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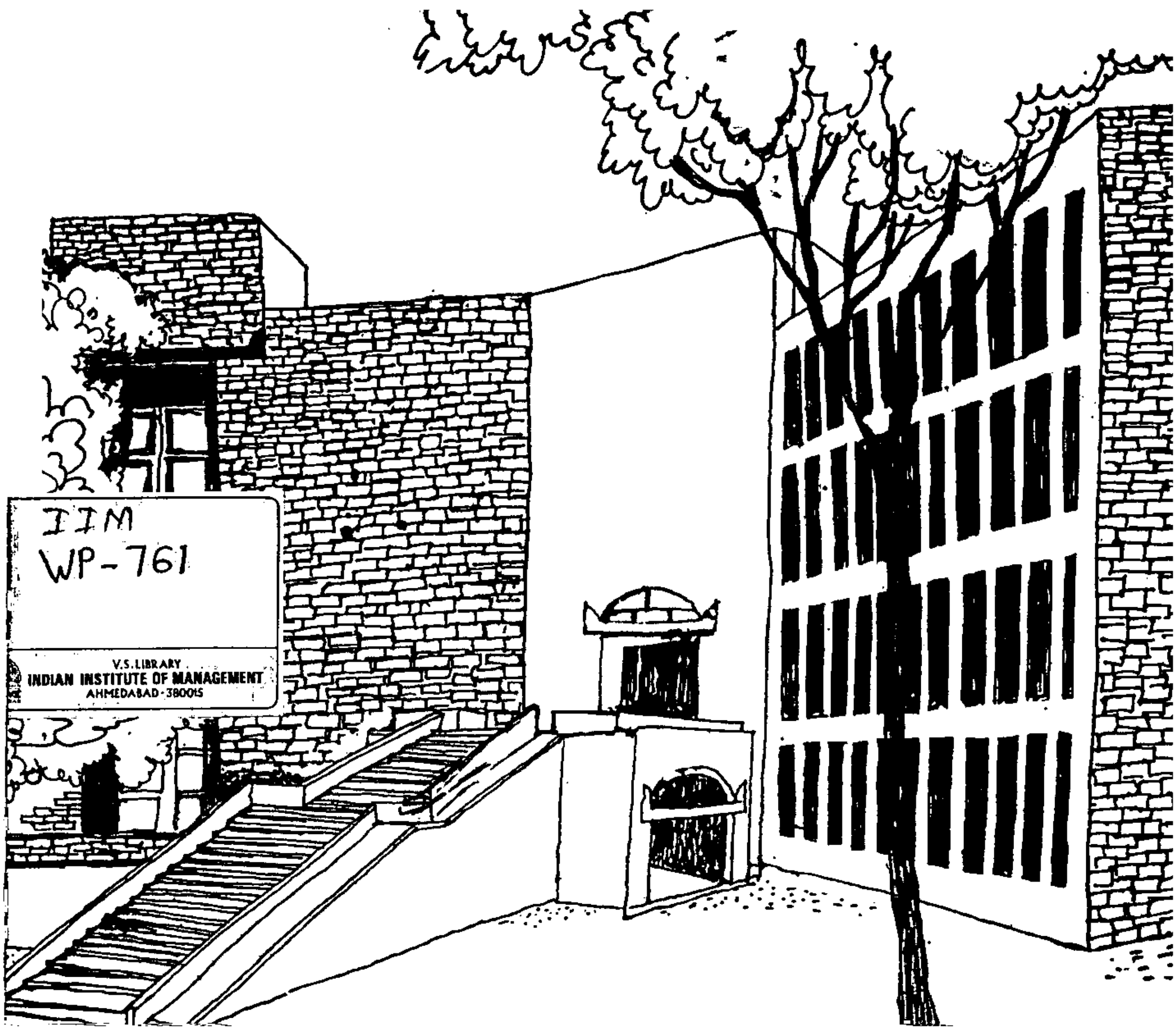

THE MEDIUM TO LONG - TERM IMPACTS OF FALLING ENERGY PRICES AND WELFARE CHANGES IN AGRICULTURE SECTOR

By

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The Medium- to Long-Term Impacts of Falling Energy Prices and Welfare Changes: A Case of Saskatchewan Agriculture

Since the first energy price shock of 1973 a number of studies have reported the impacts of rising energy prices on agriculture sector (see for a review Tewari, 1988). However, in recent years the energy prices in the international market have been falling and energy price trend seems reversed. Falling energy prices in the international market are followed by falling prices of energy-related inputs (fuel and fertilizers) to producers. Impacts of falling energy prices on agriculture are not well studied, partly because falling energy prices are a recent phenomenon and people still believe that long-run trend of energy price is of increasing type, and partly because impacts may not be felt so early because of the adjustment lags involved.

