the importing developing countries?

Adams referred to the need to generate locally produced food and energy supply self-sufficiency systems to counteract rising energy prices. However, it is widely known that in order to make the production of ethanol (gasohol) economical, the Government of Brazil has levied a duty of about 60 percent or more on oil. Has it not already raised transport costs, as well as costs of operating tractors and other farm machinery and of food as well? What is the tradeoff between the benefits accruing from the present policy and the exorbitant burdens on the people it is causing? Further, how does one compare (on an equity basis) the benefits to sugarcane growers in one region with hardships in other regions?

Kulshreshtha et al. reveal that effects of energy price increases on production, exports, and prices in Saskatchewan would not be seriously disturbing. The position appears too good to be true. In countries like India where irrigated areas are used intensively for raising two or three crops a year, increases of 100 percent or more in input prices can create serious difficulties for production.

RAPPORTEUR'S REPORT—Charles L. Beer

The question was raised of what price of sugarcane was used in calculating the cost of alcohol produced from biomass.

Concern was expressed that energy cost was a relatively small proportion of total production costs, so that the estimates presented may be misleading. Some suggested that the use of U.S. energy consumption figures may be misleading since farmers in most European and developing countries use less energy in agricultural production than do U.S. farmers.

The assumptions regarding increasing energy prices were questioned in light of the current trends in energy supplies and prices. There was also concern about the assumptions that instantaneous changes in energy prices and producers' reaction to them may be unrealistic.

The increased efficiency of the fertilizer industry in converting energy to fertilizer was apparently ignored in the model. Fertilizer prices may not rise at the same rate as energy prices.

It was asked whether Brazil had considered other alternatives, such as more public transport, before deciding to proceed with their alcohol from biomass programme. Given the decision to proceed with the programme, what decisions were made on the equity question regarding the value of land affected by this programme? Would production of biomass be on current cropland or would it be produced on the frontier?

The shortage of fuelwood for use as energy in developing areas was of concern; improved forest management practices could improve the availability of the energy source in many developing countries.

In reply, the authors stated that energy cost is still a relatively small part of total agricultural production costs. Also, changes in production practices may well offset increasing energy costs. Special emphasis on energy conservation was discussed briefly.

Some work is being done on alternative sources of energy directed toward on-farm energy production systems; for example, use of vegetable oil as an energy source. There are also real opportunities for increased energy conservation efforts in many areas of agricultural production.

The increased energy price estimates used in the Canadian model are realistic, based upon past experience. However, there are differences between positive and normative models, which might yield different results.

The papers may have been overly pessimistic in predicted results as they did not adequately treat potential new developments in crop varieties and in production practices which might substantially reduce the effects of energy supply and price.

Participants in the discussion included Charles Capstick, R. J. Dancey, Victor Palma-Valderrama, Michel Petit, J. S. Sarma (Session Chairman), D. S. Tyasi, and Adolf Weber.