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LAbor Productivity and Turnover in Manufacturing Industries: The Case of a Five County Region in Southeastern Ohio

Dissertation

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

Emmanuel Turkson Acquah, B.S., M.S.

* * * * *

The Ohio State University

1976

Reading Committee:  
Professor Leroy Hushak  
Professor David Shapiro  
Professor Francis Walker

Approved By

Leroy J. Hushak  
Adviser  
Department of Agricultural Economics
To

Norman and June Ulsaker; and John V. Strikland.
ACKNOWLEDGMENTS

I am indebted to my adviser, Dr. Leroy J. Hushak, for his effective personalized counseling and encouragement throughout my graduate education.

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Finally, I thank my wife, Sarah, for her courage, interest, patience, and love.
VITA

November 21, 1943 . . . . Born - Saltpond, Ghana

1972 . . . . . . . . . B. SC., University of Maryland, Princess Anne, Maryland

1972-1973 . . . . . . University Fellow, The Ohio State University, Columbus, Ohio

1973-1975 . . . . . . Graduate Research Associate, Department of Agricultural Economics, The Ohio State University, Columbus, Ohio

1976 . . . . . . . . . University Fellow, The Ohio State University, Columbus, Ohio

FIELDS OF STUDY

Major Field: Agricultural Economics


Studies in Production Economics. Professors Francis Walker and Leroy Hushak

Studies in Quantitative Methods. Professors Steven C. Reimer, Michael L. Liestein, and Francis Walker
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEDICATION</td>
<td>ii</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>iii</td>
</tr>
<tr>
<td>VITA</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vii</td>
</tr>
<tr>
<td>Chapter</td>
<td></td>
</tr>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>The Problem</td>
<td></td>
</tr>
<tr>
<td>Objectives of the Study</td>
<td></td>
</tr>
<tr>
<td>The Data</td>
<td></td>
</tr>
<tr>
<td>II. THEORY AND LITERATURE REVIEW</td>
<td>14</td>
</tr>
<tr>
<td>Human Capital and the Production Process</td>
<td></td>
</tr>
<tr>
<td>Literature Review</td>
<td></td>
</tr>
<tr>
<td>Theory of Production</td>
<td></td>
</tr>
<tr>
<td>Aggregation, Separability and Their Relevance in Production</td>
<td></td>
</tr>
<tr>
<td>Analysis</td>
<td></td>
</tr>
<tr>
<td>Value Added Versus Gross Output Functions</td>
<td></td>
</tr>
<tr>
<td>Functional Forms Used in the Study</td>
<td></td>
</tr>
<tr>
<td>Theory of Human Capital and Labor Turnover</td>
<td></td>
</tr>
<tr>
<td>III. MANUFACTURING AND THE ECONOMY OF THE FIVE-COUNTY REGION</td>
<td>51</td>
</tr>
<tr>
<td>The Economy of the Five-County Region</td>
<td></td>
</tr>
<tr>
<td>Shift Share Analysis</td>
<td></td>
</tr>
<tr>
<td>Manufacturing Activities in the Region</td>
<td></td>
</tr>
<tr>
<td>Characteristics of Manufacturing Sample</td>
<td></td>
</tr>
<tr>
<td>IV. PRODUCTION ANALYSES</td>
<td>71</td>
</tr>
<tr>
<td>Specification of Models</td>
<td></td>
</tr>
<tr>
<td>Variable Measurements</td>
<td></td>
</tr>
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<td>Selection of Appropriate Model</td>
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<td>Analysis of the Sample</td>
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<tr>
<td>Analysis of Sub-Classifications of Firms</td>
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</table>
TABLE OF CONTENTS (Continued)

Chapter................................................................................................................. Page

V. LABOR TURNOVER ANALYSES ................................................................. 91

The Quit Rate Model
The Layoff Model

VI. CONCLUSIONS AND IMPLICATIONS .................................................. 103

Conclusions
Implications
Further Research

APPENDICES

A ......................................................................................................................... 113

Employment by Major Industry Groups for the State of Ohio, 1973-1975
Shift Share Analysis Matrix, 1960-1970
Distribution of Firms in the Five Counties, 1971-1975
Employment and Income Generated by Manufacturing Sector in the Five-County Region, 1960-1974

B COPY OF QUESTIONNAIRE ................................................................. 118

C RESULTS OF FITTING ALTERNATIVE VERSIONS OF MODELS I-1, II-1, II-2, and II-3 TO THE SAMPLE .. 130

BIBLIOGRAPHY ............................................................................................... 135
<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Employment in Five Counties of Southeastern Ohio by Section, 1960 and 1970</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Income by Five Counties, by Sectors in Southeastern Ohio, 1968 and 1972</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Median School Years Completed and Median Family Income for the Five Counties, Ohio, and U.S., 1970</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Major Industry Group (Non-Agricultural) Employment in the Five Counties</td>
<td>52</td>
</tr>
<tr>
<td>6</td>
<td>Income Distribution by Major Industry Group (Non-Agricultural) for the Five Counties</td>
<td>57</td>
</tr>
<tr>
<td>7</td>
<td>Shift Share Matrix for the Five-County Region (1960-1970)</td>
<td>59</td>
</tr>
<tr>
<td>8</td>
<td>Major Classification of Manufacturing Industries in the Five-County Region</td>
<td>62</td>
</tr>
<tr>
<td>9</td>
<td>Number and Changes in Firm Establishments (1971-1975)</td>
<td>63</td>
</tr>
<tr>
<td>10</td>
<td>Employment and Payroll by Manufacturing Sector in the Five-County Region</td>
<td>66</td>
</tr>
<tr>
<td>11</td>
<td>Summary Characteristics of the Sample</td>
<td>68</td>
</tr>
<tr>
<td>12</td>
<td>Results for Selected Fitted Regressions for the Sample</td>
<td>79</td>
</tr>
<tr>
<td>13</td>
<td>Results for Selected Fitted Regressions for Sub-Classes and the Sample</td>
<td>87</td>
</tr>
<tr>
<td>14</td>
<td>Mean and Standard Deviations of Variables by Employment</td>
<td>94</td>
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<td>Table</td>
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<tr>
<td>15</td>
<td>Quit Rate Regression Results</td>
<td>96</td>
</tr>
<tr>
<td>16</td>
<td>Layoff Rate Regression Results</td>
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CHAPTER I

INTRODUCTION

The major purposes of this study are to: (1) determine if human capital investment significantly influences the productivity of labor and other inputs in manufacturing production processes, and (2) test the propositions that the layoff rate is negatively related to a firm's investment in specific human capital, while the quit rate is negatively related to worker's investment in a specific human capital.¹

Many local policy decisions are based on findings and implications of national or regional aggregate studies. Production studies which aggregate at such levels may fail to adequately capture the impact of some variables for micro purposes. A production function is a micro-economic concept which deals with alternative allocations of resources that exist for a firm. Results of studies using published data for industrial totals at various levels of aggregation may not depict the true picture of a micro issue. The use of findings from national aggregate production studies for local (micro) policy

¹Specific human capital is defined as the difference between the discounted sum of the worker's marginal product in his present firm and his greatest discounted marginal product net of transfer cost in alternative firms (Parsons, 1972). See also Becker, Human Capital (1964) for a broader discussion of specific and general training.
decision-making usually arises because of lack of micro level data and other resource constraints. However, there are many problems or issues which are micro in nature and should be addressed by micro analysis.

The focus of this study is on a five-county region of southeastern Ohio. The area covers Athens, Gallia, Jackson, Meigs, and Vinton counties, which is part of Appalachia. It is part of the least developed area of the state of Ohio.²

Recent increases in agricultural and energy prices, the employment and tax base which was generated by the deep shaft coal mines, and the Gavin Power plant are indications that there is opportunity to make necessary investments needed to facilitate economic development in the region. The manufacturing sector is a crucial component affecting the economic development of the economy. Knowledge about its possible contributions toward the economic growth of the area is needed. It is important that one understand the intricacies of the production processes of the manufacturing sector.

A manufacturing sector generally provides opportunities for employment, generates income, acts as a source of material inputs for other industrial sectors, and hence contributes to economic growth. Available data indicates that the manufacturing sector has been and continues to be one of the major sources of employment and income in the region. In 1960, manufacturing employed more workers than any

²For a history of economic activities since 1788, see (Battelle, 1964), (Land Reform, 1974), (Silterly, 1975), and Sadr, 1976).
other industry. During that year 26.8 percent of the employed labor force (7,135) was engaged in manufacturing activities. In 1970, the manufacturing sector was the second largest source of employment next to trade with 7,922 workers or about 30.7 percent of the employed labor force. Table 1 gives a detailed distribution of labor employment by different sectors in the region for 1968 and 1970.

The distribution of income by major economic sectors in the five-county area is shown in Table 2 for 1968 and 1972. In 1968, the manufacturing sector was the second largest source of income, next to the state and local government sector. It contributed 12.5 percent of the total income in the five counties. In 1972, manufacturing activities generated the third largest source of income (10.6 percent) while state and local government generated 23.11 percent and 10.83 percent came from property income.

The Problem

The literature abounds with discussions of the influence of education, measured by years of schooling, on income distribution (Chiswick, 1967; Denison, 1964; Houthaker, 1959; Mincer, 1962; Schultz, 1960; Becker, 1964). The distribution of personal income is related to investment in human capital. The presence and frequent use of income-by-education figures in the literature is a testimony to the general acceptance of the positive relationship between personal income and level of education. The pure contribution of education to income levels has been questioned recently, because the possible contribution of other factors such as "ability" and quality of schooling are all lumped under "contribution of education" (Becker and Chiswick,
### TABLE 1. Employment in Five Counties of Southeast Ohio by Section, 1960 and 1970

<table>
<thead>
<tr>
<th>Section</th>
<th>Athens</th>
<th>Gallia</th>
<th>Jackson</th>
<th>Meigs</th>
<th>Vinton</th>
<th>Total</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1960 (number)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Agriculture</td>
<td>781</td>
<td>1,193</td>
<td>592</td>
<td>906</td>
<td>299</td>
<td>3,771</td>
<td>14.41</td>
</tr>
<tr>
<td>Mining</td>
<td>421</td>
<td>295</td>
<td>205</td>
<td>344</td>
<td>162</td>
<td>1,427</td>
<td>5.35</td>
</tr>
<tr>
<td>Construction</td>
<td>845</td>
<td>413</td>
<td>604</td>
<td>542</td>
<td>228</td>
<td>2,632</td>
<td>9.87</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>2,264</td>
<td>798</td>
<td>2,523</td>
<td>931</td>
<td>709</td>
<td>7,135</td>
<td>26.77</td>
</tr>
<tr>
<td>Transportation</td>
<td>1,309</td>
<td>864</td>
<td>934</td>
<td>1,095</td>
<td>--</td>
<td>4,202</td>
<td>15.76</td>
</tr>
<tr>
<td>Trade</td>
<td>2,515</td>
<td>1,265</td>
<td>1,572</td>
<td>1,068</td>
<td>334</td>
<td>6,754</td>
<td>25.34</td>
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<td>Finance</td>
<td>253</td>
<td>122</td>
<td>168</td>
<td>136</td>
<td>53</td>
<td>732</td>
<td>2.74</td>
</tr>
<tr>
<td>Total</td>
<td>8,388</td>
<td>4,860</td>
<td>6,598</td>
<td>5,022</td>
<td>1,785</td>
<td>26,653</td>
<td>100.00</td>
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<tr>
<td><strong>1970 (number)</strong></td>
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<tr>
<td>Agriculture</td>
<td>409</td>
<td>525</td>
<td>204</td>
<td>395</td>
<td>206</td>
<td>1,739</td>
<td>6.74</td>
</tr>
<tr>
<td>Mining</td>
<td>143</td>
<td>83</td>
<td>181</td>
<td>232</td>
<td>70</td>
<td>709</td>
<td>2.75</td>
</tr>
<tr>
<td>Construction</td>
<td>1,177</td>
<td>601</td>
<td>642</td>
<td>679</td>
<td>236</td>
<td>3,335</td>
<td>12.93</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>2,421</td>
<td>1,133</td>
<td>2,525</td>
<td>1,038</td>
<td>805</td>
<td>7,922</td>
<td>30.73</td>
</tr>
<tr>
<td>Transportation</td>
<td>935</td>
<td>562</td>
<td>604</td>
<td>619</td>
<td>222</td>
<td>2,942</td>
<td>11.41</td>
</tr>
<tr>
<td>Trade</td>
<td>3,453</td>
<td>1,334</td>
<td>1,713</td>
<td>1,256</td>
<td>436</td>
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<td>31.78</td>
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<tr>
<td>Finance</td>
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<td>220</td>
<td>119</td>
<td>42</td>
<td>937</td>
<td>3.63</td>
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<tr>
<td>Total</td>
<td>8,923</td>
<td>4,409</td>
<td>6,089</td>
<td>4,338</td>
<td>2,017</td>
<td>25,776</td>
<td>100.00</td>
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Source: Regional Economic Information System, Bureau of Economic Analysis U.S. Department of Commerce.
TABLE 2. Income by Five Counties, by Sectors in Southeast Ohio, 1968 and 1972

<table>
<thead>
<tr>
<th>Sector</th>
<th>Athens</th>
<th>Gallia</th>
<th>Jackson</th>
<th>Meigs</th>
<th>Vinton</th>
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<th>% of Total</th>
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<td>397</td>
<td>852</td>
<td>836</td>
<td>1,338</td>
<td>328</td>
<td>3,751</td>
<td>1.38</td>
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<td>12,288</td>
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<td>14,299</td>
<td>2,183</td>
<td>2,183</td>
<td>34,101</td>
<td>12.56</td>
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<tr>
<td>Mining</td>
<td>1,172</td>
<td>1,428</td>
<td>1,731</td>
<td>534</td>
<td>501</td>
<td>5,366</td>
<td>1.98</td>
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<tr>
<td>Construction</td>
<td>4,801</td>
<td>3,340</td>
<td>3,410</td>
<td>2,799</td>
<td>1,461</td>
<td>15,811</td>
<td>5.82</td>
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<td>Transportation</td>
<td>9,156</td>
<td>5,937</td>
<td>4,175</td>
<td>2,660</td>
<td>1,121</td>
<td>23,049</td>
<td>8.49</td>
</tr>
<tr>
<td>Trade</td>
<td>13,708</td>
<td>5,923</td>
<td>7,463</td>
<td>4,990</td>
<td>1,749</td>
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<td>1,463</td>
<td>554</td>
<td>292</td>
<td>5,823</td>
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<td>Services</td>
<td>12,285</td>
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<td>4,144</td>
<td>2,655</td>
<td>467</td>
<td>24,989</td>
<td>9.21</td>
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<td>Others</td>
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<td>245</td>
<td>198</td>
<td>103</td>
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<td>534</td>
<td>557</td>
<td>427</td>
<td>188</td>
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<td>1.15</td>
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<td>Federal Military</td>
<td>585</td>
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<td>222</td>
<td>163</td>
<td>87</td>
<td>1,247</td>
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<td>State and Local Government</td>
<td>34,372</td>
<td>10,218</td>
<td>5,691</td>
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<td>2,129</td>
<td>55,275</td>
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<td>Property Income</td>
<td>12,148</td>
<td>5,119</td>
<td>6,999</td>
<td>3,312</td>
<td>1,392</td>
<td>28,970</td>
<td>10.67</td>
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<td>Total for Personal Less Contributions</td>
<td>11,002</td>
<td>6,751</td>
<td>8,210</td>
<td>6,606</td>
<td>2,286</td>
<td>34,855</td>
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<tr>
<td>Total</td>
<td>116,221</td>
<td>49,341</td>
<td>59,445</td>
<td>31,284</td>
<td>15,041</td>
<td>271,332</td>
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TABLE 2. (Continued)

<table>
<thead>
<tr>
<th></th>
<th>Athens</th>
<th>Gallia</th>
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<th>Meigs</th>
<th>Vinton</th>
<th>Total</th>
<th>% of Total</th>
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<td>1972 ($1,000)</td>
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<td>Agriculture</td>
<td>11,223</td>
<td>1,232</td>
<td>736</td>
<td>966</td>
<td>246</td>
<td>5,403</td>
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<tr>
<td>Manufacturing</td>
<td>11,501</td>
<td>6,453</td>
<td>15,830</td>
<td>2,554</td>
<td>5,611</td>
<td>41,949</td>
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<tr>
<td>Mining</td>
<td>516</td>
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<td>906</td>
<td>7,462</td>
<td>1.89</td>
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<td>29,226</td>
<td>7.41</td>
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<td>8.65</td>
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<td>800</td>
<td>402</td>
<td>7,385</td>
<td>1.87</td>
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<tr>
<td>Services</td>
<td>14,430</td>
<td>8,733</td>
<td>5,403</td>
<td>3,373</td>
<td>704</td>
<td>32,643</td>
<td>8.28</td>
</tr>
<tr>
<td>Others</td>
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<td>289</td>
<td>232</td>
<td>185</td>
<td>90</td>
<td>1,283</td>
<td>.32</td>
</tr>
<tr>
<td>Federal Civilian</td>
<td>2,113</td>
<td>614</td>
<td>675</td>
<td>683</td>
<td>237</td>
<td>4,322</td>
<td>1.09</td>
</tr>
<tr>
<td>Federal Military</td>
<td>887</td>
<td>255</td>
<td>297</td>
<td>224</td>
<td>119</td>
<td>1,782</td>
<td>.45</td>
</tr>
<tr>
<td>State and Local</td>
<td>59,691</td>
<td>16,660</td>
<td>7,734</td>
<td>3,887</td>
<td>3,096</td>
<td>91,068</td>
<td>23.11</td>
</tr>
<tr>
<td>Government</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property Income</td>
<td>15,716</td>
<td>9,505</td>
<td>10,321</td>
<td>4,987</td>
<td>2,177</td>
<td>42,706</td>
<td>10.83</td>
</tr>
<tr>
<td>Transfer Payments for</td>
<td>17,989</td>
<td>9,885</td>
<td>13,409</td>
<td>9,770</td>
<td>3,729</td>
<td>54,782</td>
<td>13.90</td>
</tr>
<tr>
<td>Personal Less</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contributions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>161,784</td>
<td>90,680</td>
<td>77,802</td>
<td>41,550</td>
<td>21,401</td>
<td>394,063</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Source: Regional Economic Information Systems, Bureau of Economic Analysis, U.S. Department of Commerce.
1966; Layard and Psacharopoulos, 1974). However, even if downward adjustments are made to account for the impact of "ability" and other factors, the contribution of years of schooling on income differentials is still significant (Manpower Report of the President, 1974). In general, there is evidence that differences in years of schooling do play a major role in determining differences in wages and income, if other things are held constant (Griliches, 1970).

The general level of education in the five counties is below that of the State of Ohio as well as the nation. Table 3 presents the median years of school completed for the counties, the state, and the nation for 1970. The median year of school completed in Athens county is greater than that of the state. The median school year completed for the other counties was below the state and the national levels.