Casually one tends to believe that falling energy prices are good to producers but this notion may be falsified in a medium- to long-term situation when the impact of falling energy prices on the product price level is also taken into account. This, however, is an empirical question. In this paper, an attempt is made to estimate the impacts of falling energy prices on producers and consumers of Saskatchewan agriculture sector with the presumption that a falling energy price trend would continue in the future. The material of this paper is arranged as follows: conceptual model is developed in the next section, followed by the description of the empirical model, data, and method of estimation. Falling energy price and welfare impacts are discussed thereafter followed by conclusions and implications.

Conceptual Model

A conceptual model for estimating impacts of falling energy prices on agriculture sector is shown in Figure 1. Assume that agriculture sector is characterized by perfectly competitive conditions in input as well as in output markets. Suppose the marginal value product of energy inputs (MVPe = MPPe.P) represents the aggregate energy demand from agriculture sector as shown in Figure 1(a). Given exogenous energy price, p, the q amount of energy is consumed when the product price level is fixed at P which is determined by the interaction of aggregate demand, DD', and aggregate supply, SS', schedules of farm produce (Figure 1b). Now assume that price of energy inputs to producers fall from p to p' exogenously. Producers respond to this by increasing energy use from q to q'. But, increased energy consumption results into increased production or supply of farm produce in the market under <u>ceteris paribus</u> condition. Or, in other words, it results into a shift in aggregate product supply schedule, SS', to S"S"', causing a decline in product price level from P to P'. Producers then adjust to the decreased product price level and the MVPe shifts downward as shown in Figure (1a). The new energy use level is now q" instead of q'.

