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# **Regional Variations in the Potential for Energy Substitution in United States Manufacturing**

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The impact of energy price changes on the total cost of producing a good depends on how difficult or easy it is to substitute other inputs for energy in the manufacturing process. Highly aggregative estimates of "the" production function for U.S. manufacturing have yielded conflicting results, leading even to disagreement as to whether capital and energy are, overall, complements or substitutes.

An obvious problem is that no two manufacturing processes are the same: changing energy prices may have very large effects on costs in one and not in another. A less obvious problem is that manufacturing methods and conditions are not the same over the whole United States, for a host of historical, social and climatological reasons.

In this study, energy substitution possibilities are examined for fifteen broad (two-digit) manufacturing sectors in three geographical regions. This is accomplished through the estimation of a dual cost function which assumes four aggregate inputs: capital, labor, energy and materials. A relatively stable period is studied, 1971-73, so that static analysis is

plausible. Pooled cross-section/time-series data based primarily on the Census of Manufacturers are used.

As a preliminary measure, various definitions of economic regions were tested, using a separate data set. Regions based on capital vintage, and on input price ratios were considered and rejected. Ultimately, the greatest explanatory power was found to result from using traditional geographical regions, specifically the Northeast, Southeast, and West.

The major result of the study is the calculation of own- and cross-price elasticities for capital, labor, energy, and materials, by sector and region. Energy is found to be generally substitutable with materials. Labor and energy have a more varied relationship; interestingly, they appear to be more easily substituted for each other in the South than elsewhere. Finally, capital and energy exhibit a complex pattern of complementarity and substitutability; however, a great many values are close to, and not significantly different from, zero.

## Master's Thesis Award of Merit

# The Determinants of Early Enrollment in the Massachusetts Special Supplemental Feeding Program for Women, Infants, and Children (WIC)

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It has been shown in previous studies that *early* enrollment of high risk pregnant women in the special supplemental feeding program for women, infants and children (WIC) improves birth outcomes. But the emphasis is on *early*; these studies show negligible impacts on birth outcomes for women joining after the first trimester of pregnancy. To the extent that women at risk are attracted to the WIC program late rather than early, it has been suggested that WIC has become more an "income supplement" than a "health-oriented" program.

The premise of the research reported here is that if high risk women can be attracted into the WIC program *earlier*, the benefits of the program will be enhanced even at constant budget levels. Therefore, it is important to understand the extent to

which high risk pregnant women are attracted early and what factors (program as well as individual characteristics) enhance or impede the likelihood of early enrollment. This question has not been addressed in previous work.

The data involve records for 1270 Massachusetts WIC participants and questionnaire responses from the directors of 11 WIC centers in Massachusetts. An encouraging conclusion is that the means appear to be available to attract even the hard-to-find higher-risk groups by maintaining program operations, providing child care facilities, opening longer at more convenient hours, increasing media utilization and switching to retail food delivery wherever convenient.

## Master's Thesis Award of Merit

# An Analysis of Residential Water Demand Under an Increasing Block Price Policy as Applied in the Washington Suburban Sanitary District

**Frances Hornick Smith**

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An analysis of the demand for water by the residential sector was conducted in order to discern consumer response to a change from a uniform to an increasing block rate method of pricing. The study area was the Washington Suburban Sanitary District, which encompasses Prince George's and Montgomery Counties in Maryland.

Residential consumers have reduced average daily water consumption, and seasonal peak usage has lessened, since inception of the IBR policy.

A model was constructed based on the equality of quantity demanded and supplied at market equilib-

rium. Demand and supply equations were estimated simultaneously using two-stage least squares. Reduced-form coefficients, significant at the five percent level resulted, which in terms of direction of impact fulfilled the predictions of prior comparative statics analysis.

Results indicated that a twenty-nine gallon per day reduction in water consumption by the household would follow a one dollar increase in average price. The price elasticity of demand (based on average price) was found to be -0.25.

# Optimal Timing of Pesticide Applications for the Control of the Colorado Potato Beetle

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**Advisor: J. M. Gates**

The objective of this study is to develop a comprehensive model describing the interrelationships between the CPB, the potato plant, and insecticide treatments; and to propose a simple and practical decision rule for spray applications. Some implications for policy making are also suggested.

Simulation is the principal method used in this study. Simulations are used to evaluate the economic threshold decision rule and an improved decision rule derived via output response surface techniques. It is known from the optimality conditions of dynamic programming (DP) that the economic threshold rule may result in excessive use of pesticides. DP is not used as a solution method however because of computational considerations.

The results suggest that the economic threshold decision rule yields net revenues which are significantly less than optimal and results in too many applications of pesticide. This is generally true when damage is caused by multiple age classes and when insecticides have a significant residual or persistence effect on multiple classes.

The determinants of the optimum decision points

are analyzed using ordinary least squares regressions to compress results into a simple, easily applied decision rule. This decision rule is a threshold rule triggered by pest levels and is therefore easy for a grower to use. Unlike the standard threshold rule, however, it is a time variant threshold rule which distinguishes critical periods during the growth season. These periods relate to the life cycle of the pest. The critical threshold levels are also conditional upon cumulative degree-days and the ratio of pesticide cost to potato price. Simulations using this simplified decision rule yields net revenues which are nearly optimal. The largest error was at high infestation levels and here the net revenue reduction was less than five percent.

A normative pesticide demand function is synthesized which indicates how producers will respond in the long run as they become better optimizers. The results indicate that pest infestation level is a critical variable and should be included in statistical estimations using field data. The ratio of insecticide cost to potato price is also significant but is relatively less important.