The median family income in the five counties and the State of Ohio is also presented in Table 3. The median family income for each of the counties is considerably lower than that of the State of Ohio and the United States.

The quality of inputs in a production activity has been recognized as a very important determinant of the productivity of these inputs. With specific reference to labor, changes in its quality have been used to account for the changes in its productivity growth (Griliches, 1963). From the labor characteristics information presented for the five counties, a suggested hypothesis is that low labor quality is one of the factors accounting for low income and low productivity in the region. Human capital might therefore be a constraint on the general development potential of the five-county area.
<table>
<thead>
<tr>
<th></th>
<th>Athens</th>
<th>Gallia</th>
<th>Jackson</th>
<th>Meigs</th>
<th>Vinton</th>
<th>Ohio</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>12.2</td>
<td>9.6</td>
<td>10.3</td>
<td>10.3</td>
<td>9.6</td>
<td>12.1</td>
<td>10.9</td>
</tr>
<tr>
<td>Females</td>
<td>12.2</td>
<td>10.3</td>
<td>10.6</td>
<td>10.6</td>
<td>10.4</td>
<td>12.1</td>
<td>12.2</td>
</tr>
<tr>
<td>Median Family Income ($)</td>
<td>7,628</td>
<td>6,916</td>
<td>6,635</td>
<td>6,485</td>
<td>6,334</td>
<td>10,313</td>
<td>9,867</td>
</tr>
</tbody>
</table>

If quality of labor is a constraint to economic development in the area, then policy makers will have to make decisions as to how human capital formation could be increased so as to relax the constraint it imposes on development potentials. One logical and pragmatic way of assessing the impact of labor quality in the manufacturing industries and hopefully of providing economically meaningful information to the local decision makers is a micro level production analysis. The intent is to use the production analysis as a diagnostic procedure to analyze and understand what is happening in manufacturing. The labor turnover analysis is also a stepping stone to understanding the underlying factors which affect quit and layoffs. The diagnostic approach is useful in an attempt to address questions like: What kinds of labor skills are in short supply in the region?; What are the alternatives for providing or developing the labor skills needed by manufacturing?; Is labor turnover a meaningful adjustment mechanism or a problem in the region?.

Objectives of the Study

The specific objectives of the study are:

1. To describe with particular focus on labor the role of manufacturing and what has happened to it in the five-county area over time.

2. To specify and estimate firm level micro production functions for the manufacturing industries in the five county area:
   a. To determine (i) the most "appropriate" production function for the sector, and (ii) empirically some theoretical properties of the appropriate function.
b. To test if and how different labor qualities affect production, such as worker and allocative effects of labor.

3. To test the investment hypothesis that: "layoff rate is negatively related to a firm's investment in specific human capital, while quit rate is negatively related to a worker's investment in specific human capital" in the manufacturing sector.

4. To draw policy implications from objectives (1), (2), and (3).

Objective 1 is achieved through the use of secondary data. Primary data are used for objectives 2 and 3. The neoclassical production theory and multiple regression analysis are used for the analysis of objective 2. Multiple regression analysis is used to attain objective 3.

The Data

In this study the primary set of data is cross sectional micro level data for calendar year 1974 or a fiscal year with greatest overlap of 1974. It is used to analyze the production processes and labor turnover rates of the manufacturing sector in the five-county region of southeastern Ohio.

Because of variations in survey response, timing, and differences in industrial definitions used by various agencies which publish data on manufacturing, data for similar years but from different agencies may not be comparable. Since all the secondary data needed for the study were not available in the form wanted from any one source, different sources were consulted. To avoid inconsistencies due to data from uncomparable sources, the following approach was adopted. In describing the economic activities of the region, data from the
Ohio Bureau of Employment Services is used. Although changes occur between 1971 and 1972 with respect to the number of people covered versus those not covered in the unemployment compensation data, the changes would not be serious from one year to the next. The major advantage is that it enables one to trace trends. In discussing the manufacturing activities in the region, the data source used is the Ohio directory of manufacturers. That enables one to trace on a disaggregated nature the activities of all firms classified under the two-digit Standard Industrial Classification (SIC) code.

The 1975 directory of Ohio Manufacturers was utilized as the primary source of identification of manufacturing firms in the five-county area. The directory listed 121 manufacturing firms in the five-county area for the 1974 calendar year. After a series of visitations and consultations with managers of firms, the Extension area agent for community resource development identified 17 more manufacturing firms which were in operation in 1974 but were not included in the directory of manufacturers. A total of 138 questionnaires were mailed in January of 1976. There were reasons to be optimistic about the success of the sample survey: (a) Most of the information requested was similar to that manufacturing firms report to state and federal agencies; (b) The wording of most of the questions was similar to that used by state and/or federal agencies which request similar data from the firms; and (c) There were local committees associated with the Community Resource Development Extension Program which were

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³A copy of the questionnaire is in Appendix B.
aware of the research effort. By the end of the second week of mailing, however, only three completed questionnaires had been returned.

In a telephone followup, most of the contact persons claimed they had not received the questionnaire. A second questionnaire was mailed to almost all the firms. Eleven, 8.6 percent, of the mailed questionnaires were returned unfilled because the firms were no longer in business. Approximately 27 percent of the firms refused to participate in the study. About 31 percent simply neglected the survey.

Through telephone conversations and correspondence, four major reasons were found to be responsible for the lack of response. First, most of the data required were considered by many, particularly the private corporations, to be sensitive and confidential. The firms were reluctant to provide some of the data because they saw no guarantee that the information would be kept confidential, despite such a promise in writing in the cover letter from the Dean of the College of Agriculture. Some of the contact persons were fed up with increasing numbers of private and public surveys in which their firms were asked to participate, which in their opinions have not and will not benefit the area in any way. Some of the smaller firms who use consulting accountants were not prepared to pay for such accounting consultation costs.

Visits were made to some firms who were willing to cooperate but did not have the necessary help and assistance to complete the questionnaire. At the end of March 1976, it was decided to contact those who refused to provide sensitive information and ask them to complete the sections needed for the labor turnover analysis. At that
time there were 35 returned questionnaires which could be used for
the production analysis and 43 for the turnover analysis. This new
request brought in ten more useable questionnaires for the labor
analysis and 4 for the production analysis.

Out of the 53 questionnaires which were returned, 39, which is
28.2 percent of the 138, were fully completed for the production
analysis, while 49 were useable for the labor turnover analysis.

The theory of production and specific human capital is pre­
sented in Chapter II. The role and activities of the manufacturing
sector in the five-county area are described in Chapter III. In
Chapter IV, statistical models for manufacturing production processes
are formulated, and the results of the empirical analysis are presented.
Chapter V is devoted to the empirical analysis of labor turnover
models. The final chapter deals with major conclusions and policy
implications drawn from the study.
CHAPTER II

THEORY AND LITERATURE REVIEW

In this chapter the neoclassical theory of production is first presented. The literature is then reviewed on certain aspects of theory and empirical works which are relevant to this study. The theory of human capital and its effects on production processes are also developed. Finally, relationships between specific human capital and labor turnover are derived.

Human Capital and the Production Process

The productive value of human capital can be thought of as being imbedded in two forms: a "worker" effect and an "allocative" effect. The forms can be distinguished based on how they affect production processes. The worker effect is defined as the marginal product of human capital (Welch, 1970; pp. 35-39). This is the increase in output per unit change in human capital with the ceteris paribus assumption imposed. In general, the worker effect enables one to accomplish more physical output with given resources as a result of increases in human capital.

The allocative effect is defined as changes in output as a result of improvement in the ability to make resource allocation decisions through an increase in human capital. Theoretically, the two
effects could occur in one person if an individual has the opportunity to make allocative decisions as well as being involved in physical production activity. Agriculture is one industry where an individual's activities are so diversified that allocative decisions are often made by individuals who are also directly involved in physical production.

In manufacturing industries, workers' responsibilities are clearly defined and most, if not all, of the production workers do not make any important allocative decisions. It is very likely that the only contribution of non-managerial workers is the worker effect. Managerial workers are hypothesized to have allocative effect in manufacturing industries, since allocation decisions are normally made by the managers. It is conceivable that the impact of human capital in manufacturing industries has been understated because many previous production studies have not allowed for an allocative effect.

It is generally agreed that education contributes to the growth of an economy. However, there is no uniform consensus as to how the contribution is made. Denison (1964, pp. 13-55) has suggested that more education contributes to growth by (a) raising the quality of the labor force and presumably increasing labor productivity; and (b) accelerating the rate at which society's stock of knowledge advances. This (b) could lead to improvement in productivity because of advancement in the state of the arts. Denison's point (a) is equivalent to the worker effect. The implication from (b) is that advancements in the state of the arts lead to possibilities for more efficient coordination or allocations of scarce resources. At the firm level, the ability of a firm's management to adopt or utilize these advances is the allocative effect.
Theory of Production

For any commodity, the production function is the relationship between the quantities of various inputs used per period of time and the maximum possible quantity of output that can be produced per period of time. The transformation of inputs into output is made up of a number of determinants which are technical, behavioral, organizational, and to some extent legal in nature. A production function may be specified in a mathematical or tabular form. Such a function could be represented as:

\[ q_i = f(x_1, x_2, \ldots, x_n) \]

where, \( q_i \) = output of good \( i \)
\( x_k \) = productive input \( k=1, 2, \ldots n \).

To be able to understand the relationship of the transformation process, it is instructive to work with an explicit functional relationship between the inputs and the output. This has traditionally been done by economists via mathematical forms.

Literature Review on Production Analysis

The literature on the theory and estimation of production function is large. The history of the theory of production can be traced to the 1700's.\(^1\) A comprehensive review of earlier works in production analyses is found in Hildebrand and Liu (1957). Walters (1963, pp. 1-66) presents a good survey of the literature up to the 1960's.

The current state of the arts of the theory of production and distribution is contained in Ferguson (1971). For the purposes of this study, only relevant production analyses which deal specifically with manufacturing industries and/or those which go beyond the conventional treatment of labor and capital inputs will be reviewed.

Griliches (1968, pp. 151-156) in his studies used aggregate cross-section data from the 1958 census of manufacturers and the 1960 Census of population. The basic approach was to fit a Cobb-Douglas equation by least squares to observations on establishment averages across states and across two-digit industries for all United States manufacturing industries. Value added was used as the dependent variable. Fixed assets were measured by the book value of gross fixed assets. Labor was divided into production and non-production workers. An "occupational" mix measure was used to measure quality of the labor force. Griliches concluded that quality of labor makes a difference in the manufacturing production process. The skill (quality) variables were statistically significant and their coefficients were not significantly different from those of the conventional labor input measures. In other earlier works of Griliches (1964, pp. 961-74) which were basically restricted to the agricultural sector, the education variable (used as a measure of labor quality) was also significant.

Besen (1968, pp. 494-497) used the same data as Griliches (1968, pp. 151-61) but a different methodology\(^2\) to assess the role of labor force quality (educational attainment) in explaining interstate

\(^2\)The difference in the two methodologies is found in Besen (1968, p. 495).
production differentials in manufacturing in the United States. Using cross-section data, a Cobb-Douglas type production function in which returns to scale were not restricted was estimated for 18 two-digit manufacturing industries. Besen found that in six industries the coefficients of educational attainment were significantly greater than zero at the 5 percent level (one tail test); and in five more industries the education coefficient became significant at the 10 percent level.

In an attempt to explain the international pattern of labor productivity and wages, Mitchell (1962, pp. 50-79) categorized labor into skilled and unskilled. The skilled labor included: managers, professional and technical workers, craftsmen and foremen. Clerks and kindred workers made up the unskilled group. Although Mitchell did not have the necessary data to do a direct test, he concluded his study by stated that: "One can, however, have some confidence that labor quality does play a very important role in determining interindustry differences in productivity and wages, and that such systematic differences are pervasive over a number of developed countries."

Hildebrand and Liu (1965), in an attempt to measure the contribution of education in manufacturing industries in the U.S., incorporated an education variable in their functional specification by assuming that it could modify the exponent of a conventional measure of labor in a Cobb-Douglas production function in which labor was divided into production and non-production components. The quality of labor force for individual industries in a state was measured as the educational level of the total labor force in a state. Because of lack of confidential data, their results did not support their hypothesis.
There have been few research efforts to assess the impact of labor quality using microlevel data due to lack of data. Kisler (1965) used county micro data but found little or no returns to schooling. Sines (1975) in his model specification classified labor into four different groups in an attempt to capture the influences of different labor qualities in manufacturing production in Venezuela. Using firm level data he classified labor into (a) services of managers; (b) services of professional and sub professionals; (c) services of skilled workers, and (d) services of semi-skilled and unskilled workers. Sines found that the coefficients of the different labor variables were statistically significant and more importantly the contribution (marginal productivity) of those with more education (higher skills or higher quality) was greater than that of those with lesser education.

Aggregation, Separability and Their Relevance in Production Analysis

Aggregation is a process whereby part of a detailed set of information available for solving a problem is sacrificed for the purpose of making the problem more manageable. In its common form, a set of numbers, i.e., quantities of various factors of production, are replaced by one or a smaller set of numbers called aggregates. Aggregation usually occurs because several different inputs, in the case of the theory of production, are utilized to maximize output. There may be so many such inputs, which can be distinguished by some unique features such as brand or quality, that it becomes imperative to reduce the number of some of the inputs through grouping. Under such situations, the process of grouping the inputs might be satisfactory to a
researcher if the cost associated with non-aggregated analysis greatly exceeds that which involves aggregation, while there is not any significant change in the results. Under such trade-off conditions, one then becomes more interested in satisfying conditions under which consistent aggregation is attained. Green (1964, p. 3) defines consistent aggregation as follows: "Aggregation will be said to be consistent when the use of information which is more detailed than that contained in the aggregates would make no significant difference to the results of the analysis of the problem at hand."

The aggregation of factors of production into fewer variables, like the grouping of all types of labor into one factor "Labor" for production analysis, may have its merit depending on the level and issues at hand. When the analysis is at a micro level where results are anticipated to be useful in local policy derivation, as is the case of this study to address various human capital formation issues, then aggregation of all types of labor with different qualities into one labor variable at a micro level poses serious problems. Instead of conditions for consistent aggregation, the major concern is how far variables can be disaggregated to satisfy a particular need.

To extend the argument, it can be said that no two inputs are alike in all respects; hence, disaggregation may have to go all the way to include each and every input as a separate input. However, if this rationale is pursued, then a production function for an industry does not exist because the production function for each firm becomes unique. It therefore becomes necessary to assume that it is possible to disaggregate to a point (without reaching the stage where each
factor is treated uniquely in its own right) where the inputs included in each aggregation become perfectly substitutable. It is at this level of aggregation (or disaggregation) where the basic inputs in a production theory are obtained that can meaningfully be subjected to marginal analysis.

The concept of functional separability is very useful in efforts to disaggregate to attain "basic" inputs and also to specify functional forms. Functional separability addresses the conditions under which various inputs used in a production process can be aggregated to obtain basic input levels. Alternatively, it can be viewed as the conditions under which inputs used for a production process can be grouped separately. Bemdt and Christensen (1973, pp. 403-410) serves as the basis for illustration of the relevance of functional separability in production analysis. They utilize a strictly quasi concave homothetic production function with finite inputs. Each input is assumed to have positive marginal product. The function is represented as:

\[ q = F(X) = F(X_i, \ldots, X_n) \]

The n inputs represented as \( N = (1, \ldots, n) \) are then partitioned into r mutually exclusive and exhaustive subsets as \( (N_1, \ldots, N_r) \). The partition is termed R. The function is defined to be weakly separable with respect to the partition R if the marginal rate of substitution between any two inputs \( X_i, X_j \) from any subset of \( N_g \) does not depend on the quantities of inputs outside of \( N_g \), i.e.:
\[
\frac{\partial}{\partial x_k} \left( \frac{f_i}{f_j} \right) = 0 \text{ for all } i, j \in N_s, \text{ and } k \notin N_s
\]

where \( f_i/f_j \) = marginal rate of substitution between \( X_i \) and \( X_j \).

The function is said to be strongly separable with respect to \( R \) if the marginal rate of substitution between any two inputs from subsets \( N_s \) and \( N_t \) does not depend on the quantities of inputs outside \( N_s \) and \( N_t \), i.e.,

\[
\frac{\partial}{\partial x_k} \left( \frac{f_i}{f_j} \right) = 0, \text{ for all } i \in N_s, j \in N_t; k \notin N_s \cup N_t
\]

Strong separability implies weak separability but weak separability implies strong separability only when \( R \) is partitioned into only two subsets. Two fundamental results of functional separability are presented as theorems.

**Theorem I.** Weak separability with respect to the particular \( R \) is necessary and sufficient for a production function \( F(x) \) to be of the form \( F(x^1, \ldots, x^r) \), where \( x^s \) is a function of elements of \( N_s \) only. (Consistent aggregation as defined by Green occurs when weak separability exists.)

**Theorem II.** Strong separability with respect to \( R \) is necessary and sufficient for the production function \( F(x) \) to be of the form \( F(x^1 + x^2 + \ldots + x^r) \), where \( x^s \) is a function of the elements of \( N_s \) only.

Weak separability is a condition for aggregating while strong separability is a condition for functional specification. With weakly
separable inputs, one can aggregate to an input set \( X^S \), \( S < n \), without loss of information (consistent aggregation as defined by Green exists).

Berndt and Christensen then stated and proved new theorems which establish that separability restrictions on production functions are equivalent to certain equality restriction on elasticities of substitution as defined by Allen (AES).

Theorem 3. Weak separability of \( F(x) \) with respect to the partition \( R \) at any point in input space is necessary and sufficient for all proper AES \( \sigma_{ik}, \sigma_{jk} \) \((i, j \in N, k \in N)\) to be equal at that point.

When the production function exhibits constant returns to scale, then the following are equivalent restrictions on \( F(x) \) at any point in input space:

(i) Weak separability of \( N_s \) with respect to the portion \( R \),

(ii) Equality of AES \( \sigma_{ik} = \sigma_{jk} \) for all \( i, j \in N_s, k \in N_s \),

(iii) The existence of a consistent aggregate price index \( P^S \) and consistent aggregate quantity index \( X^S \) on elements of \( N_s \).

Theorem 4. Strong separability of \( F(x) \) with respect to the partition \( R \) at any point in input space is necessary and sufficient for all proper AES \( \sigma_{jk}, \sigma_{ik} \) \((i = N_s, j \in N_t, k \in N_s \cup N_t)\) to be equal at that point.

Theorem 5. Complete strong separability of \( F(x) \) at any point in input space is necessary and sufficient for all proper AES \( \sigma_{ij} \) to be equal at that point.
Complete strong separability denotes the partition with \( r = n \) subsets where each factor input quantity forms its own subset. When the concept is applied to all points in input space, theorem 6 is obtained.