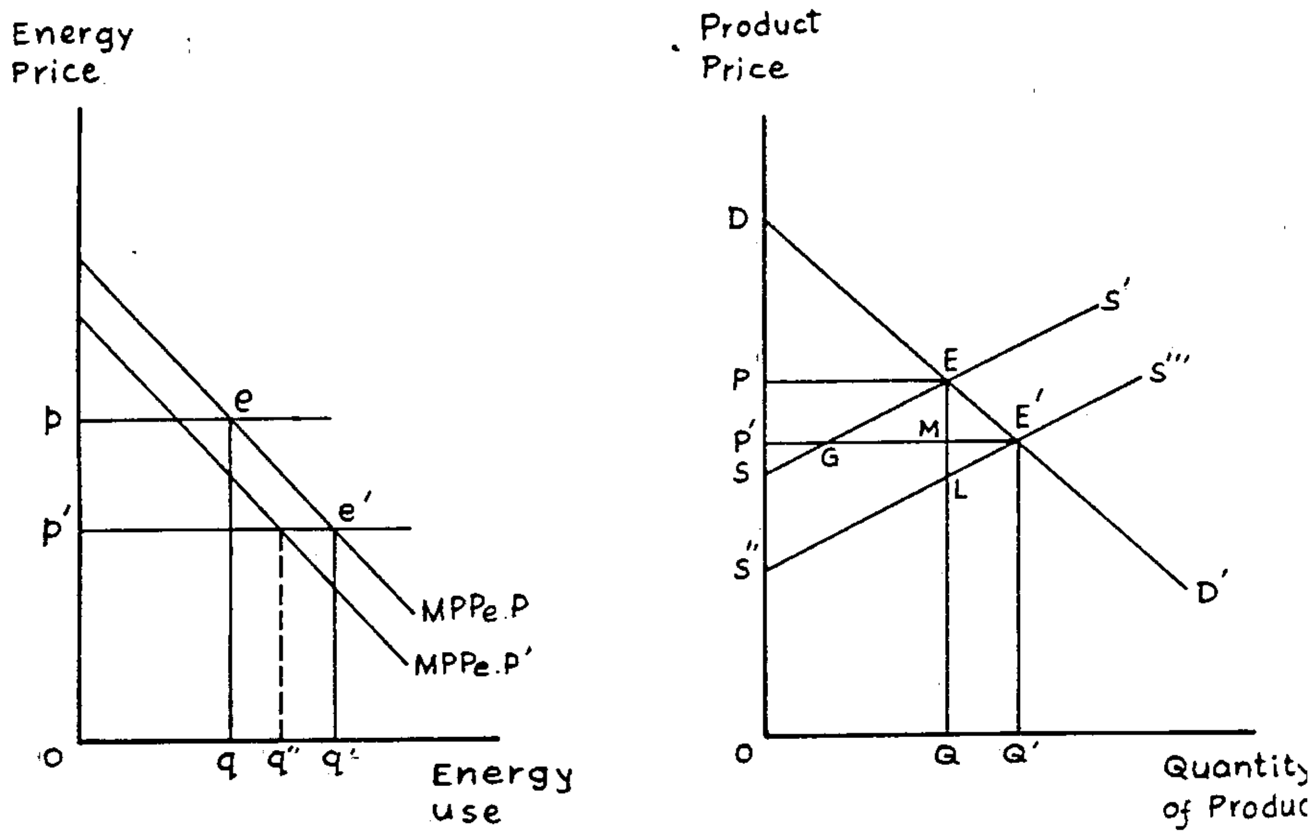

Figure 1. The Conceptual Model

Thus the aggregate consumption of energy on farms increases finally from q to q", not from q to q

In the product market, the new price and quantity produced are respectively P′ and Q′. Note that consumers of farm produce receive an increase in consumer surplus equal to area PP′E′E, and producers gain area (SS"E′G−PP′GE) if area SS"E′G is greater than area PP′GE and lose if area SS"E′G is less than area PP′GE (Figure 1b). In terms of revenue the gain or loss to producers is equal to area (MQQ′E′ − PP′ME) respectively if MQQ′E is greater or less than the area PP′ME.

So far only the supply side responses to falling energy prices are taken into consideration, and demand side responses are ignored. Thus model is of partial equilibrium nature. To make the model of general equilibrium nature the demand side responses have to be considered also. That is, the aggregate product demand schedule can shift due to income effects resulting from falling energy prices. As energy prices fall, consumers now have to pay less for their energy bills particularly fuel and it may release extra consumer dollars to be spent on food from domestic market and importing countries.

Countries which are net energy exporter cum net importer of agricultural products such as middle income oil economies may experience declining income and hence may reduce their imports of agricultural produce. This may shift the ~~export~~ aggregate demand towards left to the DD′. In this case agricultural produce exporting region will not be able to sell Q′ but actual quantities sold will be less than Q′ and market price will be more than P′. On the other hand, countries, which are net importer of both agricultural products and energy, may find enough foreign exchange at their disposal to buy grains or oilseeds from the international market. In this case the positive income effect on the aggregate demand can shift the DD′ towards right, i.e., agricultural produce exporting region will be able to sell more than Q. Domestic consumers may also contribute to the shift in demand schedule depending upon the income elasticities of food.

The over-all net effect on the aggregate demand will however depend upon which income effect, positive or negative, dominates finally from both domestic and foreign consumers. Note that under partial equilibrium framework a new point on fixed demand schedule is to be determined as energy prices fall, while in the case of general equilibrium framework both point on the demand schedule and the position of demand schedule are to be determined.

Empirical Model, Data, and Method of Estimation

The aforementioned conceptual model of agriculture sector was applied to the Saskatchewan agriculture in a partial equilibrium framework. That is, the net income effect on the aggregate product demand from the international market is assumed to be nil. This may be a reasonable assumption because the income elasticities of food are generally inelastic.[1] Shifts in the aggregate demand would therefore may not be very large enough as to endogenize them. Most times in economic analysis a partial equilibrium framework is preferred over the general equilibrium because of empirical tractability, cost effectiveness, and powerful analytical results of the former (Hertel).