Theorem 6. The following three restrictions on \( F(x) \) are equivalent:

(i) Complete strong separability at every point in input space,
(ii) Equality and constancy of all proper AES,
(iii) \( F(x) \) can be written in the form:

\[
F(x) = L(\sum_{i} a_i \log X_i)
\]

where \( L \) is any twice-differentiable strictly monotone increasing function and the \( a_i \) are constant.

Theorem 4 implies that the multifactor constant elasticity of substitution (CES) production function, with the Cobb-Douglas (C-D) as a special case, is compatible with complete strong separability at every point in input space. The implication of theorem 4 for this study is that with strong separability, production functions such as the CES (with C-D as a special case) are valid; while without it a more complex functional form such as modified Cobb-Douglas, variable elasticity of substitution, or translog is needed.

It is not only important to use a valid functional form for a production analysis. The restrictions or features which are associated with a functional form should be thoroughly examined to ensure that it is flexible enough to serve the purpose at hand. Even if the
"appropriate" form is selected for an analysis, another potential source of error is the statistical specification of an economic model to be used.

A final problem to be recognized is the problem involved in direct estimation of manufacturing production function. If all the variables in a specified function are endogenous, then a direct estimation of a single equation function could lead to simultaneous equations bias. However, if it is assumed that the objective of a firm is to maximize expected profit and if expected output \( E(q) \) is different from actual output \( q \), then direct estimation is feasible.

In the quest for an appropriate algebraic form of a function for analysis, useful guides can be obtained by understanding the environment in which the production process or phenomenon occurs. Some useful factors for such an exercise are biological and/or economical in nature and can be attained from prior information. Theoretical fruitfulness and computational manageability of function are also important in selecting an appropriate algebraic form to represent the production process. Because of the cumulative nature of scientific knowledge and previous research done in production analysis of manufacturing industries, the task of searching for the appropriate functional form(s) underlying manufacturing production processes can be considerably reduced by making use of findings from previous studies.

Besen (1967) attempted to find out if a generalized constant elasticity of substitution (CES) production function, which allows for non-constant returns to scale, is an appropriate representation of the production processes in United States manufacturing industries.
He used data on manufacturing establishments across states within two-digit manufacturing industries and tested the hypotheses that:

(a) elasticity of substitution is unity;
(b) there are constant returns to scale.

In 19 out of the 20 industries, hypothesis (a) was not rejected and in 15 out of 20 cases hypothesis (b) was also not rejected. Besen (1967, p. 281) concluded the study by suggesting that "Thus, it appears that within the class of CES production functions, the unitary elasticity of substitution production functions need not be rejected in favor of a more general form . . . " Griliches (1968, p. 292) using aggregate data to analyze the United States manufacturing sector concluded that: "in general, all the estimated elasticities are not different from unity, the significant deviation if anything occurring above unity rather than below it." Sines (1975) also found that a hypothesis that elasticity of substitution is equal to unity could not be rejected based on the data he used. The implication for variable specification is that weak separability allows one to consistently aggregate (or disaggregate) factors of production. Strong separability provides conditions for functional form. The literature reviewed indicates that the functional forms used for previous studies have imposed strong separability. If any of the inputs used in such studies are not separable, then it implies that inappropriate functional forms were used for those production analyses.
Value Added Versus Gross
Output Production Functions

Most manufacturing production studies (Griliches, 1968; Besen, 1968; Hildebrand and Liu, 1965) have used value added instead of gross output functions. The value added approach is the most common method used when information on intermediate inputs is not directly available. Gross output is used in this study as the dependent variable instead of value added because the latter approach underplays the importance of one of the major components of factors of production (intermediate inputs) in most manufacturing industries. The value added approach does not treat intermediate inputs as a direct input. Such an approach could result in misspecification of a function since it assumes that the elasticity of substitution between intermediate inputs and all other inputs is zero.

Sines (1975, pp. 137-145) has shown that the value added specification leads to inconsistencies in parameter estimates and poorer fit; while the gross output specification gives better results and produces no inconsistencies in estimates.

Functional Forms Used in the Study

Drawing from the works of Griliches (1968), Hildebrand and Liu (1965), Besen (1967), Christensen (1973, pp. 28-45) and more recently the study of Sines (1975), Cobb-Douglas, modified Cobb-Douglas and transcendental logarithmic production functions are utilized in this study. A Cobb-Douglas production function is used as a working hypothesis and tested against a modified Cobb-Douglas, and a transcendental logarithmic (translog) production function. These functions were
selected because (i) they are easy to use since they are linear in the logarithmic forms and can be estimated directly by ordinary least squares method, and (ii) the modified Cobb-Douglas and the translog can be used to test for separability of inputs. Gross output is used as the dependent variable.

The Cobb-Douglas Function

The Cobb-Douglas production function is very popular, convenient for estimation purposes (because it is linear in the logarithms of the variables) and has the ability to handle more than two inputs. The mathematical form of the function is:

\[ O = A \alpha_1 X_1 \]

where \( O \) is the gross output, \( X_1 \) the inputs, \( A \) and \( \alpha_1 \) are parameters to be estimated. Economic theory suggests certain concepts or properties which are useful in production analysis: marginal productivity, the degree of substitutability of factors, economics of scale, extent of labor or capital intensity of the production process, and efficiency.

One of the crucial concepts in the theory of production is the marginal product. It is the partial derivative of the output with respect to an input, holding all the other inputs constant. From equation (2) the marginal product of the \( i \)th input (\( MP_i \)) is:

\[ \frac{\partial O}{\partial X_i} = \alpha_i \frac{O}{X_i} \]

The elasticity of production (output elasticity) is defined as the percent change in output with respect to a one percent change in input. The elasticity of production is defined as:
By substituting for \( \frac{\partial O}{\partial X_1} \) from equation (3), equation (4) becomes:

\[
E_i = \frac{\partial O}{\partial X_1} \frac{X_i}{O} = \alpha_i, \quad 0 < \alpha_i < 1
\]

Hence in the Cobb-Douglas function, the elasticity of production is the exponent of the respective input, which is constant and does not vary over the range of the function.

The marginal product of each input is expected to be positive and decrease with increases in the input level, given other inputs. From equation (3), the marginal product is positive so long as \( \alpha_i \) is positive. The diminishing (decreasing) characteristic of the marginal product is shown by differentiating equation (3) with respect to \( X_1 \):

\[
\frac{\partial^2 O}{\partial X_1^2} = \alpha_i (\alpha_i - 1) \frac{O}{X_1^2}
\]

Equation (6) is negative since \( \alpha_i \) is restricted to be less than unity.

Theoretically, the sum of the output elasticities yields the measure of economies of scale. If \( \Sigma \alpha_i \) is less than one, greater than one, or equal to one, then there is decreasing, increasing, or constant returns to scale, respectively. However, in interpreting returns to scale, the possibility of specification error with respect to the inputs of production must be considered.

A measure of factor substitutability which is free from units of measurement is the elasticity of substitution. It is defined as the measure of the relative responsiveness of the ratio of two inputs to
changes in the marginal rate of technical substitution between the two inputs. The formula is:

\[
\sigma_{ij} = \frac{d(X_i/X_j)}{X_iX_j} - \frac{MRTS_{ij}}{d(MRTS_{ij})}
\]

In the Cobb-Douglas case, the elasticity of substitution for any two factors is unity.

The ratio of the elasticities of output is useful in defining the degree of factor intensity in the production process. The larger the \(\alpha_i/\alpha_j\) ratio, in two input cases, the more \(X_i\) intensive is the production process if input price ratio is constant.

Efficiency in a production process is determined by how resources are allocated for a given production process. If perfect markets are assumed, then the condition for efficient allocation of resources is to equate the marginal productivity of each resource with its real price (wage). In the Cobb-Douglas, this condition for resource allocation is:

\[
\frac{\sigma_0}{\sigma_i} = \alpha_i X_i = W_i
\]

where \(W_i\) is the money wage or price of factor \(i\). Comparison can then be made between marginal productivity and the opportunity cost for each productive input.

The Cobb-Douglas function implies strong separability and that elasticity of substitution between two inputs is equal to unity. In addition, the specification of the function only allows for the worker effect and no allocative effect. If management is a basic input, then the Cobb-Douglas specification implies that managers contribute only
worker effect. In this respect, the popular Cobb-Douglas production function is not capable of determining the allocative effect of managers.

Modified Cobb-Douglas Model

The constant elasticities of production assumption which characterizes the Cobb-Douglas model has been a worrisome one for users of the model. If different production techniques do exist in any defined area, then it is possible that partial output elasticities differ among firms. The implication is that not all inputs are strongly separable. For example, if managers have significant allocative effect, then managers will not be separable from the other inputs. There may be differences in techniques of production among firms or industries in one locality or region if, for instance, some firms are able to attract better trained or more educated labor than others or when some firms are more capital intensive while others may be labor intensive.

The modified Cobb-Douglas model is used to determine if the constant elasticities of production assumption is unrealistic for manufacturing processes in the five-county area, and therefore make the Cobb-Douglas model an inappropriate model for analyzing production processes in the area. To account for possible variations in output elasticities, Ulveling and Fletcher (1972, pp. 234-237) have introduced a Cobb-Douglas production function with variable returns to scale. Their model allows for variable partial production elasticities and returns to scale. The modified Cobb-Douglas function is:
For the purpose of this study $b_i(D_j)$ is defined as:

$$b_i(D_j) = b_i + b_i^*D_j$$

The various production elasticities are assumed to be influenced by the variable "D". The choice of "D" is not restricted beyond the requirement that it should be quantifiable. It could be one or more variables which are assumed to affect the partial production elasticities of one or more of the inputs, and hence, returns to scale. It might represent quality of labor, different types of capital, different levels of managerial abilities, etc. If the "D" variable is a ratio, then the function will be homogeneous, but if it is a simple variable, then the function becomes non-homogeneous.

From equation (10), the marginal product of the $i$th input is:

$$\frac{\partial Q}{\partial x_i} = f_i = (b_i + b_i^*D_j) \frac{0}{x_i}, \text{ for } i = 1, 2, \ldots, n;$$

and assuming that $\frac{\partial (D_j)}{\partial x_i} = 0$.

The elasticity of production for the $i$th input is represented as:

$$E_i = \frac{\partial Q}{\partial x_i} \frac{x_i}{Q}$$
Using the value of $f_i$ from equation (11):

\[
E_i = (b_1 + b_i^* D_j) \frac{0}{X_i} X_i
\]

(12')

\[
= (b_1 + b_i^* D_j)
\]

From equation (12'), the elasticity of production is not constant but varies with $D_j$ as long as $b_i^*$ is not equal to zero.

The elasticity of substitution between two inputs is obtained by using equation (13).

\[
\sigma_{ij} = \frac{-f_i f_j (X_i f_i + X_j f_j)}{X_i X_j (f_i^2 f_{ii} - 2f_i f_j f_{ij} + f_j^2 f_{jj})}
\]

From equation (10), the following properties are derived:

(14a)

\[
f_{ii} = (b_1 + b_i^* D_j) - 1)(b_1 + b_i^* D_j) \frac{0}{X_i^2}
\]

(14b)

\[
f_{ij} = f_{ji} = (b_1 + b_i^* D_j)(b_1 + b_i^* D_j) \frac{0}{X_i X_j}
\]

By substituting equation (11) and (14) in equation (13), the elasticity of substitution between any two inputs is obtained. The extent to which the inputs are substitutable, is then influenced by the $b$s, $b_s$ the inputs as well as the "$D_j$" variable. If "$D_j$" is a direct input or a ratio of any of the direct inputs, then elasticity of substitution will no longer be restricted to unity as in the Cobb-Douglas model.

In this study it is hypothesized that management influences the production elasticities of the other inputs. Management intensity is defined as the ratio of management services to each of the inputs
Three formulations are used. The first is:

$$0 = A M b_0 (b_i + b_i^* \frac{M}{X_i^1})$$

where $0$ is gross output, $A, b_0, b_i, b_i^*$ are parameters to be estimated, $M$ is management services and $X_i^1$ the other inputs. The input variables for the modified C-D and the translog functions are transformed before they are used for estimation. The transformation involves the creation of a ratio with each input as the numerator and the sample arithmetic mean of the appropriate input as the denominator. The transformation technique used is:

$$z_i = \frac{X_i}{X_i^1}, \quad 0 = \frac{0_i}{0}, \quad M = \frac{M_i}{M}$$

where $X_i^1 = \text{sample arithmetic mean of } X_i$

$X_i = \text{input; } i=1, \ldots, n$

$0 = \text{sample arithmetic mean of output}$

$0_i = \text{output for the } i\text{th firm; } i=1, \ldots, n$

The marginal productivity ($F_i$) for the inputs are:

$$f_i = \frac{0}{X_i} (b_i + b_i^* \frac{M}{Z_i^1}) - (b_i^* \frac{M}{Z_i^1} \ln Z_i)$$

$$f_m = \frac{0}{M} (b_0 + \sum b_i^* \frac{M}{Z_i^1} \ln Z_i)$$

Although this approach is used, the transformation can also be done by transforming the regression results based on the raw variables.

The same scaling technique was used by Shih (1975, p. 23)
The elasticities of production ($E_i$) as defined in equation (12) are:

\begin{equation}
E_i = (b_i + b_{iZ_1}^M) - (b_{iZ_1}^M \ln Z_1)
\end{equation}

\begin{equation}
E_m = (b_0 + \sum_{Z_1} b_{iZ_1}^M \ln Z_1)
\end{equation}

The specification of the modified Cobb-Douglas, as is in equation (15), allows for both allocative and worker effects. The function does not impose strong separability between $M$ and $X_i$, but it does between $X_i$ and $X_j$. The ability of the function to capture specific interactions between management and other inputs is the attractive feature of the modified Cobb-Douglas as far as this study is concerned, since the feature enables one to test for allocative and worker effects.

The second version of the modified Cobb-Douglas function used is:

\begin{equation}
0 = AM^{\theta_1} \theta_{11} + \theta_{12} \ln(M)
\end{equation}

where $0$, $A$, $M$, and $X_i$ are as defined for equation (15) and $\theta_0', \theta_1'$, and $\theta_1''$ are parameters to be estimated.

\begin{equation}
f_i = \frac{0}{X_i}((\theta_1' + \theta_1'' \ln(M)) - (\theta_1'' \ln(Z_i))
\end{equation}

\begin{equation}
f_m = \frac{0}{M}(\theta_0' + (\sum_1^{\theta_1'' \ln(Z_i)})
\end{equation}

\begin{equation}
E_i = ((\theta_1' + \theta_1'' \ln(M)) - (\theta_1'' \ln(Z_i)))
\end{equation}
The third version of the modified Cobb-Douglas function is:

\[
E_m = (\theta_o + \sum \theta_i \ln(Z_i))
\]

(24)

The third version of the modified Cobb-Douglas function is:

\[
0 = AM_i n X_1 \quad \gamma_o (\gamma_1 + \gamma_1 \ln(M) + \gamma_1 \ln(X_1))
\]

(25)

where the \(\gamma\)s are parameters and all other variables are as defined for equation (15).

\[
f_i = \frac{O}{X_1}((\gamma_1 + \gamma_1 \ln(M) + \gamma_1 \ln(Z_1)) + O(\ln(Z_1)\left(\frac{\gamma_1}{M} + \frac{\gamma_1}{Z_1}\right))
\]

(26)

\[
f_m = \frac{O}{M}(\gamma_o + \sum Z_1 \ln(Z_1) + \sum \frac{\gamma_1}{Z_1} M)
\]

(27)

\[
E_i = ((\gamma_1 + \gamma_1 \ln(M) + \gamma_1 \ln(X_1)) + O(\ln(Z_1)\left(\frac{\gamma_1}{M} + \frac{\gamma_1}{Z_1}\right))
\]

(28)

\[
E_m = (\gamma_o + \gamma_1 \ln(Z_1) + \gamma_1 \ln(M) Z_1)
\]

(29)

Equation (25) is an unconstrained form of equation (20) in the sense that it does not constrain \(\gamma_1\) to have a negative sign. The formulation in equation (20) constraints \(\gamma_1 = -\gamma_1\). Apart from the restrictions imposed in equation (20), the two functional forms are identical.

Transcendental Logarithmic Production Function (Translog)

It is reasonable to assume that in production processes, some inputs may interact with others and that such interaction could be meaningful in understanding the total production process. The third function used in this study is a translog function which is capable of determining more general interaction effects of specified inputs.
The form and derivation of the properties of the translog function draws heavily from Christensen (1971, pp. 28-45), Layard (1971, pp. 154-166) and Shih (1975, pp. 22-25). The function is represented as:

\[(30) \quad \ln O = \ln A + b_i \ln X_i + \frac{1}{2} \Sigma C_{ij} \ln X_i \ln X_j\]

where,

- \(O = \) output
- \(X_i, X_j = \) inputs
- \(A, b_i = \) parameters as defined for the Cobb-Douglas model
- \(C_{ij}, C_{ji} = \) parameters (coefficients of interaction terms)
- \(C_{ij} = C_{ji} = \) a symmetry restriction imposed because the Hessian of the production function is symmetric.

The difference between the translog function presented in equation (30) and the logarithmic form of the Cobb-Douglas function is the addition of the last term in equation (30). It is this modification that allows for the interaction between inputs and also relaxes the assumption of unitary elasticity of substitution.

Equation (30) is obtained as a second order Taylor Series expansion around the point \(\ln X_i = 0\) for all inputs. If the modified Cobb-Douglas, as presented in equation (25), is generalized, a translog function is also obtained.

The marginal product for the \(i\)th input is:

\[(31) \quad f_i = (b_i + \Sigma C_{ij} \ln x) \frac{O}{X_i}\]
Output elasticity \((E_i)\) becomes:

\[
E_i = b_1 + \sum_{j}^{} C_{ij} \ln z_j
\]

The output elasticity will not be a constant as in Cobb-Douglas except when \(\ln z_j\) is equal to zero for all \(j\). The returns to scale are defined as:

\[
\Sigma E_i = \Sigma (b_1 + \sum_{j}^{} C_{ij} \ln z_j)
\]

The final property of interest is the elasticity of Substitution, which is presented as equation (34)^6

\[
\sigma_{ij} = \frac{-(b_i + b_j)}{b_i + b_j - C_{ii} b_i^2 - 2C_{ij} b_i b_j + C_{jj} b_i^2}
\]

Beyond the interesting features of the function (capability of not restricting the \(\sigma_{ij}\) to unity, and the determination of the interaction effect between any two inputs) the function has some drawbacks. The main disadvantages of the function are:

1. There are large numbers of adjustable parameters;
2. It requires calculation of functions of the coefficients to produce estimates for marginal products and elasticities of substitution, and even then only asymptotic standard errors for the parameters are possible;
3. The production function may not be a concave function of the inputs, so minimum cost method of production for any output may not exist.