A sectoral price endogenous quadratic programming model of agriculture sector, which has been developed by Tewari (1986), was applied to estimate the impacts of falling energy prices. This model incorporates all the essential features of Saskatchewan agriculture. The objective of model is to maximize the net social benefits--the sum of consumers' and producers' surpluses--subject to resource availability constraints.

Both sectoral product demand and sectoral resource supply schedules are incorporated in the objective function. The other important part of the model is the technology matrix--the source of supply in the model--which contains information about technical coefficients. The sectoral product supply (which is the sectoral marginal cost curve) and sectoral resource or input demand (which is the sectoral marginal value product schedule) are endogenously generated from the technology matrix. The to and fro flow of information between objective function and technology matrix helps find the equilibrium. The objective function is the major driving force in determining what to produce and how much to produce based upon the endogenously determined opportunity costs of resources and products.

There are two blocks--crop and livestock--in the model. The crop production block includes three production subregions based on soil characteristics: brown, dark brown, and black soil zones. The model includes five crop (wheat, oats, barley, flaxseed, and rapeseed) and three livestock products (slaughter steers, feeder steers, and market hogs). All of these enterprises contribute about 83 percent of total farm cash receipts in Saskatchewan. Depending upon the historical existence of markets of these products in Canada and outside Canada, two types of demand--domestic and export--are specified. Domestic market comprised Canada including Saskatchewan, while export market was defined as the regions outside Canada. For oats and livestock products only domestic demand was included as export markets for these are nonexistent. All other products have both domestic and export demand schedules. Feed demand for barley is endogenized through livestock production in the model. Demand for feed wheat is treated as exogenous to the model.

The product demand schedules were constructed from the average quantities and prices of various products in the base period (1979-83) and elasticity estimates obtained from past studies (see Hazell and Norton, p.117 for the method of construction of demand schedule). Demand elasticities computed from various sources are given in Appendix A.

On the supply side, supply schedules of nitrogen, phosphorous, fuel, total labor (hired plus family), capital and total cultivated land (which includes land in crop and summerfallow both) are incorporated in the objective function. All resource supply schedules except land are treated as perfectly elastic. Land supply is assumed perfectly inelastic or fixed since available land acreage is fixed for each soil zone and opportunity cost of land outside agriculture is assumed to be zero.

The perfectly elastic supply schedules for fertilizers, fuel, and capital are justified on following grounds; (1) Saskatchewan's share in the North American market of these inputs is relatively small; (2) Saskatchewan as a regional economy is more open to resource mobility than Canadian or North American market as a whole; (3) there may be extra production capacity in these resource industries (for example, Blue Johnson and associates estimate that there is unused capacity in the North American fertilizer industry).

The assumption of perfectly elastic supplies of labor is difficult to defend because labor is a relatively scarce resource in North America. Although elasticity estimates of labor supply for Canada are reported to be inelastic (Abott and Ashenfelter, Rea), this cannot be generalized for a region or a sector in the economy. Econometric estimates of labor supply schedules for Saskatchewan agriculture are virtually non-existent, and those existed are not necessarily reliable. For example, Lopez and MacMillan estimated the hired labor supply elasticities of 0.76 and -1.35 respectively for the Canadian and Praires agriculture. A negatively sloped labor supply schedule was felt to be inappropriate in agriculture sector. And, since hired labor is a very small proportion (less than one percent) of total labor supply on Saskatchewan farms as revealed by FARMLAB data (Tewari, 1986, p.105), estimates of total farm labor or family labor supply would have been more appropriate. Bearing all these considerations in the mind, a perfectly elastic labor supply in a medium to long-term period situation was thus justified.

The technology matrix contained two blocks-crop and livestock--as mentioned earlier. In each soil zone in the crop production block, five major crops can be grown on summerfallow and/or stubble land. The summerfallowing practice implies a 50:50 rotation of summerfallow:crop. For each crop in each soil zone, yield response to fertilizers are incorporated in piecewise linear fashion for stubble and summerfallow cropping. The crop production block is linked directly with the livestock block through barley transfer row. That is, barley from crop production block serves as an input to beef cattle and hog raising activities, and thus the barley feed demand is endogenized. A prototype which shows the general structure of the model is shown in Table 1

(Insert Table 1)

The prototype model shows only one soil zone (brown) in the crop production block with two crops (wheat and barley). For each crop there are two types of production; crop on summerfallow and crop on stubble, and for each rotation (summerfallow or stubble) there are only four combinations of fertilizers shown here. However, in the empirical model all the possible combinations of nitrogen and phospherous were included. The model has the four major components; one, the product demand schedule for five products; two, resource supply schedules; three, technology matrix containing fertilizer application rates for two crops; four, total land constraint for the brown soil zone.