^6The formula is derived in Layard (1971, p. 157).
The translog function can be used as an approximation of CES by imposing certain restrictions (Kmenta, 1967; p. 180). If $C_{ij}$ are restricted to be zero for all $i$ and $j$, then the function reduces to a Cobb-Douglas function. The modified Cobb-Douglas in equation (25) is obtained by imposing $C_{ij} = 0$ for all second order terms except the $(\ln Z_i)^2$ and those which involve the management variable. The translog function does not impose strong separability between any two inputs. The allocative and worker effect become more difficult to distinguish if interactions occur between inputs not involving management.

**Human Capital and Labor Turnover**

Human capital can be in either general form, specific form, or both forms at a point in time (Becker 1964; Parsons 1972). If an individual accumulates skills or knowledge which is peculiar to a specific firm and hence finds it economically difficult to move into an alternative job, then such an individual is thought of as having firm specific human capital. The greater the cost of adjusting (information, transfer, and retraining cost) to an alternative job, the greater the specificity of the human capital formed.

The separation of specific human capital into firm financed and worker financed components is useful in understanding quit and layoff decisions, and how such decisions affect profitability of specific human capital. Research on labor turnover up to date can be grouped under two approaches. The first group of analyses basically use a traditional eclectic approach in analyzing quit rates. Some of the studies in this area are Burton and Parker (1969, pp. 199-216), Pencavel (1969), and Stoikov and Raimon (1968, pp. 1283-1293).
The second group of analyses has used the specific human capital approach in analyzing labor turnover rates. Oi (1967), Mincer (1962, pp. 50-79) and Rosen (1966) used the specific human capital approach in their labor turnover studies. However, they failed to distinguish between quit and layoff components. Telser (1969) and more recently Parsons (1972, pp. 1120-1142) also used the specific human capital approach in analyzing labor turnover. Telser and Parsons further decomposed labor turnover into quit and layoff rates. The decomposition of labor turnover into these two distinct components makes the interpretation of labor turnover analysis more meaningful. Parsons then tested the investment hypothesis that "quit rates are negatively related to worker-financed (owned) specific human capital, while layoff rates are negatively related to firm financed (firm-owned) specific human capital" on some three-digit manufacturing industries for the U.S. His findings supported the investment hypothesis.

**Related Theory of Specific Human Capital and Quit and Layoff Rates**

Specific human capital (SHC) is defined as the difference between the discounted sum of the worker's marginal product in his present firm and his greatest discounted marginal product net of transfer cost in alternative firms. This is mathematically represented as:

\[
SHC = \sum_{t=0}^{N} \left( MP_{jt} - (MP_{it} - C_{it})s^t \right)
\]

The definition and its mathematical representation can be found in Parsons (1972).
where $N$ is the remaining working life of the worker, $MP$ is the value of marginal product, $C_i$ is the total cost of transfer from present job$_j$ to firm$_i$, and $\delta$ is $\frac{1}{1+r}$, where $r$ is the interest or discount rate.

There are two major features which affect the relationship between specific human capital and labor turnover. These are (a) the volume and (b) its division into worker and firm financed human capital. These components are incorporated into the definition in equation (35) to obtain:

$$
(36) \quad \text{SFC}_j = \text{SFC}_{fj} + \text{SFC}_{wj} = \sum_{t=0}^{N} \left( (MP_{jt} - W_{jt}) \delta^t \right)
$$

$$
+ \sum_{t=0}^{N} (W_{jt} - (MP_{jt} - C_{it}) \delta^t
$$

where $W_{jt}$ is wage rate in current employment for an individual worker.

The breakdown of labor turnover into quit and layoff components, and the distinction between firm-financed and worker-financed specific human capital, enables a determination of how the turnover components are influenced by the type of specific human capital.

If it is assumed that an entity (worker or firm) wants to maximize the returns on its investment in human capital, then one would expect that quit behavior (an act which is initiated by an individual worker) would be influenced by the worker-financed specific human capital; while layoff behavior (an act which is initiated by a firm) would be influenced by firm-financed specific human capital.
Drawing from Parsons (1972), quit and layoff behavior may then be represented as follows:  

\[
\begin{align*}
(37) & \quad l_y = f(S_f, D) \\
(38) & \quad q = q(S_w, D)
\end{align*}
\]

where \( l_y \) = layoff rate
\( S_f \) = firm-financed specific human capital
\( D \) = some dynamic elements which cause specific capital to change (increase) seasonally or cyclically
\( q \) = quit rate
\( S_w \) = worker-financed specific human capital.

The investment hypothesis holds that layoff rates are negatively related to firm-financed specific human capital, while quit rates are negatively related to worker-financed specific human capital. Hence, a change in quit or layoff rate due to a change (increase) in \( S_f, S_w, \) or \( D \) is expected to be negative:

\[
\begin{align*}
(39) & \quad \frac{\partial l_y}{\partial S_f}, \frac{\partial l_y}{\partial D} < 0 \\
& \quad \frac{\partial q}{\partial S_w}, \frac{\partial q}{\partial D} < 0
\end{align*}
\]

Because \( S_f \) and \( S_w \) cannot be measured directly, it is impossible to estimate (37) and (38), so some indirect approach has to be used. The approach used by Parsons (1972) is utilized here. \( S_w \) and \( S_f \) are redefined for a single period as:

---

8 The quit and layoff in (37) and (38) are rates per production worker for a firm. All terms which refer to an individual in a specific (jth) job will carry subscript "j".
\[ S_f = MP - W \]
\[ S_w = W - (WA - TC) \]

where \( W \) = wage in current job
MP = marginal product
WA = alternative wage
TC = transfer cost.

The human capital approach holds that \( W \) is a function of the quantity of general human capital \((G)\) and worker-specific human capital \((S_w)\) embodied in a worker. To a linear approximation:

\[
W = \alpha_1 G + \alpha_2 S_w; \quad \alpha_1, \alpha_2 > 0
\]

Solving for worker-specific human capital,

\[
S_w = \frac{W}{\alpha_2} - \frac{\alpha_1}{\alpha_2} G
\]

Since the rate of return received by the worker on these two forms of capital should be roughly comparable, it is assumed that \( \frac{\alpha_1}{\alpha_2} = 1 \). Hence,

\[
S_w = \frac{W}{\alpha_2} - G
\]

where \( \frac{W}{\alpha_2} \) is the capitalized value of the worker's income stream. Let

\[
G = T - S
\]

where \( T \) = total marketable human capital, and
\( S \) = total specific human capital.

\[ ^9 \text{G is the multiperiod equivalent of WA-TC.} \]
The total marketable human capital and the total specific human capital are functions of various human investments undertaken by an individual and/or firm.\(^{10}\) Considering the human capital of workers in a given firm,\(^{11}\) the variables which are expected to influence \(T\) and \(S\) per worker are indicated in (44) and (45).

\[
(44) \quad T = (EDUC, BRTEN, UNION, FEM, YOUNG, OLD)
\]

\[
(45) \quad S = (WAGE, EDUC, BRTEN, UNION, FEM, YOUNG, OLD)
\]

where \(EDUC\) = mean years of school completed

\(BRTEN\) = percent of production workers with the firm for a short time

\(UNION\) = percent of production workers unionized

\(FEM\) = percent of female workers

\(YOUNG\) = percent of young workers

\(OLD\) = percent of old workers

\(WAGE\) = average wage rate of production workers.

In terms of regression variables \(T\) per production worker is expected to increase with direct measures of years of schooling. Length of time (tenure) with a firm is a qualitative measure of skill, hence a short or brief tenure is expected to be negatively related to total human capital. Inasmuch as industries with strong unions pay high wages, entrance to such industries will generally require investments by the

\(^{10}\)Such investments could be in formal education, on-the-job training, etc.

\(^{11}\)Individual firms are used as the unit of observation in the regression analysis; hence, \(T, S, S_w, S_f\) are discussed from the perspective of each firm's production worker force (i.e., per worker).
production worker, so the presence of unions is expected to be positively related to $T$. Because females are generally viewed as having higher turnover rates, fewer firms would finance the acquisition of on-the-job training by females. Such discrimination against women in the acquisition of human capital leads to women generally having relatively less human capital; therefore, the percent of production workers who are female is expected to be negatively related to total human capital. Young people will have relatively less total capital because they are still investing and accumulating total human capital, hence a negative relationship is expected between $\text{Young}$ and $T$. Old people are expected to have greater investment in human capital, but at the same time they will have greater depreciation in the investment they have made. An expected relationship with $T$ therefore depends on the magnitude of the two factors. The above discussion leads to the expected signs of the variables in equation (44).

The factors which are expected to influence specific human capital are those related to decreased transferability of production workers due to either lack of demand for the skill or high search and transfer cost. Education as a measure of skills of a worker is expected to increase the amount of specific human capital. Tenure is a proxy for on-the-job training (formal or informal) and other information or knowledge about the organization. A worker with brief tenure is expected to have less information, knowledge, and specific skills, hence brief tenure is expected to be negatively related to specific...
human capital. Highly unionized industries are more likely to have relatively more specific human capital per worker. Since production workers are expected to have made some investments to be able to get jobs in such industries, it is expected that most of such investments might be firm specific. Union is therefore expected to be positively related to specific human capital. Firms may be reluctant to provide specific training to workers who are likely to have higher turnover rates. Since females are generally viewed to have higher turnover rate, fewer firms are expected to finance the acquisition of specific human capital by females. Such discrimination against women leads to women generally having relatively less specific skills. This suggests that they would change jobs more frequently than men (because they have relatively more general human capital). However, due to high cost of hiring, firms would not readily hire females. This in turn imposes higher costs of job hunting on women and could cause them to stay longer with their current jobs and acquire more specific skills. The expected relationship of female to specific human capital, therefore, depends on the magnitude of the two effects.

Wages or income are directly related to transfer cost. The higher the wage of an individual, the higher the opportunity cost of his time. The physical cost of transfer from one job to another may also be increased since personal belongings are highly correlated with income. High wage rates are expected to lead to fewer transfers, which in turn leads to more firm specific human capital. Wage rate is therefore expected to have positive relationship with specific human capital. The more young workers an industry has, the greater the
chances of transfer from one job to another. Transfer cost becomes less because (1) personal belongings and other social investments made by young workers are relatively small, (2) specific training accumulates over time and young workers primarily have general training.

Young then is expected to be negatively related to specific human capital. Old people may be less mobile because (1) they have accumulated more specific capital and transfer cost may be high; (2) they may have family ties and sentimental attachments to their work, community, and friends; and (3) they have fewer years to capture returns on any investments made after transfer from one job to another. Old is therefore expected to have a positive relationship with specific human capital. The expected signs in equation (45) were imposed based on the above arguments. The models represented as equations (44) and (45) will provide the basis for derivation of quit and layoff equations which will be derived below and estimated in Chapter V.

Derivation of Relationships Between Dependent and the Independent Variables

The relationships between the quit rate and the independent variables are obtained mathematically from:

\[
\frac{\partial q}{\partial X_1} = \frac{\partial q}{\partial S_w} \frac{\partial S_w}{\partial X_1},
\]

where \( q \) = the quit rate, and

\( X_1 \) = any variable expected to influence the stock of human capital and hence, \( q \). From equations (42) and (43):
Given the expected signs of \( \frac{\partial q}{\partial x_1} \), \( \frac{\partial S}{\partial x_1} \), and \( \frac{\partial q}{\partial x_1} \) from equations (44), (45), and (39), respectively, evaluation of equations (46) and (47) yields the following expected signs of the relationship between the quit rate and the specific variables.

\[
q = q(WAGE, EDUC, BRTEN, UNION, FEM, YOUNG, OLD)
\]

The coefficients of the ambiguous variables are of some interest since they provide information on the relative magnitudes of \( \frac{\partial q}{\partial WAGE} \) and \( \frac{\partial S}{\partial WAGE} \). The evaluations of \( \frac{\partial q}{\partial WAGE} \) and \( \frac{\partial q}{\partial EDUC} \) are provided as an illustration of how the signs in equation (48) are obtained.

\[
\frac{\partial q}{\partial WAGE} = \frac{\partial q}{\partial S_W} \cdot \frac{\partial S_W}{\partial WAGE}
\]

From equation (47), \( \frac{\partial S_W}{\partial WAGE} = \left( \frac{1}{\alpha_2} \right) + \left( \frac{\partial S_W}{\partial WAGE} \right); \frac{\partial S_W}{\partial WAGE} > 0 \) from equation (45).

From equation (39), \( \frac{\partial q}{\partial S_W} < 0 \), hence \( \frac{\partial q}{\partial WAGE} < 0 \).

\[
\frac{\partial q}{\partial EDUC} = \frac{\partial q}{\partial S_W} \cdot \frac{\partial S_W}{\partial EDUC}
\]

From equation (47), \( \frac{\partial S_W}{\partial EDUC} = -\frac{\partial T}{\partial EDUC} + \frac{\partial S}{\partial EDUC} \). From equation (44), \( \frac{\partial T}{\partial EDUC} > 0 \), and from equation (45), \( \frac{\partial S}{\partial EDUC} > 0 \), which results in \( \frac{\partial S_W}{\partial EDUC} \) being indeterminate. Since \( \frac{\partial q}{\partial S_W} < 0 \), if \( \frac{\partial T}{\partial EDUC} > \frac{\partial S}{\partial EDUC} \), then \( \frac{\partial q}{\partial EDUC} > 0 \),
and if \( \frac{2S}{\delta \text{EDUC}} > \frac{2T}{\delta \text{EDUC}} \), then \( \frac{2q}{\delta \text{EDUC}} < 0 \). There are so many ambiguous signs in the quit rate equation due to the \( \left( -\frac{2T}{\partial x_1} + \frac{2S}{\partial x_1} \right) \) expression from equation (47) coupled with the fact that the partial derivatives of \( T \) and \( S \) usually have the same sign.

For the layoff rate analysis,

\[
\frac{\partial y}{\partial x_1} = \frac{\partial y}{\partial S_f} \frac{\partial S_f}{\partial x_1}
\]

is used to derive the expected signs of the independent variables. By definition,

\[
S_f = S - S_w
\]

where \( S = \) total specific human capital. Substituting equations (42) and (43) into (50) yields:

\[
S_f = T - G - \frac{W}{\alpha^2} + G
= T - \frac{W}{\alpha^2}
\]

The expected regression signs for the independent variables in the layoff rate analysis are obtained through the use of:

\[
\frac{\partial S_f}{\partial x_1} = -\frac{1}{\alpha^2}; \text{ if } x_1 = \text{Wage}
\]

\[
(51)
\]

\[
\frac{\partial S_f}{\partial x_1} = \frac{\partial T}{\partial x_1}; \text{ if } x_1 \neq \text{Wage}
\]

From equations (39), (44), and (51), the following expected relationships are derived for the layoff rate:
(52) \[ ly = 1(\text{WAGE, EDUC, BRTEN, UNION, FEM, YOUNG, OLD}) \]

There are more firm sign expectations here because of the evaluation of equation (51). The evaluations of \( \frac{\partial ly}{\partial \text{Wage}} \) and \( \frac{\partial ly}{\partial \text{BRTEN}} \) are provided as illustrations of how the signs of the variables in equation (52) are obtained. From equation (49) \( \frac{\partial ly}{\partial \text{Wage}} = \frac{\partial ly}{\partial S_f} \times \frac{\partial S_f}{\partial \text{Wage}} \). From equation (51) \( \frac{\partial S_f}{\partial \text{Wage}} = -\left(\frac{1}{\alpha_2}\right) < 0 \). From equation (39) \( \frac{\partial ly}{\partial S_f} < 0 \), hence \( \frac{\partial ly}{\partial \text{Wage}} > 0 \).

\( \frac{\partial ly}{\partial \text{BRTEN}} = \frac{\partial ly}{\partial S_f} \times \frac{\partial S_f}{\partial \text{BRTEN}} \). From equation (51), \( \frac{\partial S_f}{\partial \text{BRTEN}} = \frac{\partial T}{\partial \text{BRTEN}} < 0 \) from equation (44). Since \( \frac{\partial ly}{\partial S_f} < 0 \) from equation (39), then \( \frac{\partial ly}{\partial \text{BRTEN}} > 0 \).
CHAPTER III

The area under study covers Athens, Gallia, Jackson, Meigs, and Vinton Counties. This five-county area which is in southeastern Ohio is part of Appalachia. For all practical purposes, the area is the least developed part of the State of Ohio. The economic status of the area is vividly depicted when the economy is compared to other parts of the State in terms of socio-economic measures of levels of living. The manufacturing sector has and continues to play an important role in the economic development of the region. The purpose of this chapter is to describe the role of manufacturing in the economy of this five-county area.

The Economy of the Five-County Region

For the purposes of this study, the economic activities discussed do not include Agricultural activities. The major industries which constitute the economy are classified as: Quarry and Mining, Contract Construction, Manufacturing, Transportation and Utilities, Wholesale and Retail Trade, Finance, Insurance and Real Estate, and Services. In Table 4 the distribution of employed persons (labor force) by major industry groups for the region is presented.

Employment in the Mining and Quarry Industry declined from 1960 to 1973. Mining employment started to pick up in 1974 and the momentum continued through 1975. Contract construction increased
TABLE 4. Major Industry Group, Employment, Non-Agricultural in the Five Counties (%)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Employment for the Region</th>
<th>Quarry and Mining</th>
<th>Contract Construction</th>
<th>Manufacturing</th>
<th>Transportation and Utilities</th>
<th>Wholesale and Retail</th>
<th>Finance, Insurance and Real Estate</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>14069</td>
<td>8.2</td>
<td>4.2</td>
<td>34.8</td>
<td>11.7</td>
<td>30.3</td>
<td>3.2</td>
<td>6.7</td>
</tr>
<tr>
<td>1970</td>
<td>16235</td>
<td>3.5</td>
<td>6.0</td>
<td>31.6</td>
<td>14.6</td>
<td>30.7</td>
<td>4.9</td>
<td>8.3</td>
</tr>
<tr>
<td>1971</td>
<td>24566</td>
<td>1.9</td>
<td>16.5</td>
<td>22.6</td>
<td>10.3</td>
<td>26.4</td>
<td>4.6</td>
<td>15.7</td>
</tr>
<tr>
<td>1974</td>
<td>34151</td>
<td>5.0</td>
<td>13.9</td>
<td>23.9</td>
<td>10.8</td>
<td>25.4</td>
<td>4.9</td>
<td>15.2</td>
</tr>
<tr>
<td>1975</td>
<td>23677</td>
<td>8.9</td>
<td>5.8</td>
<td>23.1</td>
<td>11.6</td>
<td>27.7</td>
<td>4.1</td>
<td>17.9</td>
</tr>
</tbody>
</table>

Source: Ohio Bureau of Employment
between 1960 and 1970 and continued to increase from 1971 to 1973. However, the proportion of the labor force employed in contract construction decreased from 13.9 percent in 1974 to 5.8 percent in 1975.

The manufacturing sector has experienced a decline in the proportion of the labor that it employed. With 34.8 percent of the labor force in manufacturing in 1960, the percentage of workers employed continued to decrease from 1970 through 1973, when it provided employment for 22.6 percent of the labor force in the region. In 1974 the proportion increased to 13.9 percent but it declined again to 23.1 percent in 1975. Transportation and utilities engaged 11.7 percent of the labor force in 1960. Its contribution toward employment opportunities increased in 1970 and 1971 but started to decline in 1973. There were increases in the proportion of the labor force employed by the sector in 1974 and 1975.

The wholesale and retail trade industry hired 30.35 percent of the labor force in 1960. It experienced a small increase in percent of labor force employed by 1970. There was a consistent decrease in the proportion of the labor force that it employed from 1971 through to 1974. Then in 1975, the sector started to pick up in its activities and percentage of labor force employed increased to 27.7. In 1960, 3.2 percent of the labor force were engaged in Finance, Insurance, and Real Estate activities. By 1970 the proportion of workers in the sector had increased to 4.9 and in 1971 it provided jobs for 5 percent of the labor force. Starting from 1973 with 4.6 percent of the labor force that decline continued through 1975 when it employed 4.1 percent of the labor force.
The proportion of the labor force engaged in the services in 1960 was 6.7 percent. By the end of 1970 the sector was providing employment for 8.3 percent of the total workers. The percentage of the labor force which was engaged in service activities in 1971 was 8.5, and by the end of 1973 it employed 15.7 percent of the labor force. However, in 1974 its share of employment decreased to 15.2 percent but increased again in 1975 to 17.9 percent.

The manufacturing sector had been the leading source of employment for 1960, 1970, and 1971. It has been followed in order of importance of job creation during the period by wholesale and retail trade, and transportation and utilities, respectively. The situation was changed in 1973 when wholesale became the leading employer with 26.4 percent of the labor force. Manufacturing moved to the second position employing 22.6 percent of total workers and it was followed by contract construction, and services with 16.5 percent and 15.7 percent of labor force, respectively. From 1974 to 1975, wholesale and retail continued as the leading employer in the region, when it employed 25.4 percent and 27.7 percent of the workers in 1974 and 1975, respectively. Next to wholesale and retail in order of provision of jobs was the manufacturing sector with 23.9 percent of the labor force in 1974 and 23.1 percent in 1975. Services moved to a third position by producing jobs for 15.2 percent of the workers in 1974 and 17.9 percent in 1975.

The distribution of employment by major industry groups for Ohio is presented in Table 3 of Appendix A. Using the last three years to compare the employment activities in the five counties with


the State of Ohio's economy, it is observed that the Manufacturing sector provided more jobs than any of the other sectors for the State. It was followed by the wholesale and retail trade sector, and services. Although the ranking positions vary slightly between the State and the region, the manufacturing, wholesale and retail trade, and the State and local government sectors stand out as the major generators of employment in both economies. A look at the employment distributions for the nation supports the relative importance of the above three sectors of the economies as the leading employers of the labor force over time. Table 5 presents the major industry group of employed persons from 1947 to 1972 for the nation. Total employment, as well as employment in manufacturing for the region, increased over time from 1960 up to 1974, but decreased in 1975.

The total payroll generated in the five-county region by the major industrial groups is presented in Table 6. Total payroll for all major industries as well as manufacturing has increased over time. In 1960, manufacturing with more employees than any other major sector provided 21.8 million dollars which is 39.5 percent of the total payroll. Wholesale and retail trade generated the second largest source of income of 12.8 million dollars, which is about 23.3 percent of the total. Transportation and utilities was third with 8.5 million dollars (15.5 percent). As evident from Table 6, manufacturing, wholesale and retail, and transportation maintained their 1960 rankings in 1970 and 1971. In 1973 contract construction with 16.5 percent of labor force produced the highest payroll of $55.3 million, which is about 23.6 percent of total payroll. It was followed by State and
<table>
<thead>
<tr>
<th>Year</th>
<th>Mining</th>
<th>Contract Construction</th>
<th>Manufacturing Durable Goods</th>
<th>Manufacturing Non-Durable Goods</th>
<th>Transportation and Public Utilities</th>
<th>Wholesale and Retail Trade</th>
<th>Finance and Insurance</th>
<th>Real Estate Services</th>
<th>Government</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947-49</td>
<td>2.2</td>
<td>4.7</td>
<td>18.2</td>
<td>16.1</td>
<td>9.3</td>
<td>20.8</td>
<td>4.1</td>
<td>11.7</td>
<td>12.8</td>
</tr>
<tr>
<td>1950-52</td>
<td>1.9</td>
<td>5.3</td>
<td>18.7</td>
<td>15.3</td>
<td>8.8</td>
<td>20.6</td>
<td>4.2</td>
<td>11.8</td>
<td>13.4</td>
</tr>
<tr>
<td>1953-55</td>
<td>1.6</td>
<td>5.3</td>
<td>19.2</td>
<td>14.7</td>
<td>8.3</td>
<td>20.7</td>
<td>4.5</td>
<td>12.1</td>
<td>13.5</td>
</tr>
<tr>
<td>1956-58</td>
<td>1.6</td>
<td>5.5</td>
<td>18.2</td>
<td>13.9</td>
<td>7.9</td>
<td>20.7</td>
<td>4.7</td>
<td>12.9</td>
<td>14.5</td>
</tr>
<tr>
<td>1959-61</td>
<td>1.3</td>
<td>5.4</td>
<td>17.3</td>
<td>13.5</td>
<td>7.4</td>
<td>21.0</td>
<td>5.0</td>
<td>13.8</td>
<td>15.5</td>
</tr>
<tr>
<td>1962-64</td>
<td>1.1</td>
<td>5.2</td>
<td>17.0</td>
<td>13.0</td>
<td>6.9</td>
<td>20.8</td>
<td>5.1</td>
<td>14.7</td>
<td>16.3</td>
</tr>
<tr>
<td>1965-67</td>
<td>1.0</td>
<td>5.1</td>
<td>17.4</td>
<td>12.4</td>
<td>6.5</td>
<td>20.8</td>
<td>4.9</td>
<td>15.0</td>
<td>16.9</td>
</tr>
<tr>
<td>1968-70</td>
<td>0.9</td>
<td>4.8</td>
<td>16.6</td>
<td>11.8</td>
<td>6.3</td>
<td>20.9</td>
<td>5.1</td>
<td>16.0</td>
<td>17.5</td>
</tr>
<tr>
<td>1971-72</td>
<td>0.9</td>
<td>4.6</td>
<td>15.0</td>
<td>11.3</td>
<td>6.3</td>
<td>21.5</td>
<td>5.4</td>
<td>16.9</td>
<td>18.2</td>
</tr>
</tbody>
</table>

TABLE 6. Income ($1,000,000) Distribution by Major Industry Group, Non-Agricultural, for the
Five Counties

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Income</th>
<th>Quarry and Mining</th>
<th>Contract Construction</th>
<th>Manufacturing</th>
<th>Transportation and Utilities</th>
<th>Wholesale and Retail</th>
<th>Finance, Insurance and Real Estate</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>55.2</td>
<td>4.8</td>
<td>2.6</td>
<td>21.8</td>
<td>8.5</td>
<td>12.8</td>
<td>1.8</td>
<td>2.3</td>
</tr>
<tr>
<td>1970</td>
<td>97.2</td>
<td>4.5</td>
<td>9.1</td>
<td>32.4</td>
<td>18.8</td>
<td>21.4</td>
<td>3.4</td>
<td>6.1</td>
</tr>
<tr>
<td>1971</td>
<td>107.</td>
<td>5.6</td>
<td>10.8</td>
<td>35.</td>
<td>20.5</td>
<td>23.1</td>
<td>4.8</td>
<td>6.7</td>
</tr>
<tr>
<td>1973</td>
<td>234.9</td>
<td>8.5</td>
<td>55.3</td>
<td>39.1</td>
<td>26.1</td>
<td>31.3</td>
<td>7.1</td>
<td>18.6</td>
</tr>
<tr>
<td>1974</td>
<td>288.3</td>
<td>16.</td>
<td>54.9</td>
<td>44.9</td>
<td>30.8</td>
<td>34.5</td>
<td>8.1</td>
<td>21.8</td>
</tr>
</tbody>
</table>

Source: Ohio Bureau of Employment
local government which generated $45.4 million, or 19.3 percent of the total payroll; while manufacturing provided 16.7 percent of total payroll, which was $39.1 million. In 1974 State and local government provided the highest income for the labor force. The sector generated $73.2 million, which is about 25.4 percent of the total payroll of $288.3 million. It was followed by contract construction with $54.9 million and manufacturing, which provided $44.9 million to its workers.

Shift Share Analysis\(^1\)

To provide additional information on how the manufacturing sector has performed in the five-county area, a shift-share analysis is used to compare manufacturing performance in the region to that of the nation from 1960 to 1970. The shift-share matrix for the region is presented in Table 7.

Nationally, manufacturing was a slow growth industry during the 1960-1970 decade.\(^2\) However, when manufacturing is decomposed into its major component industries, electrical and other machinery manufacturing, and miscellaneous manufacturing industries come out as rapid growth industries. The manufacturing sector in the five-county area had a slow growth industrial mix. All the major components of manufacturing with exception of electrical and other machinery, and

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\(^1\)The figures presented here are compiled from Shift-Share analysis for Ohio by the Ohio Department of Economic and Community Development, 1974.

\(^2\)The rate of growth of a particular national industry is characterized as rapid if it exceeds and slow if it falls short of the growth rate of all national industries combined over a given period. The growth rate for all industries in U.S. for 1960-1970 period was 18.3 percent.
TABLE 7. Shift-Share Matrix for the Five-County Region (1960-1970)

<table>
<thead>
<tr>
<th></th>
<th>NG</th>
<th>IM</th>
<th>RG</th>
<th>Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food and kindred products</td>
<td>155</td>
<td>-380</td>
<td>195</td>
<td>-32</td>
</tr>
<tr>
<td>Textile</td>
<td>72</td>
<td>-74</td>
<td>-102</td>
<td>-104</td>
</tr>
<tr>
<td>Lumber</td>
<td>138</td>
<td>-229</td>
<td>104</td>
<td>73</td>
</tr>
<tr>
<td>Printing</td>
<td>206</td>
<td>-204</td>
<td>-477</td>
<td>-474</td>
</tr>
<tr>
<td>Chemicals</td>
<td>118</td>
<td>-56</td>
<td>-12</td>
<td>50</td>
</tr>
<tr>
<td>Electrical</td>
<td>158</td>
<td>36</td>
<td>-168</td>
<td>25</td>
</tr>
<tr>
<td>Transportation</td>
<td>40</td>
<td>-12</td>
<td>114</td>
<td>142</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>464</td>
<td>36</td>
<td>406</td>
<td>930</td>
</tr>
<tr>
<td>Total</td>
<td>1351</td>
<td>-883</td>
<td>60</td>
<td>550</td>
</tr>
<tr>
<td>IM + RG = NC</td>
<td></td>
<td></td>
<td></td>
<td>-823</td>
</tr>
</tbody>
</table>

NG = Change related to national growth  
IM = Change related to industrial mix  
RG = Change related to regional share  
NC = Net relative change  
Δ = Total change

Source: Shift-share analysis for Ohio, by Paul Miller and Earl Stephanson, June, 1974.
miscellaneous industries were categorized as slow-growth. In general, the region had an unfavorable distribution of industries.

When the analysis is carried further down to county levels, each of the five counties also had a slow growth manufacturing sector. The shift-share matrix is presented in Table 2 of Appendix A. However, some counties experienced rapid growth in some of the major component industries. Miscellaneous manufacturing industries had rapid growth in Athens, Gallia, Jackson, and Vinton counties, while electrical and other manufacturing industries experienced rapid growth in all the counties.

Manufacturing employment grew in the region, although the rate of growth is less than in the country as a whole. The negative regional share contribution experienced in textile and fabricated textile products; printing, publishing and allied industries; chemical and allied products; and electrical and other machinery manufacturing industries were offset by rapid employment growth in food and kindred products; lumber and wood products; transportation equipment; and miscellaneous manufacturing industries.

The realized change in manufacturing employment in the region fell short of the national employment growth standard by 823 workers between 1960 and 1970. In Gallia county, during the same period, the realized change in manufacturing employment was 261 workers in excess of the national employment growth standard. Athens, Jackson, Meigs, and Vinton counties fell short of the national employment growth standard by 362, 547, 117, and 58 workers, respectively.
Manufacturing Activities in the Region

In this study, manufacturing industries were identified as all the industries which are classified as secondary industries. Because the census bureau uses more disaggregated components, and a considerable amount of information is also obtained from that data source, a second major classification of industries used in the study is the two-digit Standard Industrial Classification (SIC). Table 8 gives the composition of the two classifications used for those components located in the five-county region.

Table 9 presents the number and changes in firms established in the region from 1971 to 1975. The region experienced a net decrease in total number of established manufacturing firms from 158 in 1971 to 118 in 1973. With the exception of Meigs county, all the other counties experienced a decline in total number of established firms. In Athens county, there was a net loss of 15 established firms. Of the SIC-code firms that were in operation in 1971, twenty-three went out of business and six new ones were established by 1973. Three firms in new SIC codes were established during that period.

Gallia county lost three firms in total. Nine of the established firms died out; there were six new firms of which four were in SIC-codes firms which did not exist in the county. Jackson county had one firm in a new SIC-code, gained seven other firms, and lost 15 of those which were in operation in 1971, for a net loss of seven.

3This is the classification used by Ohio Department of Economic and Community Development.

4See Appendix A Table 3 for a detailed distribution of firms disaggregated for 17 SIC codes.
### TABLE 8. Major Classification of Manufacturing Industries

<table>
<thead>
<tr>
<th>SIC Code</th>
<th>SIC Method Type of Firm</th>
<th>Secondary Industries Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Food and kindred products</td>
<td>(a) Food and kindred products</td>
</tr>
<tr>
<td>22</td>
<td>Textile mill products</td>
<td>(b) Textiles and fabricated textile products</td>
</tr>
<tr>
<td>23</td>
<td>Apparel and other textile products</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Lumber and woods</td>
<td>(c) Lumber, wood products, and furniture</td>
</tr>
<tr>
<td>25</td>
<td>Furniture and fixtures</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Printing and publishing</td>
<td>(d) Printing, publishing, and allied industries</td>
</tr>
<tr>
<td>28</td>
<td>Chemical and allied products</td>
<td>(e) Chemicals and allied products</td>
</tr>
<tr>
<td>36</td>
<td>Electrical equipment and supplies</td>
<td>(f) Electrical and other machinery</td>
</tr>
<tr>
<td>38</td>
<td>Instruments and related products</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Miscellaneous manufacturing industries</td>
<td>(g) Miscellaneous manufacturing industries</td>
</tr>
<tr>
<td>35</td>
<td>Machinery except electrical</td>
<td>(h) Transportation equipment</td>
</tr>
<tr>
<td>32</td>
<td>Stone, clay and glass products</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Primary metal industries</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Fabricated metal products</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Leather and leather products</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td></td>
<td>No. of Firms</td>
<td>Net Δ OB NE NF</td>
</tr>
<tr>
<td>Athens</td>
<td>46</td>
<td>-15 23 6 2</td>
</tr>
<tr>
<td>Gallia</td>
<td>23</td>
<td>-3 9 2 4</td>
</tr>
<tr>
<td>Jackson</td>
<td>48</td>
<td>-7 15 7 1</td>
</tr>
<tr>
<td>Meigs</td>
<td>14</td>
<td>- 4 3 1</td>
</tr>
<tr>
<td>Vinton</td>
<td>27</td>
<td>-15 18 2 1</td>
</tr>
<tr>
<td>Region</td>
<td>158</td>
<td>-40 69 20 9</td>
</tr>
</tbody>
</table>

Δ = Change  
OB = Firms which went out of business  
NE = New firms in existing SIC codes  
NF = Firms in new SIC codes.

Source: Compiled from Ohio Directory of Manufacturers.
Meigs county lost four established firms and gained four of which one was a new SIC-code firm. In Vinton county, fifteen firms were lost. The county picked up one firm in a new SIC-code, gained two others, but lost 18 of the firms it had.

By the end of 1974, the direction of changes in established firms had been reversed. Meigs county experienced no net change in the total number of established firms it had. Of the firms in 1973, six were lost but six more were established. Athens county lost two of its firms but picked up nine more. No firms in new SIC-codes were established. In Gallia county there was a gain of three firms; however, two other firms went out of business. One firm was in a new SIC code. Jackson was the only county in 1974 which continued to lose firms. Eight firms were lost by the end of the year. Vinton county experienced a net gain of two firms, both in new SIC-codes. For the region as a whole, four firms were gained in 1974.

Another change in firm establishment activities in the region occurred in 1975. A net loss of 10 firms occurred during 1975. In Jackson county what seemed to be a trend of dying out of firms stopped. There was a gain of one firm. Meigs county had no net change in its established firms. The loss of two firms was offset by a gain of two other firms. In Vinton county, five firms which operated in the previous year went out of business. Gallia county experienced a loss of one of its established firms. The net loss of five firms in Athens county was due to the loss of seven firms and a gain of two firms.
Manufacturing Employment Potentials

The major contribution that a sector of an economy makes as far as the residents of the given area are concerned is the provision of jobs. Another factor used to assess the importance of a major industrial sector of an economy by its citizens is income generated by that sector. In Table 10 a summary of total number of workers employed by manufacturing industries and their total payroll is presented for the region. In Appendix A Table 4 this data is provided for each county.

By 1973 the proportion of the labor force employed by the manufacturing sector had declined to about 19 percent and hired 5429 workers. In 1973, the total employees' payroll was $39,137,800. In 1974, the percentage of the labor force engaged in manufacturing activities decreased further to 18 percent. A total of $44,935,500 was paid to 5909 people who worked in the manufacturing sector. If the services and the State and local government continue to increase their employment opportunities as has been happening since 1973, then it would be expected that the proportion of the labor force engaged in manufacturing as well as some of the other sectors might follow their decreasing trend as suggested by Table 4.

Characteristics of the Manufacturing Sample

Of the firms which responded adequately to the questionnaire, 68 percent were corporations, while 32 percent were individual proprietors or partnerships. To classify the firms into new and old

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5 For the rest of the chapter "firms" refers to those who completed the questionnaire. A firm as used in the study may be a single complete firm or a branch plant of a larger firm.
<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Employees</th>
<th>Total Payment ($1,000,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>4,900</td>
<td>21.8</td>
</tr>
<tr>
<td>1970</td>
<td>5,112</td>
<td>32.4</td>
</tr>
<tr>
<td>1971</td>
<td>5,254</td>
<td>35.1</td>
</tr>
<tr>
<td>1973</td>
<td>5,429</td>
<td>39.1</td>
</tr>
<tr>
<td>1974</td>
<td>5,909</td>
<td>44.9</td>
</tr>
</tbody>
</table>

Source: Compiled from the Ohio Directories of Manufacturers.
firms, all firms which were established before 1970 were classified as old and those established in or after 1970 were categorized as new firms. Of the firms, 83 percent were classified as old and 17 percent as new.