Data for building this model were constructed from various sources: yield response functions were obtained from the Department of Soil Science, University of Saskatchewan; various cost budgets were based upon FARMLAB program at the University Saskatchewan. Other data were obtained from various published sources and primarily from Saskatchewan Agriculture.

The model was solved and key variables of the model were validated against the actual levels of these in the base period of 1979/80 to 83/84. These key variables included: demand in domestic and international markets, farm gate prices; major supply characteristics at the sector as well as at production region level such as crop acreages, yield, production, land summerfallowed; and, gross farm income, net returns over energy inputs among others. The simulated or solved values were reasonably close to the actual values for most of the key endogenous variables. Validation results are not being given here to conserve space. For more details on validation results, one can see Tewari (1986 pp.132-150).

Analysis was carried out in a comparative statics manner. That is, the validated model served as a benchmark or control for comparison with the low energy price scenario. Energy prices were exogenously reduced and the model was resimulated and these results were compared with the benchmark results. The differences between the two explained the impacts of falling energy prices.

For low energy price scenario, base energy prices were lowered by 25 percent from the benchmark level. However prices of fertilizers were not lowered in the same proportion. But, a price possibility frontier between fertilizer price and natural gas price was estimated, and this relationship was used to project the decrease in fertilizer price resulting from a 25 percent decrease in natural gas price. Energy prices for benchmark and low energy price scenario are given in Table 2.

(Insert Table 2 here)

Falling Energy Price Impacts and Welfare gains and Losses

Impacts of falling energy prices on product disposition and supply, and product prices are presented respectively in Table 3 and 4. Note that quantity demanded (which also equals to quantity supplied or produced under the perfectly competitive market assumption in the model) increases; the percent increase from respective benchmark values varies from 0.30 percent for feeder steers to about 14 percent for domestic barley demand. With a 25 percent decrease in energy prices the wheat production is expected to increase by about 2.80 percent from the benchmark level of 448,140 thousand bushels in the province. The decreases in product prices range from 1.5 percent for feeder steers to 7.2 percent for oats. The differential in decreases (increases) in product prices (product demands) can be explained in terms of differential in demand elasticities and nature of aggregate supply functions generated for each product from the technology matrix.

(insert Tables 3 and 4)

As a result of falling product prices consumers are decidedly better off as evidenced by increase in consumers' surplus (Table 5). With a 25 percent fall in energy prices consumers of Saskatchewan Agriculture would enjoy an extra surplus of CDN$183 million from the benchmark level, of which CDN$ 138 and 45 millions would be enjoyed respectively by foreign and domestic Canadian consumers. Relative consumer surplus gains are little higher for foreign consumers compared with their Canadian counterpart as shown by percent increases in consumer surplus in Table 5.

Producers' welfare is approximated through changes in gross farm income and net returns over energy inputs with and without the energy price fall. The gross farm income and net returns over energy inputs would decrease by CDN$ 67 million and CDN$ 23 million respectively (Table 5). This means the increase in revenue by the increase in sales of farm produce are more than offset by the decrease in product price levels under falling energy price regime.

(insert Table 5)

The decline in gross farm income and net returns can be explained in terms of magnitude of demand elasticities. Most demand elasticities are inelastic as shown in the Appendix A. The downward shift in aggregate supply schedule is thus expected to decrease the total revenue from extra sales caused by falling energy prices. This is because over the inelastic segment of aggregate demand one percent decrease in product price will cause demand to increase by less than one percent. Finally this entails a reduction in incomes in agriculture sector.

Although Saskatchewan producers in aggregate would experience a decrease in incomes under falling energy price regime, producers in three different soil zones may not be affected equally because of production transfers caused by falling energy prices. As wheat production being a major activity in Saskatchewan agriculture (contributing about 51 percent of the total farm income), transfer of wheat production from other soil zones to the black soil zone would indicate that producers of the latter soil zone would be relatively less affected under falling energy price regime (Table 6).