Sixty-nine percent of the firms reported increases in total sales for 1974 as compared to a comparable period five years earlier, or the first full reporting period if the plant was less than five years old. The mean increase in sales for these firms was 41 percent. Twenty-six percent of the firms reported no change in sales, while 6 percent experienced a decrease in sales with a mean of 15 percent. Summary characteristics of the sample is presented in Table 11.

The mean value of gross output for the manufacturing firms in the region was $1,024,035 and is expected to be lower than that of all manufacturing firms in the region. About 24 percent of the total output was sold in the townships where the firms are located, 40 percent in the county of plant location, and 56 percent in the five-county region. The percentage of the total output which was sold outside the region is approximately 44 percent. Intermediate inputs constituted a substantial portion of the capital required for production; its mean value was $501,987, while the mean value of variable and fixed capital utilized during the reporting period was $108,257. A relatively large proportion of the intermediate inputs was not purchased within the region. About 74 percent of the intermediate inputs were bought from outside the region. The region, county of plant location, and township of plant location provided 26, 18, and 8.5 percent of intermediate inputs, respectively.
TABLE 11. Summary Characteristics of the Sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output ($)</td>
<td>35</td>
<td>1024035.86</td>
<td>1619041.29</td>
</tr>
<tr>
<td>Intermediate input</td>
<td>35</td>
<td>501987.14</td>
<td>1272498.46</td>
</tr>
<tr>
<td>Fixed and Variable Capital</td>
<td>35</td>
<td>108257.81</td>
<td>140655.98</td>
</tr>
<tr>
<td>Managers</td>
<td>49</td>
<td>2.93</td>
<td>2.49</td>
</tr>
<tr>
<td>Workers</td>
<td>35</td>
<td>28.11</td>
<td>34.94</td>
</tr>
<tr>
<td>Average Employees</td>
<td>49</td>
<td>37.20</td>
<td>53.07</td>
</tr>
<tr>
<td>Hourly wage rate for production workers (non-professional)</td>
<td>49</td>
<td>13.39</td>
<td>.67</td>
</tr>
</tbody>
</table>
The mean employees per firm for the sample is 37. This is expected to be lower than that of all manufacturing firms in the region since many of the firms with large employees refused to cooperate in the study. About 42 percent of the production workers were classified by the management as skilled. Most of them acquired their skills through experience on the job or through formal on-the-job training that was financed solely by the firms. A very small proportion (6 percent) of the total employees for the firms resided outside the region. About 55 percent of all the employees resided in the township where the firms were located, while approximately 86 percent of total employees resided in the county of plant location. About 34 percent of the production workers were covered by collective bargaining agreements. However, when average employment of 10 was used to classify firms into large and small firms, none of the production workers in the smaller firms were covered by collective bargaining, while about 53 percent of the production workers in the larger firms were covered by collective bargaining agreements.

A large proportion of the production workers were between the ages of 24 and 55. Only 11 percent of the production workers were under 24 years of age. The percentage of production workers above 55 years of age was approximately 16 percent. Women were disproportionately represented in manufacturing employment in the firms. About 17 percent of the average employment was female, and with exception of a few cases almost all of them were engaged in clerical duties.

The mean wage rate per hour production worker was $3.39. In an attempt to generate some information on the formal education of the
workers, the following information was obtained.\textsuperscript{6} The estimated mean years of formal school completed was 11.2 for the firms. When asked to indicate the level of formal schooling that the management considers to be ideal or best when hiring production workers, 62 percent of the firms preferred less than high school training; 34 percent high school with general program; 28 percent high school with vocational program; 20 percent post high school with vocational or technical program, and 2 percent preferred post high school general training (2-year associate degree). It was also reported that approximately 33 percent of production workers had at least attained the ideal equivalent level of formal training through other means like on-the-job training, evening classes, and others.

\textsuperscript{6}See section VI of Questionnaire in Appendix B.
CHAPTER IV

The statistical models used for the production analysis are presented in this chapter. A brief description is given about the data and variable measurements are defined. The Cobb-Douglas, modified Cobb-Douglas, and the translog models are compared to each other so as to select the most "appropriate" function for the study. The most "appropriate" model is then used to analyze the sample and other sub-classifications of the sample.

The Data

The data used for the production analysis is primary in nature and was obtained through a survey of manufacturing firms in the five-county area as indicated in Chapter I. Thirty-nine out of the total of 138 questionnaires were returned completed to be used in this section of the study. Four of the completed questionnaires were not used in this analysis because their inclusion tended to yield unstable results. Three of them had very small (component) values for their intermediate inputs as compared to their outputs. The fourth one had an unusually high component of intermediate inputs. The unit of observation was individual firm and the data is for the 1974 calendar year or fiscal year ending between July 1, 1974, and June 30, 1975.
Dependent Variable

The firm gross output was defined as the sum of U.S. dollars of the value of total sales during the reporting period plus value of unfinished and unsold finished products at the end of the reporting period minus the value of unfinished and unsold finished products at the beginning of the reporting period.

Predetermined Variables

In the specification of the predetermined variables, the intent was to disaggregate the inputs into homogeneous groups as much as possible. The classifications used were arrived at after a series of experimentation with the data. Capital was disaggregated into two main groups: (a) intermediate inputs and (b) fixed plus variable capital.

The intermediate input was defined as the dollar value of raw materials, packaging materials, fuel and lubricants, and other purchased materials which were utilized during the reporting period. Hence, it is a flow concept. For the sample, the mean value of intermediate input was roughly one-half of the mean value of gross output.

Variable capital was the sum of dollar value of purchased services used during the reporting period. The services included the following: solid waste expenses, insurance expenses, publicity and advertisement, water, sewer, electricity, telephone, consultant services, and property tax. The fixed capital was obtained from stock of land, buildings, machinery (office and plant), transport equipment, and tools. To measure the flow of services from the stock of which was
actually used during the reporting period the following formula was used:

\[ F = 0.10 \left( \frac{1}{2} I + V \right) + (D + E) \]

where \( F \) = flow of service from a capital stock
\( I \) = investment made during the year in a given capital item
\( V \) = book value of an item
\( D \) = value of depreciation during the year
\( E \) = expenses incurred for renting an item.

In cases where depreciation and book value were not known, the following formulae were used:

\[ F = 0.15 (R) + E \]

or

\[ F = 0.20 (V + \frac{1}{2} I) + E \]

where \( R \) = replacement cost of an item.

There were six observations with missing values for either depreciation or replacement cost.

Labor was categorized into two major groups. The first group consisted of: (a) production workers, and (b) managers and professionals. The second group was made up of: (a) all other workers, and (b) managers.\(^1\) These were measured by average monthly employment.

Production workers consisted of skilled, unskilled, and semi-skilled production workers, and office workers. Attempts to disaggregate

\(^1\)See section V of the attached questionnaire for the definitions of the various labor groups.
production workers into skilled, and semi and unskilled revealed that for the set of data at hand, no distinction could be made between the two classes of workers. The labor classification used in the text is all other workers and managers.\textsuperscript{2} This specification allows us to test for the allocative effect of managers.

\textbf{Limitation of Data}

The major shortcoming of the data is the small size of the sample. This was due to small population of firms in the region and refusal of many of the firms to participate in the study. The small number of observations (35) makes the use of other complicated models like the translog function very limited.\textsuperscript{3}

A second limitation is that information on salaries of managers and professionals were not provided by some of the firms. This prohibits the direct comparison between marginal value product of managers and professionals and their respective economic rewards.

\textbf{Model Specification}

As indicated in Chapter II, the Cobb-Douglas function is used as a working hypothesis and tested against a modified Cobb-Douglas and a translog production function to select an appropriate functional form.

Throughout the analysis, all the raw variables are transformed by dividing each variable by its sample mean. This transformation does

\textsuperscript{2}The results for the alternative labor classification are in Appendix C.

\textsuperscript{3}The response is good compared to other attempts to obtain similar micro-level firm data. For example, Hilderbrand and Liu in their 1957 study had 1.5 percent response.
not affect the estimates of the Cobb-Douglas function except for the constant term. The transformation was done because (i) the modified Cobb-Douglas and translog used are not invariant to scale and computations at the mean are simpler, with the transformed data, and (ii) to the extent that the modified functions are approximations, the approximation by a Taylor Series expansion is more precise when made about the mean.

**Model I**

This is the Cobb-Douglas model. The statistical form of the function defined as equation (2) in Chapter II is:

\[(I) \quad \ln y = \ln A + a_1 \ln F + a_2 \ln I + a_3 \ln W + a_4 \ln M + u.\]

**Model II**

This is the modified Cobb-Douglas model with three different versions. The statistical form of the first version identified as equation (15) in Chapter II is:

\[(II-1) \quad \ln y = \ln Q + b_1 \ln F + b_2 \ln I + b_3 \ln W + b_4 \ln M + b_5(M \ln F) + b_6(M \ln I) + b_7(M \ln W) + e.\]

The statistical form of the second version of the function which is represented as equation (20) in Chapter II is:

\[(II-2) \quad \ln y = \ln K + \theta_1 \ln F + \theta_2 \ln I + \theta_3 \ln W + \theta_4 \ln M + \theta_5(M \ln F) + \theta_6(M \ln I) + \theta_7(M \ln W) + e.\]
The third version of the modified Cobb-Douglas function which is equation (25) in Chapter II is statistically represented as:

\[(\text{II-3}) \quad \ln O = \ln Y + \gamma_1 \ln F + \gamma_2 \ln I + \gamma_3 \ln W + \gamma_4 \ln M \\
+ \gamma_5 (\ln M \ln F) + \gamma_6 (\ln F)^2 + \gamma_7 (\ln M \ln I) \\
+ \gamma_8 (\ln I)^2 + \gamma_9 (\ln M \ln W) + \gamma_{10} (\ln W)^2 + \psi.\]

**Model III**

The statistical form of the translog function which is equation (30) in Chapter II is:

\[(\text{III}) \quad \ln O = \ln T + C_1 \ln F + C_2 \ln I + C_3 \ln W + C_4 \ln M \\
+ \frac{1}{2} C_{11} (\ln F)^2 + C_{12} (\ln F \ln I) + C_{13} (\ln F \ln W) \\
+ C_{14} (\ln F \ln M) + \frac{1}{2} C_{22} (\ln I)^2 + C_{23} (\ln I \ln W) \\
+ C_{24} (\ln I \ln M) + \frac{1}{2} C_{33} (\ln W)^2 + C_{34} (\ln W \ln M) \\
+ \frac{1}{2} C_{44} (\ln M)^2 + \nu.\]

where 0 = value of gross output ($) divided by the sample mean. 

F = value ($) of the flow services of the sum of fixed and variable capital, divided by the sample mean. 

I = value ($) intermediate input used during the year divided by the sample mean. 

M = average number of managers divided by its sample mean. 

W = average of the sum of skilled production workers; unskilled and semi skilled production workers; office workers; and professional and sub-professional workers divided by its sample mean.
$u, e, e, \psi, \mu = \text{error terms}$

$\ln K, \ln Q, \ln Y, \ln T, \ln A, \alpha, b_1, \theta_1, \gamma_1, C_i, C_{ij}$ are parameters to be estimated.

$C_{ij} = C_{ji}$. This is a symmetry restriction imposed because the Hessian of the production function is symmetric.

**Conditions for Selecting the Most "Appropriate" Functional Form**

As indicated earlier, three production functions are compared to select the most "appropriate" functional form underlying manufacturing production in the five-county area. The models based on these functions are: Model I (Cobb-Douglas), Model II (Modified Cobb-Douglas), and Model III (Translog). The difference between Model I and Model II is the additional parameters due to interactions between managers and the other independent variables. In Model III more parameters are added as a result of interaction between all the independent variables and the second order terms (squared) of the basic independent variables.

The rules for selection are as follows:

(1) Signs of all first order variables coefficients are positive.

(2) If any of the estimated additional parameters generated in Models II and III are significantly different from zero, then the Cobb-Douglas function (Model I) will be considered as not being the most appropriate functional form.

(3) Further comparison if necessary will then be made between Models II and III by comparing number of significant variables and goodness of fit.
Comparisons of Regression Models

There are four estimated equations\(^2\) presented in Table 12 from which the "best" is selected. Equations II-1, II-2, II-3 are different versions of the modified Cobb-Douglas function.\(^3\) Based on an F test the change in \(R^2\) between Model I and each of the three versions of Model II is statistically significant at the .05 level. Since changes in \(R^2\) are significant and at least one of each of the additional estimated coefficient in Models II-1, II-2, and II-3 is significant at conventional levels, it is concluded that the Cobb-Douglas function is not the most appropriate function underlying the production process in the manufacturing sector of the five-county area. When Model II-1 is compared to Model II-2 on the basis of goodness of fit, the two models have about the same fit. Except that there are four variables significant at the .01 level in Model II-1 while Model II-2 had three, no other significant difference is found between the two models. Model II-1 is preferred to Model II-2 because it is simpler while having a higher \(R^2\).

The comparison of Models II-1 and II-3 on the basis of goodness of fit does not give either one any major advantage over the other. Although each model has five significant variables, Model II-1 has four of them significant at \(\alpha = .01\), while Model II-3 has three at

\(^2\)The results of other versions for each model which used the production worker--Management and Professionals labor classification is presented in Appendix C.

\(^3\)Equation II-3 is an unconstrained modified Cobb-Douglas which turned out to be the same as the best result obtained for the translog model (III). Therefore, equation II-3 also represents the translog function.
**TABLE 12. Results for Selected Fitted Regressions for the Sample.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>I</th>
<th>II-1</th>
<th>II-2</th>
<th>II-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln F$</td>
<td>.21***</td>
<td>.25***</td>
<td>.32***</td>
<td>.26***</td>
</tr>
<tr>
<td></td>
<td>(.09)</td>
<td>(.11)</td>
<td>(.10)</td>
<td>(.08)</td>
</tr>
<tr>
<td>$\ln I$</td>
<td>.50**</td>
<td>.56***</td>
<td>.55***</td>
<td>.47***</td>
</tr>
<tr>
<td></td>
<td>(.05)</td>
<td>(.05)</td>
<td>(.05)</td>
<td>(.04)</td>
</tr>
<tr>
<td>$\ln W$</td>
<td>.21***</td>
<td>.27***</td>
<td>.17***</td>
<td>.38***</td>
</tr>
<tr>
<td></td>
<td>(.08)</td>
<td>(.08)</td>
<td>(.07)</td>
<td>(.10)</td>
</tr>
<tr>
<td>$\ln M$</td>
<td>.12</td>
<td>.06</td>
<td>.08</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.09)</td>
<td>(.09)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\ln F \ln F$</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\ln M \ln F$</td>
<td></td>
<td>.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.04)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\ln M \ln I$</td>
<td></td>
<td>-.004***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.001)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\ln M \ln I$</td>
<td></td>
<td>-.03*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\ln M \ln I$</td>
<td></td>
<td>-.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.06)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\ln M \ln W$</td>
<td></td>
<td>-.02*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.01)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\ln M \ln W$</td>
<td></td>
<td>-.08**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.03)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\ln M \ln W$</td>
<td></td>
<td></td>
<td></td>
<td>.15*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(.10)</td>
</tr>
<tr>
<td>$(\ln W)^2$</td>
<td></td>
<td></td>
<td></td>
<td>.05**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(.03)</td>
</tr>
<tr>
<td>Constant</td>
<td>.13</td>
<td>.17</td>
<td>.10</td>
<td>.06</td>
</tr>
<tr>
<td></td>
<td>.95</td>
<td>.97</td>
<td>.96</td>
<td>.96</td>
</tr>
<tr>
<td>F ratio</td>
<td>145.54***</td>
<td>129.05***</td>
<td>105***</td>
<td>111.7***</td>
</tr>
<tr>
<td>No. of Observations</td>
<td>35</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
</tbody>
</table>

Standard errors are in parentheses.

** = Significant at $\alpha = .10$

* = Significant at $\alpha = .05$

A two tailed $t$ test was used to test significance for interaction coefficients.

A one tailed $t$ test was used to test significance for interaction coefficients.
that level. The estimation of Model II-3 was terminated to constrain $(\ln F)^2$, $(\ln I)^2$, and $\ln M \ln F$ from entering the equation because their inclusion resulted in boosting the coefficients of the interaction terms and made $\ln F$ insignificant. Because of the small number of observations, it was difficult to determine whether the results were due to "true" interaction effects or multicollinearity. Both models have about the same potential to explain the behavior of the dependent variable, and since II-1 is simpler than II-3, and has higher $R^2$, Model II-1 is preferred to Model II-3. Model II-1 is therefore considered the most appropriate model for analyzing the manufacturing sector.

**Empirical Analysis of the Manufacturing Sector**

Two important properties of production functions which have commanded empirical testimony are the elasticity of substitution between any two basic factors of production and the returns to scale which exist within manufacturing production processes. If the most "appropriate" production function underlying manufacturing production in the five-county area had been a Cobb-Douglas function, then the elasticity of substitution between any two inputs equal to unity would have been accepted. The modified Cobb-Douglas production function which was selected as the most appropriate function has variable returns to scale. Since $\frac{M}{X_1}$ is a continuous variable, there could be infinite sets of partial elasticities of production. The estimated elasticities of production for the factors of production are obtained
through the use of equations (18) and (19) in Chapter II. The estimated elasticities of production at the arithmetic mean are: \(^5\)

\[
\begin{align*}
E_F &= (.25 + .01) = .26 \\
E_l &= (.56 - .004) = .556 \\
E_w &= (.27 - .02) = .25 \\
E_M &= .06
\end{align*}
\]

Returns to scale at the arithmetic mean for the sample is 1.126. A t test was used to test if constant returns to scale existed.

\[
H_0: \quad \Sigma E_I = 1 \\
H_A: \quad E_I > 1
\]

\[
t_{10,27} = \frac{1.126-1}{.338}
\]

The null hypothesis was not rejected. Returns to scale were not significantly different from one, so constant returns to scale cannot be rejected. Scales returns decline as \(M\) increases.

The allocative effect of managers is constrained to be zero at the arithmetic mean. Below the mean the allocative effect is positive but as the number of managers exceed the mean, the allocative effect becomes negative. This implies that as \(M\) increases above the mean economies of scale is exhausted.

\(^5\)As a second order Taylor expansion, the function was expanded around arithmetic mean, hence the use of arithmetic mean instead of geometric mean is more meaningful.
The marginal product for the inputs are obtained through the use of equations (16) and (17) in Chapter II. The estimated marginal products at the arithmetic mean are:

\[
\begin{align*}
MP_F &= \frac{1024035}{108297} \times (.25 + .01) = 2.46 \\
MP_I &= \frac{1024035}{501987} \times (.56 - .004) = 1.13 \\
MP_W &= \frac{1024035}{28} \times (.27 - .02) = 9,143.16 \\
MP_M &= \frac{1024035}{3} \times (.06) = 20,480.7
\end{align*}
\]

Worker and Allocative Effect of Managers in Manufacturing

The worker and allocative effects which were presented in Chapter II are empirically tested in this section. A generally accepted role of management in an enterprise is to make decisions which involve combinations of productive inputs with the intent of obtaining efficient use of the resources involved. In performing such duties, the management augments (influences) the productivity of the factors of production. Various arguments have been presented in the literature to justify this unique role of management in production processes. Kindleberger (1965, p. 118) suggests that "all other factors tend to be substitutable for one another . . . but organization is a complement rather than a substitute". Others go to the extent of implying that differences in managerial organization explain differences in labor productivity among firms. The work of Harbison (1965, pp. 368-371) is a good example to support this view.

As indicated in Chapter II, a manager could, theoretically, contribute both "allocative" and "worker" effects simultaneously in
production activities. Based on the argument presented in Chapter II, it is hypothesized that management contributes allocative effect in the manufacturing sector. With reference to Model II-1, the following hypothesis is tested:

\[ H_{01} : b_5 = b_6 = b_7 = 0 \]
\[ H_{A1} : b_5 \neq 0, b_6 \neq 0, b_7 \neq 0 \]

Based on Model II-1 in Table 12, the results support the view that managers have significant impact on the allocation of other inputs. A two-tailed t test shows that the estimated coefficient associated with \( \ln I \) is significant at \( \alpha = .01 \), while the estimated coefficient for \( \ln W \) is significant at \( \alpha = .1 \). The null hypothesis \( (H_{01}) \) is rejected.

A second hypothesis to be tested is that managers do not have worker effect.

\[ H_{02} : b_4 = 0 \]
\[ H_{A2} : b_4 > 0 \]

The coefficient of \( \ln M(b_4) \) is not significantly different from zero, hence the null hypothesis \( H_{02} \) is not rejected. The empirical result supports the hypothesis that managers contribute only allocative effect.

The results suggest that the F variable is separable from all other inputs, I and W are separable from each other and F but they are not separable from M.
Impact of Labor Quality on Output

If there are substantial differences in human capital embodied in the labor force utilized in production, then by the weak functional separability theorem, they could be disaggregated into some "homogeneous" groups. Under the assumption that formal education and other non-formal education, e.g., on-the-job training, are the primary sources of accumulation of human capital, it was expected that labor could be disaggregated into skilled, unskilled, professional, and managers. Such disaggregation would have allowed direct assessment of the impact of different labor skills on output. Unfortunately, analysis revealed that production workers could not be empirically disaggregated into skilled and unskilled groups; although managements reported such differences.  

An examination of hourly wages reported for the two groups of production workers did not show much difference in their wage rates. In a survey of the labor force of selected firms which participated in this study, Osman found that in some cases the production workers could not determine readily whether they were classified as skilled or unskilled. The production worker variable was subsequently defined to include all employees except the managers. Since only ten firms employed professionals, it was not feasible to assess directly the impact of this class of labor which is expected to have higher quality.

---

6 Results fitting a C-D function using such disaggregation of labor is presented in Appendix C.

7 The survey was conducted by Alan Osman at the Ohio State University for his forthcoming dissertation. The workers were interviewed about the same time that data was being collected for this study.
or skills. Given the above limitations an indirect approach is utilized to assess the impact of labor quality and to assess how well the selected model represents various production processes in the area. The approach is to fit the model to some sub-classification of manufacturing firms in the area.

Analysis of Sub-Classification of Firms

As an attempt to assess the representative nature of the model and the impact of human capital on production, the selected model was estimated for three sub-classifications of firms. These are firms: (a) which did not have professionals on their labor force, (b) which have experienced growth in their sales, and (c) corporate firms.

There were substantial differences in the observations to warrant the classifications. There were eight firms in the sub-class (b) which were not included in sub-class (c). There were 13 firms which were in sub-class (a) and not included in sub-class (c). There were 14 firms in sub-class (a) which were not included in sub-class (b).

In general, the results in all sub-classification are similar and not very different from the sample results. Any differences in marginal productivity of W are then due primarily to differences in C/W ratio, and not output elasticities of W.

The first sub-classification is firms which did not employ professional production workers (NP). To assess the impact of human capital on production, the intent was to estimate the function for firms which employed professionals in order to test directly the impact of that group of workers expected to have higher levels of human capital. Since there were only ten firms which employed professionals, that
group was not sufficient for estimation. The alternative was to estimate for the NP sub-classification. The W variable in Model II-1 then reduced to a labor group which is made up of office, skilled, and semi- and unskilled workers. Professionals, as defined in the study, are expected to have accumulated more human capital and hence have a higher labor quality than the other production workers. Theory of human capital suggests that productivity of professionals is higher than the other production worker classes of labor. It is hypothesized that the marginal productivity of W in the NP would be lower than the marginal productivity of W for the sample. The results of fitting the selected model to NP is presented in Table 13.

The significance of the coefficient for $\ln M$ indicates that in firms where no professionals are hired, managers contribute both worker and allocative effects. One possible explanation is that in NP firms, the managers perform professional activities. Also, since these firms are smaller, the managers are more likely to be the owners and to perform direct production activities.

The marginal productivity of W in NP at the arithmetic mean is:

$$MP_W = (b_3 + b_7) \frac{0}{W}$$

$$= (0.21484 - 0.03058) \frac{883279}{17.32}$$

$$= 9396$$

Since output elasticities of inputs in the sub-classifications are about the same as that of the sample, an alternative approach for computing marginal productivity was to assume that the sample function is valid for each sub-class and use the marginal product function of
TABLE 13. Results for Selected Fitted Regression for Sub-Classes and the Sample

Model: \( \ln O = \ln A + B_1 \ln F + B_2 \ln I + B_3 \ln W + B_4 \ln M \)

\[ + B_5 \left( M \ln F \right) + B_6 \left( M \ln I \right) + B_7 \left( M \ln W \right) + u \]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample</th>
<th>CF</th>
<th>GF</th>
<th>NP</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ln F )</td>
<td>.25***</td>
<td>.21</td>
<td>.23</td>
<td>.20</td>
</tr>
<tr>
<td></td>
<td>(.11)</td>
<td>(.18)</td>
<td>(.18)</td>
<td>(.16)</td>
</tr>
<tr>
<td>( \ln I )</td>
<td>.56***</td>
<td>.49***</td>
<td>.57***</td>
<td>.59***</td>
</tr>
<tr>
<td></td>
<td>(.05)</td>
<td>(.07)</td>
<td>(.09)</td>
<td>(.05)</td>
</tr>
<tr>
<td>( \ln W )</td>
<td>.27***</td>
<td>.24**</td>
<td>.20</td>
<td>.21**</td>
</tr>
<tr>
<td></td>
<td>(.08)</td>
<td>(.13)</td>
<td>(.18)</td>
<td>(.12)</td>
</tr>
<tr>
<td>( \ln M )</td>
<td>.06</td>
<td>.03</td>
<td>-.03</td>
<td>.15*</td>
</tr>
<tr>
<td></td>
<td>(.09)</td>
<td>(.11)</td>
<td>(.14)</td>
<td>(.09)</td>
</tr>
<tr>
<td>( M/F \ln F )</td>
<td>.01</td>
<td>.03</td>
<td>.03</td>
<td>.01</td>
</tr>
<tr>
<td></td>
<td>(.02)</td>
<td>(.05)</td>
<td>(.04)</td>
<td>(.03)</td>
</tr>
<tr>
<td>( M/I \ln I )</td>
<td>-.004***</td>
<td>-.004***</td>
<td>-.009</td>
<td>-.003***</td>
</tr>
<tr>
<td></td>
<td>(.001)</td>
<td>(.001)</td>
<td>(.01)</td>
<td>(.0008)</td>
</tr>
<tr>
<td>( M/W \ln W )</td>
<td>-.02**</td>
<td>.04</td>
<td>.03</td>
<td>.03</td>
</tr>
<tr>
<td></td>
<td>(.01)</td>
<td>(.04)</td>
<td>(.05)</td>
<td>(.19)</td>
</tr>
<tr>
<td>Constant</td>
<td>.17</td>
<td>.19</td>
<td>.19</td>
<td>.08</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>.97</td>
<td>.96</td>
<td>.96</td>
<td>.98</td>
</tr>
<tr>
<td>F ratio</td>
<td>129.03***</td>
<td>50.43***</td>
<td>57.56***</td>
<td>154.89***</td>
</tr>
<tr>
<td>No. of Observations</td>
<td>35</td>
<td>21</td>
<td>23</td>
<td>25</td>
</tr>
</tbody>
</table>

*** = Significant at \( \alpha = .01 \)
** = Significant at \( \alpha = .05 \)
* = Significant at \( \alpha = .10 \)

Standard errors are in parentheses.
A two tailed t test was used to test significance of the interaction coefficients.
A one tailed t test was used to test significance of other input coefficients.
the sample in estimating the marginal products of \( W \) for the sub-
classes. The alternative marginal productivity of \( W \) in \( NP \) at the
arithmetic mean evaluated with the sample function is:

\[
MP_W = \left( (b_3^* + b_7^* \cdot \frac{M^*}{W^*}) - (b_7^* \cdot \frac{M^*}{W^*} \cdot nW^*) \right) \frac{\hat{A}}{W}
\]

where \( b_3^*, b_7^* \) = estimated coefficient for sample.
\( M^* \) = average managers in \( NP \) divided by average managers of
the sample.
\( W^* \) = average workers in \( NP \) divided by average workers of
the sample.
\( \hat{A} \) = average computed output of \( NP \) from the sample function.\(^6\)

\[
MP_W = (0.27273 - 0.03233 + 0.01566) \frac{0.0134148}{17.32} = 15,288
\]

The marginal productivity of \( W \) for the sample is less than that for
\( NP \). Therefore, the hypothesis that marginal product of \( W \) is lower in
\( NP \) than in the sample is not supported by the data.

The second sub-classification is a group of firms which
realized increases in total sales at the end of the reporting period
as compared to a comparable period five years earlier or the first full
reporting period if the plant was established less than five years.
Although such firms are classified as growth firms (GF), the rate of
growth was below the national level.

\(^6\)For the rest of the chapter \( b_3^*, b_7^*, M^*, W^* \), and \( \hat{A} \) are defined
as above with the appropriate sub-classification.
It was hypothesized that firms which experienced growth were more likely to have higher quality labor force. The marginal productivity of W was then expected to be higher in GF than in the sample. The result for fitting the model to GF is presented in Table 13.

The marginal productivity of W in GF at the arithmetic mean is:

\[ MP_W = \left( b_3 + b_7 \right) \frac{O}{W} \]
\[ = (0.19899 - 0.03353) \frac{1273827}{28.43} \]
\[ = 10416. \]

The alternative marginal productivity of W in GF at the arithmetic mean evaluated with the sample function is:

\[ MP_W = \left( (b_3^* + b_7^{M*}) - (b_7^* W^{M*} \ln W^*) \right) \frac{O}{W} \]
\[ = (0.27273 - 0.02814 + 0.00031) \frac{1,850,948}{28.43} \]
\[ = 15,941. \]

Both marginal products of W for GF are greater than MP of W for the sample (9143.16). The result supports the hypothesis that MP of W is greater in GF than in the sample. The result tends to support the view that the higher productivity might have been realized due to higher labor skills in the GF firms.

The third sub-classification for which the model was estimated is corporate firms (CF). It was hypothesized that corporate firms employ production workers with proportionately higher skills than the total sample. The marginal productivity of W in CF is then expected
to be greater than that of the sample. The result of the analysis is presented in Table 13.

The marginal productivity of W in CF at the arithmetic mean is:

\[
MP_W = (b_3 + b_7)W^0 = (.24248 - .04373) \frac{1480926}{40} = 10422.
\]

The alternative marginal productivity of W in CF evaluated with the sample function at the arithmetic mean is:

\[
MP_{W1} = ((b_3^* + b_7^*W^*) - (b_7^*W^*lnW^*)W^0 = (.27273 - .02034 + .00751)\frac{2105090}{40} = 13453.
\]

Each of the two marginal products of W in CF is greater than that of the sample (9143). This implies that the difference between the marginal productivity W in CF and the sample may be due to contribution of better or higher quality.
CHAPTER V

In this chapter estimating equations are specified for quit and layoff\(^1\) rates among production workers in the manufacturing industries. The expected relationships between the dependent and independent variables derived in Chapter II are tested through the use of multiple regression on firm level cross-sectional data for 1974.

The Basic Models

Based on the models presented in Chapter II, the following simple linear equations are estimated for the quit and layoff rates:

\[ q = \alpha_0 + \alpha_1 \text{BRTEN} + \alpha_2 \text{EDUC} + \alpha_3 \text{WAGE} + \alpha_4 \text{OLD} + \alpha_5 \text{YOUNG} + \alpha_6 \text{FEM} + \alpha_7 \text{UNION} + U_1, \]

\[ l_y = \beta_0 + \beta_1 \text{BRTEN} + \beta_2 \text{EDUC} + \beta_3 \text{WAGE} + \beta_4 \text{OLD} + \beta_5 \text{YOUNG} + \beta_6 \text{FEM} + \beta_7 \text{UNION} + V_1. \]

\(^1\)A "quit" is defined as a termination of employment initiated by the employee for any reason except to retire or to transfer to another establishment of the same firm. It included a person who failed to report for work after being hired and an unauthorized absence if on the last day of the month the person has been absent more than seven consecutive days.

A "layoff" is suspension from pay status (lasting or expected to last more than seven consecutive calendar days without pay) initiated by the employer without prejudice to the worker for such reasons as: lack of orders, model change-over, termination of seasonal or temporary employment, inventory taking, introduction of labor saving devices, plant breakdown, shortage of materials, etc.
where \( q \) (Quit Rate) = the ratio of total number of production workers who quit work in the reporting period to average number of workers employed during the year, multiplied by 100.

\( l y \) (Layoff Rate) = the ratio of total number of production workers who were laid off in 1974 to average number of workers employed during the year, multiplied by 100.

BRTEN = the ratio of total number of production workers who have been with the firm for less than six months as of the beginning of the reporting period to average number of workers employed during the year, multiplied by 100.

EDUC = mean years of formal school completed by production workers.

WAGE = the weighted mean wage rate of all production workers.

OLD = the ratio of number of production workers over 55 years of age at the beginning of the reporting period to average number of production workers employed during the year, multiplied by 100.

YOUNG = the ratio of number of production workers under 24 years of age at the beginning of the reporting period to average production workers during the year, multiplied by 100.
FEM = the ratio of number of female production workers to average number of production workers during the year, multiplied by 100.

UNION = the percentage of production workers covered by a collective bargaining agreement.

\( V_i, U_i \) = Stochastic disturbance terms.

It is hypothesized that:

\[ \alpha_3, \beta_2, \beta_7 < 0 \]
\[ \beta_1, \beta_3, \beta_5, \beta_6 > 0 \]

Preliminary analysis revealed that the results obtained were unstable, inconsistent with theoretical expectations, and the fit was generally poor. The grouping of the firms for the preliminary analysis showed that looking across firms by size of employment, there was substantial variation in key independent variables which were expected to influence the dependent variables. The variations in the variables might go a long way in explaining the inconsistency in the results. Table 14 presents the means and standard deviations of the variables for various size groups of firms.

Through experimentation with various classification of the firms, it was found that the group with eight or more employees (32 in number) exhibited stable and consistent results. In small firms a small change in the number of quits or layoffs leads to a large change in quit and layoff rates. This can be seen by looking at the coefficients of variation for the quit and layoff variables.
TABLE 14. Mean and Standard Deviation of Variables by Employment

<table>
<thead>
<tr>
<th>Variable</th>
<th>0-7</th>
<th>8-49</th>
<th>50 and Above</th>
<th>Total Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>11.35</td>
<td>11.25</td>
<td>11.08</td>
<td>11.24</td>
</tr>
<tr>
<td></td>
<td>(.78)</td>
<td>(1.11)</td>
<td>(.99)</td>
<td>(.96)</td>
</tr>
<tr>
<td>Union</td>
<td>0</td>
<td>29.00</td>
<td>89.91</td>
<td>33.91</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>(45.78)</td>
<td>(15.75)</td>
<td>(45.69)</td>
</tr>
<tr>
<td>Average Employment</td>
<td>4.17</td>
<td>20.65</td>
<td>111.53</td>
<td>37.20</td>
</tr>
<tr>
<td></td>
<td>(1.84)</td>
<td>(10.52)</td>
<td>(62.23)</td>
<td>(53.06)</td>
</tr>
<tr>
<td>Brief Tenure</td>
<td>8.03</td>
<td>12.21</td>
<td>3.61</td>
<td>8.6</td>
</tr>
<tr>
<td></td>
<td>(14.72)</td>
<td>(15.97)</td>
<td>(4.02)</td>
<td>(13.72)</td>
</tr>
<tr>
<td>Female</td>
<td>10.29</td>
<td>10.26</td>
<td>17.41</td>
<td>17.90</td>
</tr>
<tr>
<td></td>
<td>(26.60)</td>
<td>(19.30)</td>
<td>(26.86)</td>
<td>(4.40)</td>
</tr>
<tr>
<td>Wages</td>
<td>3.00</td>
<td>3.40</td>
<td>3.91</td>
<td>3.39</td>
</tr>
<tr>
<td></td>
<td>(.53)</td>
<td>(.64)</td>
<td>(.52)</td>
<td>(.66)</td>
</tr>
<tr>
<td>Old</td>
<td>11.62</td>
<td>9.28</td>
<td>13.73</td>
<td>11.18</td>
</tr>
<tr>
<td></td>
<td>(20.18)</td>
<td>(9.79)</td>
<td>(11.38)</td>
<td>(14.37)</td>
</tr>
<tr>
<td>Young</td>
<td>14.91</td>
<td>15.83</td>
<td>9.41</td>
<td>13.94</td>
</tr>
<tr>
<td></td>
<td>(16.17)</td>
<td>(14.02)</td>
<td>(7.96)</td>
<td>(13.65)</td>
</tr>
<tr>
<td>Quit Rate</td>
<td>11.33</td>
<td>15.7</td>
<td>7.51</td>
<td>12.18</td>
</tr>
<tr>
<td></td>
<td>(24.49)</td>
<td>(19.32)</td>
<td>(7.36)</td>
<td>(19.26)</td>
</tr>
<tr>
<td>Coefficient of Variation</td>
<td>2.16</td>
<td>1.2</td>
<td>.98</td>
<td>1.58</td>
</tr>
<tr>
<td>Layoff Rate</td>
<td>5.74</td>
<td>14.11</td>
<td>1.70</td>
<td>8.16</td>
</tr>
<tr>
<td></td>
<td>(14.26)</td>
<td>(23.65)</td>
<td>(2.17)</td>
<td>(17.82)</td>
</tr>
<tr>
<td>Coefficient of Variation</td>
<td>2.48</td>
<td>1.67</td>
<td>1.27</td>
<td>2.18</td>
</tr>
<tr>
<td>N</td>
<td>17</td>
<td>20</td>
<td>12</td>
<td>49</td>
</tr>
</tbody>
</table>

Figures in parentheses are the standard deviations.
Labor Turnover Analysis

The Quit Rate Model

The basic model presented in equation (51) was estimated using the data for 32 manufacturing firms which employed eight or more production workers. The regression results for equation (51) are presented in Table 15 as equation (I). The equation is significant at \( \alpha = .01 \), and all but two of the variables have significant coefficients. The young and female variables for which the expected signs were ambiguous had small and insignificant coefficients. The regression coefficient of the wage variable is negative as expected, and significant at \( \alpha = .01 \). A unit ($/hour) increase in the wage rate depresses the quit rate by about 5.9 percentage points. The significance of the wage variable with its negative sign is consistent with the findings of Parsons (1972, p. 1137), who also obtained highly significant wage coefficients with negative signs for both 1959 and 1963 data.