As obvious from Table 6 that wheat production in the dark brown soil zone declined by about 70 percent from the benchmark level, and increased by about more than 100 percent in the black soil zone. Although such large magnitudes of production transfer may not be realized in real-world situations because of quota constraints by the Canadian Wheat Board (CWB), political pressure by producers in the more affected regions to keep the farming alive and other social factors, the sectoral programming model results simply indicated that what possibly can happen under perfectly competitive conditions with no impediments on production system.

(insert Table 6)

Note again that model selected more wheat on stubble cropping under low energy price ~~scenand~~ scenario (Table 6). Wheat on summerfallow lands in dark brown and black soil zones under benchmark shifted to black stubble lands as energy prices were lowered. This would suggest falling energy prices would promot stubble cropping in the province, and particularly in black soi zone where enough moisture is available.

Since the Canadian production system does not provide price support to producers, falling energy prices would be directly translated into lower farm incomes. However, in the U. S. agriculture in which income support to producers is provided in terms of deficiency payments, falling energy prices are expected to increase this burden on the U.S. government. This is illustrated in Figure 2.

Suppose the target, market, and loan rate prices for the U.S. agriculture are, respectively, Pt, Pm, Pl. Then, total deficiency payments before the energy price fall can be represented by area (Pt Pm a b). After the adjustment to energy price fall, the supply schedule shifts to the right so that new

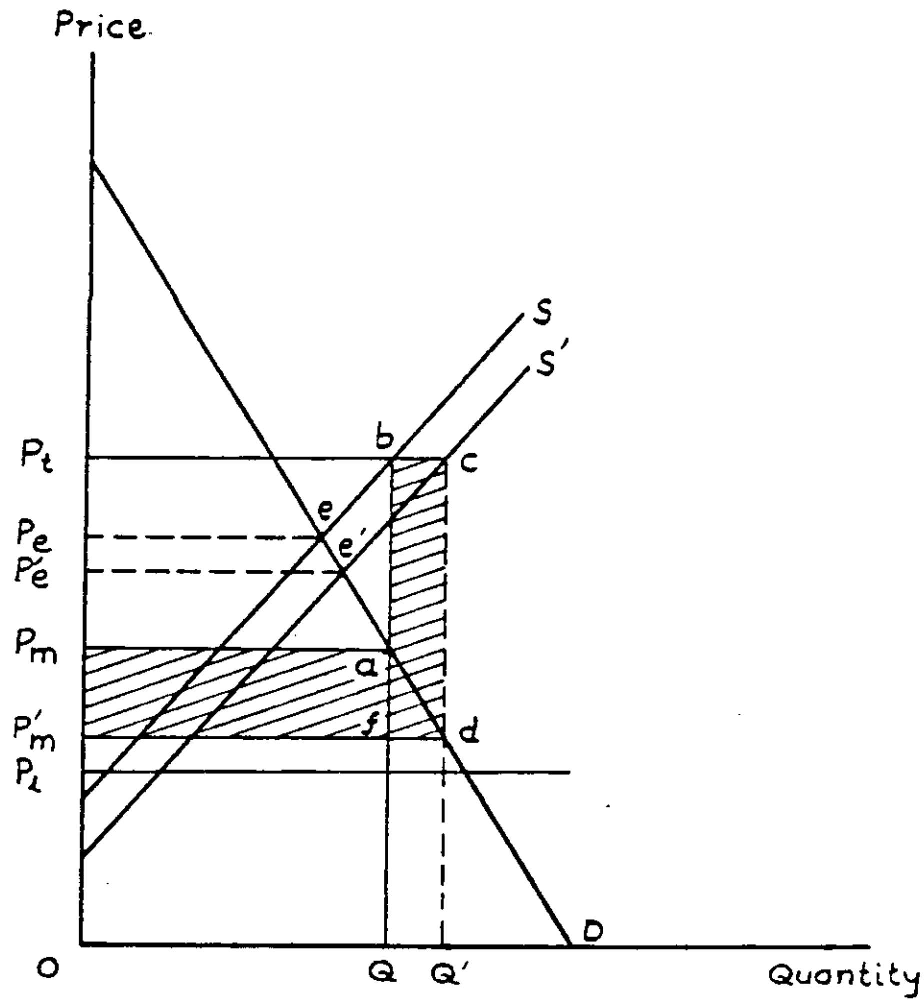

Figure 2. Rising Deficiency Payments
Under Falling Energy Prices, U.S.
Agriculture.

mararket price is Pm'. The total deficiency payments now amounts to equal to area (Pt Pm' d c), and net increase in the deficiency payments is equal to the shaded area (Pm Pm' d c b a).

Any futher pressure to increase the farm income by producers lobby groups on the government via raising support price (which is determined politically) will further add to the burden of deficiency payments. As the U.S. agriculture would be isolated from the outside through protective policies, the net trade elasticities are expected to become more inelastic (Bredahl, Meyers, and Collins). This means that decline in market price would be larger and deficiency payments will be bigger for the same level of shift in supply schedule caused by falling energy prices.

Conclusions, Implications, and Further Work

It is generally perceived that falling energy prices would reduce producers' burden and increase their incomes. This perception is true only in a short run situation when product prices remain unchanged. As soon as time of adjustment is lengthened product prices fall and quantities demanded increase as a result of the rightward shift in aggregate supply schedule caused by falling energy prices. The gross or net returns can increase or decrease depending upon the gains through increased demand and losses through decreased price level. This is therefore an empirical question. For Saskatchewan agriculture, we found that producers will be worse off under falling energy price regime as they would experience declining net returns. However, consumers would be decidedly better off.

Although Saskatchewan agriculture sector income will decline under falling energy price regime producers in different soil zones would not be affected equally. More energy intensive production region such as black soil zone would improve its comparative advantage. Producers in this zone would therefore be less affected compared to those in other soil zones. Stubble cropping, which is more energy and land intensive production, would therefore be more attractive to producers in the province, specially those in the black soil zone, as opposed to summerfallow cropping under rising energy price regime (Tewari and Kulshreshtha).

Since there are no price support programs in Canadian production system, falling energy prices will be translated in lower net farm incomes to producers. In the U.S., however, we expect an increasing deficiency payment burden under falling energy price regime. In this model we have assumed fixed demand elasticities, but welfare gains and losses can be significantly different under different demand elasticities. One may therefore look at these as trade/demand elasticities change.

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Footnotes

[1] For example, income elasticities for food may be as high as 0.7 to 0.9 in the developing economies and they fall as income levels rise. In developed countries such as the United States the income elasticity of food may be as low as 0.1 to 0.4. Josling "World Food Production", p. 94 quoted in Knutson et al (1983, p.99).

1. The Prototype Model, Saskatchewan Agriculture

Crop Production, Brown Soil Zone																Livestock Production			Product Demands							Input Supplies					RHS
BNFW				BNSW				BNFB				BNSB				Feeders	Steers	Hogs	DWE	DWD	DBE	DBD	DFDR	DST	DHG	NITR	PHOS	KPTL	FUEL	LABR	
Fertilizer Combinations																															
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4																
																			*	*	*	*	*	*	*	+	+	+	+	+	
- - - Land Coefficients - - -																															≤ A1
-1	-1	-1	-1	-1	-1	-1	-1												1	1											≥ 0
								-1	-1	-1	-1	-1	-1	-1	-1	15	71	15			1	1									≥ 0
																-1	1						1								≥ 0
																	-1							1							≥ 0
																		-1							1						≥ 0
																										-1					≤ 0
																											-1				≤ 0
- - - Input Coefficients - - -																												-1			≤ 0
																													-1		≤ 0
																														-1	≤ 0

oduct Demand Schedule
ices of Inputs

NFW - wheat on summerfallow in brown soil zone
NSW - wheat on stubble in brown soil zone
BNFB - barley on summerfallow in brown soil zone
BNSB - barley on stubble in brown soil zone
TCL1 - total cultivated acres in brown soil zone
WHTR - wheat transfer row
BRTR - barley transfer row
FDTR - feeder transfer row
STTR - slaughter steers transfer row
HGTR - hog transfer row
A1 - total cultivated acres in brown soil zone

DWE - export demand for wheat
DWD - domestic demand for wheat
DBE - export demand for barley
DBD - domestic demand for barley
DFDR - domestic demand for feeders
DST - domestic demand for slaughter steers
DHG - domestic demand for hogs
NITR - nitrogen
PHOS - phosphorous
KPTL - capital
FUEL - fuel
LABR - labour

Table 2. Energy Prices used in Benchmark and Low Energy Price Scenario, Saskatchewan Agriculture

Energy Inputs	Units	Energy Prices	
		Benchmark	25 Percent Decrease from Benchmark
Fuel	CDN$/gal.	1.59	1.1925
Nitrogen	CDN¢/lb.	28.00	22.16
Phosphorous	CDN¢/lb.	26.00	18.73
Natural gas	CDN$/100m^3	64.40	48.30

Table 3. Impacts of Falling Energy Prices on Disposition and Production, Saskatchewan Agriculture

Particulars	Energy Price Levels: Benchmark	Energy Price Levels: 25% Decrease	Increase from Benchmark
Crop Products	...000 bushels...		...Percent...
Wheat			
Export Demand	406,125	417,130	2.71
Domestic Demand	42,014	43,531	3.61
Production	448,140	460,661	2.79
Oats, Domestic Demand	46,615	49,752	6.73
Barley			
Export Demand	59,912	63,897	6.65
Domestic Demand	25,156	28,713	14.14
Feed Demand	50,350	51,006	1.30
Production	135,418	143,616	6.05
Flaxseed			
Export Demand	5,838	5,960	2.09
Domestic Demand	1,076	1,099	1.94
Production	6,912	7,059	2.13
Rapeseed			
Export Demand	24,022	25,283	5.25
Domestic Demand	18,283	18,948	3.64
Production	42,306	44,231	4.55
Livestock Products	...000 heads...		
Slaughter Steers Demand	340	347	2.05
Feeder Steers Demand	761	764	0.30
Market Hogs Demand	619	623	0.64

Table 4. Impacts of Falling Energy Prices on Product Price Levels, Saskatchewan Agriculture

Particulars	Energy Price Level: Benchmark	Energy Price Level: 25% Decrease from Bench mark	Change from Benchmark
Crop Products	..CDN$/bushel..		..Percent..
Wheat	5.588	5.297	-5.21
Oats	2.263	2.099	-7.25
Barley	2.975	2.799	-5.92
Flaxseed	7.156	6.773	-5.35
Rapeseed	6.276	6.041	-3.74
Livestock Products	..CDN$/head..		..Percent..
Slaughter Steers	899.256	877.813	-2.38
Feeder Steers	430.519	423.913	-1.53
Market Hogs	130.849	127.517	-2.55

Table 5. Impacts of Falling Energy Prices on Gross Farm Income (GFI), Net Returns over Energy Expenditure (GFI-E), and Consumer Surplus, Saskatchewan Agriculture

Particulars	Benchmark	Low Energy Price Scenario	Change from Benchmark
	...m.CDN$.........		...Percent...
Gross Farm Income	3893	3826	-1.72
Net Returns over Energy Inputs	3287	3264	-0.69
Consumer Surplus:			
total	3870	4053	+4.73
export mkt.	2362	2500	+5.84
domestic mkt.	1508	1553	+2.92

Table 6. Impacts of Falling Energy Prices upon Wheat Rotation, Saskatchewan Agriculture

Wheat Rotation	Benchmark	Low Energy Price Scenario	Change from Benchmark
Brown	...000 bushels...		...Percent..
Summerfallow	132,786	135,694	+2.19
Stubble	--	--	Nil
Dark Brown			
Summerfallow	165,559	50,698	-69.38
Stubble	--	--	Nil
Black			
Summerfallow	147,437	--	-100.00
Stubble	2,358	274,269	+115.31

Appendix A

Demand Elasticities used in the model

Demand	Elasticity
Wheat	
Export	-0.47
Domestic	-0.18
Oats, Domestic	-0.48
Barley	
Export	-1.03
Domestic	-0.98
Flaxseed	
Export	-0.44
Domestic	-0.14
Rapeseed	
Export	-1.45
Domestic	-0.86
Livestock, Domestic	
Feeder Steers	-0.22
Slaughter Steers	-0.75
Market Hogs	-0.19

Source: Tewari (1986, p.247).