The magnitude of the estimated coefficient for BRTEN was positive and significant at \( \alpha = .01 \). An increase of one percentage point in the proportion of production workers who had been with a firm for less than six months increases quits by 1.18 production workers in every hundred. The length of the reporting period (one year) makes it possible to have more than one quit for each position for the reporting period, and hence result in BRTEN having a coefficient greater than one. The positive coefficient indicates that brief-tenure has a greater negative impact on specific human capital formation than on total human capital formation, i.e.,
TABLE 15. Quit Rate Regression Results

<table>
<thead>
<tr>
<th>Equation</th>
<th>Mean of q = 12.63; N=32</th>
<th>Standard Deviation of q = 16.25</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Constant</td>
<td>BRTEN</td>
</tr>
<tr>
<td>I</td>
<td>-15</td>
<td>1.18***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.13)</td>
</tr>
<tr>
<td></td>
<td>Beta coefficient</td>
<td>.97</td>
</tr>
<tr>
<td>II</td>
<td>-15</td>
<td>1.08***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.09)</td>
</tr>
<tr>
<td></td>
<td>Beta coefficient</td>
<td>.89</td>
</tr>
</tbody>
</table>

Estimated standard errors of the estimated regression coefficient are in parenthesis.

*** Significant at .01 level
**  Significant at .05 level
*   Significant at .10 level

The t distribution was used to test for significance of estimated coefficients.
One tailed test was used for the variables with predicted signs.
Two tailed test was used for variables with ambiguous signs.
which implies higher general human capital because of lower transfer cost. The positive coefficient of EDUC implies that education has a greater effect on T than on S, i.e.,

\[
\frac{\partial T}{\partial EDUC} > \frac{\partial S}{\partial EDUC}.
\]

If wages are held constant, an increase in years of formal schooling completed means an increase in general human capital, which in turn leads to higher quit rates.

The coefficient for the proportion of production workers over 55 years of age is positive. The positive sign indicates that OLD has a positive relationship with total human capital, and it has greater impact on total human capital than on specific human capital. The estimated coefficient of the union variable (for which the sign was ambiguous) came out to be positive. This suggests that labor unions do perform other duties, like provision of information on alternative or better job opportunities. If wages are held constant, labor unions will assist their members in switching jobs.

The actual sign of brief tenure is the same as Parsons found, except that the variable was not significant in either 1959 or 1963 in Parson's study. For 1959, Parsons found a positive relationship between quit rate and education, while for his 1963 data the education variable had a negative sign. However, the coefficient for the education variable was insignificant in both cases. Considering the variables that were used both in this study and that of Parsons, except
for the education variable (for which the expected sign was ambiguous) these results based on micro level data are consistent with those of Parsons which used national aggregate data.

The relative importance of the effects of the independent variables on quit rate can be assessed by the magnitude of their Beta coefficients. Based on this criterion, a typical change in the brief-tenure variable affects quits more than a typical change in any of the other variables. Brief-tenure is followed in importance by the wage, education, and union variables.

The correlation between Young and brief-tenure was 0.7. This suggests that there might be a collinearity problem. Equation (I) of Table 11 was thus modified by dropping the brief-tenure and the young variables one at a time. The results of the modification with all the other variables retained except the brief-tenure variable were not encouraging, since only YOUNG and WAGE were significant, and hence discarded. Equation (II) of Table 15 presents the results of dropping the variable YOUNG from the basic model. Although there are small decreases in the values of the newly estimated coefficients, the signs and levels of significance of the brief-tenure, education, and wage variables are the same as in equation (I). There was no change at all in the sign and size of the female variable. Although the size of OLD decreases by only .02, it is no longer significant at its previous level of \( \alpha = .10 \). The level of significance for the union variable also decreases from \( \alpha = .05 \) to \( \alpha = .10 \), and the coefficient declines by .01. The \( R^2 \) of equation (II) is .90 and the equation is significant
at \( \alpha = .01 \). In general, not much is lost by excluding the young variable from the basic model.

**The Layoff Model**

The model in equation (52), without YOUNG, was fitted to the same data used for the quit rate analysis. The regression results are presented in Table 16 as equation (I). As expected, the fit for the layoff equation was not as good as that for the quit rate. This can partly be explained by various dynamic factors that may not be properly controlled for in a cross-section regression analysis (Parsons, 1972, p. 1136). The \( R^2 \) for equation (I) in Table 16 is .57 and is significant at \( \alpha = .01 \). Parsons (1972, p. 1137) obtained \( R^2 \)'s of .67 and .74 for 1959 and 1963 data, respectively.

The coefficient of the variable OLD, for which the expected sign was ambiguous, was significant at \( \alpha = .10 \) with a negative sign. Otherwise, all of the signs of the estimated coefficients were the same as those expected on the basis of the model in Chapter II. The negative sign of the variable OLD implies that it is negatively related to total human capital among workers in the five-county area. In other words, total human capital is greater for younger workers than for older workers.

Although the union and female variables have the expected signs, their estimated coefficients are not significant. The brief-tenure coefficient is significant at \( \alpha = .01 \). If the proportion of production workers with brief-tenure is increased by one unit, there is an associated increase in the layoff rate of 1.02. The length of the reporting period makes it possible to have more than one layoff
TABLE 16. Layoff Rate Regression Results

<table>
<thead>
<tr>
<th>Equation</th>
<th>Mean of ly = 9.45</th>
<th>Standard Deviation of ly = 19.53</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Constant</td>
<td>BRTEN</td>
</tr>
<tr>
<td>I</td>
<td>37</td>
<td>1.02***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.23)</td>
</tr>
<tr>
<td>II</td>
<td>66</td>
<td>-7.***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.88)</td>
</tr>
</tbody>
</table>

Beta Coefficients

<table>
<thead>
<tr>
<th>Equation</th>
<th>Beta Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>.70</td>
</tr>
<tr>
<td>II</td>
<td>-.38</td>
</tr>
</tbody>
</table>

Estimated standard errors of the estimated regression coefficients are in parenthesis.

*** Significant at .01 level
**  Significant at .05 level
*   Significant at .10 level

A two tailed t test was used to test the significance of OLD, while one tailed t test was used for all the other variables.
for each position for the one-year period, and hence result in \textit{BRTEN} having a coefficient greater than one. The effect of education on layoffs is significant at \( \alpha = .05 \). A one-year increase in mean years of school completed decreases layoffs by almost five in every hundred production workers. The wage variable is only significant at \( \alpha = .10 \) level.

Using the Beta coefficients to determine the relative impact of the independent variables on the layoff rate, brief-tenure has the greatest impact. The impact of old, education, and wages are about the same, given their appropriate signs. A typical change in old and education decreases layoffs by similar magnitudes; while a typical change in the average wage increases layoffs by about the same magnitude as old or education. The signs of variables used in the layoff equation are consistent with our hypotheses and support the results of Parsons' work for 1959 and 1963.

To determine if young has any significant impact on the layoff rate, it was introduced into the model. When young is introduced into equation (I) of Table 16, the signs and coefficient estimates do not change much, the coefficient of young (.13) is not significant, and the \( R^2 \) of the two equations were the same. To further check for possible colinearity effects between young and brief-tenure, the basic layoff model was modified by dropping brief-tenure and adding young to the equation. The results are presented as equation (II) in Table 16. The young and education variables are significant at \( \alpha = .01 \). The union variable which is insignificant in equation (I) becomes significant at \( \alpha = .10 \) level. However, \( R^2 \) drops from 0.57 in equation (I) to
Equation (II) is significant at $\alpha = .05$ level. In general, not much is lost by excluding the young variable from the basic model.

The empirical results for the quit and layoff rates support the investment hypothesis that the layoff rate is negatively related to a firm's investment in specific human capital, while the quit rate is negatively related to a worker's investment in specific human capital.
CHAPTER VI

CONCLUSIONS AND IMPLICATIONS

The major purposes of this study were: (1) to describe the role of manufacturing and what has happened to it in the five-county area over time; (2) to specify and estimate firm level micro production functions for the manufacturing industries in the five-county area and to determine: (i) the most appropriate production function for the sector and determine empirically some theoretical properties of the appropriate function, and (ii) to test if labor quality has a significant impact on output; and (3) to test the investment hypothesis: "layoff rate is negatively related to a firm's investment in specific human capital, while quit rate is negatively related to a worker's investment in specific human capital."

Secondary data were used to describe the role of manufacturing in the region. Micro level cross-sectional data for 1974 were used for the statistical analyses. The unit of observation was the individual firm. Thirty-five observations were used in the production analysis, and forty-nine were used for the labor turnover analysis.

Conclusions

From the descriptive analyses several important conclusions were obtained. First, as in the U.S. economy as a whole, the proportion
of the region's labor force in manufacturing employment has declined over time. However, the total number of employees has increased from 4,900 in 1960 to 5,909 in 1974. Secondly, total payroll in the manufacturing sector has increased from $2.18 million in 1960 to $4.49 million in 1974. Thirdly, the total number of established manufacturing firms has declined from 158 in 1971 to 110 in 1975.

Responses to questionnaires sent to the individual firms indicated that 62 percent of the firms preferred to hire production workers with less than a twelfth grade education. Only ten firms in the sample had professionals in their work forces. This implies that there is relatively little demand for skilled labor.

From the production analyses, the following conclusions were drawn. First, production workers could not be empirically distinguished into skilled and unskilled workers. Secondly, based on the comparison of number of significant variables and goodness of fit of the three functional forms (Cobb-Douglas, modified Cobb-Douglas, and translog) examined, the modified Cobb-Douglas was selected as the most appropriate function for analyzing manufacturing production processes in the five-county region. Thirdly, both measures of physical capital fixed and variable capital; and intermediate inputs were all highly significant and positive. Intermediate inputs had the largest elasticity of output; at the sample mean the elasticity of output was .56. Fixed and variable capital had an output elasticity of .25 at the mean.

Fourth, the worker variable was highly significant and positive with a slightly higher output elasticity than fixed and variable capital (at the same mean the output elasticity was .27).
The fifth conclusion was that the management variable was not significant as a direct input; however, the interactions between managers and intermediate inputs and between managers and workers, were highly significant with negative signs. The hypothesis that quality of labor has a significant impact on output was not rejected; however, the result should be interpreted with caution because production workers could not be distinguished and also there were not many professionals. Scale returns were found to be constant but to decrease with increases in the proportion of managers. Finally, the modified Cobb-Douglas model selected as most appropriate is very useful in explaining production processes for the sample as well as the sub-classes of firms in the five-county region.

Based on the labor turnover analyses, other important conclusions were obtained. For the quit rate regression, the brief-tenure, education, old, and union variables (whose expected signs were ambiguous) had positive and significant coefficients. The wage rate variable was significant with a negative coefficient as expected.

In the case of the layoff regression, the brief-tenure and wage variables were significant and had positive signs as expected. The old variable, whose expected sign was indeterminate, had a negative and significant coefficient. The estimated coefficient for the education variable was negative, as expected, and significant. Both the layoff and quit equations were highly significant.

These findings confirm the investment hypothesis that: 
"layoff rate is negatively related to a firm's investment in
specific human capital, while quit rate is negatively related to a worker's investment in specific human capital."

**Implications for Theory of Production and Research**

The rejection of the Cobb-Douglas function and the selection of the modified Cobb-Douglas as the most appropriate production function underlying the manufacturing process has many theoretical and research ramifications. It implies that the elasticity of substitution is not unity but varies over the range of the inputs used. Most of the previous research has assumed that the elasticity of substitution is constant and equal to unity by virtue of using the Cobb-Douglas model.

The high significance of interactions between management and two other inputs (intermediate goods and workers) and the insignificant coefficient for the management variable indicate that managers generally contribute only allocative effect in manufacturing industries. The use of Cobb-Douglas functions for manufacturing production studies does not allow for the allocative effect. In this respect, the appropriateness of the Cobb-Douglas function in previous studies of manufacturing production should be questioned, and the results of such studies should be viewed with some reservations.

The significance of the interactions between managers and intermediate inputs and workers has an important theoretical implication. The frequent use of constant elasticity of substitution production functions (with Cobb-Douglas as a special case) imposes strong separability. This implies that the set of inputs are
all separable. Based on the results of this study, it appears that while the fixed and variable capital inputs are separable, intermediate inputs and worker variables are not separable from management. Hence, the Cobb-Douglas functional form which imposes separability is not supported by the results of this study.

Value added has been used as the measure of output in many production studies. This approach assumes that intermediate goods have a zero elasticity of substitution with other inputs. Given the significant interaction between intermediate inputs and managers, the zero elasticity of substitution between intermediate inputs and all other inputs assumption imposed by the value-added approach is not supported by the results of this study.

Implications for Theory of Human Capital and Research

The positive coefficient of brief-tenure (percentage of production workers with less than six months service with the firm) in the quit-rate regression suggests that it has greater negative impact on specific human capital formation than on total human capital formation. The brief-tenure coefficient is greater than one, and this suggests that there may be a simultaneity problem, i.e., if quit rates are serially correlated, high quit rates could be causing high values of brief-tenure (as well as vice-versa). Future research on the determinants of quit rates should explicitly attempt to deal with the possibility of a simultaneity problem.

The positive sign of the education variable in the quit equation indicates that the impact of formal education is greater on total
human capital formation that on specific human capital formation. This implies that formal education has lead to more general human capital in the region.

The positive coefficient of the union variable (percentage of unionized production workers) in the quit-rate regression indicates that the positive impact of unionization is greater on total human capital formation than it is on specific human capital formation. This suggests that for production workers in the region to have access to unionized employers, the workers must have more total human capital.

The positive coefficient of the proportion of production workers over 55 years of age in the quit equation indicates that the variable is positively related to total human capital. It also suggests that the proportion of production workers over 55 years of age has a greater impact on total human capital formation than it does on specific human capital formation. The negative sign of the proportion of production workers over 55 years of age in the layoff equation is consistent with its positive sign in the quit rate in suggesting that the variable is positively related to total human capital.

**Implications for the Region**

A diagnostic approach was used in this study to attempt to address questions like: What kinds of labor skills are in short supply in the region?, What are the alternatives for providing or developing the labor skills needed by manufacturing?, Is labor turnover a problem in the area?

Based on the results of this study, there is no evidence of a shortage of needed labor skills in the manufacturing sector. There are
few skilled (professional) workers, but the demand for these workers at present is also small. This conclusion is supported by the following findings:

There was no distinction between skilled and unskilled production workers. There was not much difference between the hourly wage rates of the skilled and unskilled production workers to suggest such a classification of the labor force. The weighted average wage rate per hour per production worker was $3.39 (with about 42 percent of the production workers classified as skilled). Most firms (about 60 percent) preferred to hire production workers with less than a twelfth grade education. Only 10 firms had professionals on their labor force. From the above evidence, it was concluded that most of the production workers are unskilled or at best semi skilled, and that this is the predominant type of workers required by the firms located in the region.

There is no evidence of substantial specific training--the major means of generating specific human capital given the background of new production workers--being provided by the firms. If specific human capital or skills are needed, then the firms are expected to provide them. The positive significant coefficient of the education variable in the quit equation suggests that, relatively, not much specific training goes on in the region. The positive sign of the proportion of workers over 55 years of age is a further support for the argument that a small amount of specific training is provided to production workers. Human capital theory suggests that older workers are expected to be less mobile. One major reason is that they are
expected to have accumulated more specific human capital. The positive coefficient of old workers in the quit equation suggests that if wages are held constant, older workers are expected to have higher quit rates than other younger workers. This implies that little specific human capital has been accumulated over time by the older workers.

Labor turnover is not a problem in the region. It appears instead to serve as a meaningful adjustment mechanism. The production workers generally have low skills. Neither the worker nor the firm has made substantial investments in specific human capital. A production worker has not accumulated skills or knowledge which is peculiar to a specific firm and hence finds it economically feasible to move into alternative jobs. Quit rates are then expected to be high since there are not large costs of adjusting to alternative jobs. Inasmuch as a firm has not undertaken any major firm-financed specific human capital investment, the firm has little incentive to retain its workers when there is a fall in demand for the firm's output. Hence, it is expected that layoff rates will be high in times of slack demand. In response to increased demand for output, a firm can readily replace or augment its work force with only relatively small losses in the form of investments in the specific human capital of its work force.

Another implication concerns production of intermediate inputs in the region. If a competitive market is assumed, then the share of intermediate inputs in the total output is about 56 percent. The region supplied only about 26 percent of the intermediate inputs. This means that most of the returns to intermediate input (about 41 percent of total output) goes out of the region. To increase economic
activities in the region, it might be useful to explore linkages with other industries to provide a greater share of the intermediate inputs locally.

The manufacturing sector is one of the major sources of employment and income in the region. The sector has potential for playing a major role in developing an economic base capable of sustaining economic growth in the region. Three ways to enhance the role of the manufacturing sector are:

(1) Attract further industries requiring low labor skills. Since the region has primarily low-skilled labor, manufacturing activities which require this type of labor will be easiest to attract.

(2) To encourage increasing educational levels and per capita incomes, the development of manufacturing components which require skilled labor needs to be encouraged. The results of this study indicate that there is currently little manufacturing activity requiring skilled workers. If new firms requiring skilled labor could be attracted into the region, this would presumably have the effect of encouraging increasing educational levels and higher per capita income.

(3) Encourage new firms through inter-industry linkages to produce intermediate inputs needed in the region.

Areas for Further Studies

Based on the results of the study, several future research needs emerge. Research work in manufacturing production studies should consider the use of more general functional forms which do not impose
strong separability. The question of how management influences production output (allocative versus worker effect) should be vigorously pursued through the use of micro-level data.

More research efforts in the analysis of labor turnover through human capital approach is needed to ascertain how and what variables generally influence human capital formation. Alternative models should be considered to handle the possible serial correlation problems.

For the five-county region, analyses of other major sectors of the economy are needed to assist policymakers in developing a more comprehensive development plan for the region. There are two other ongoing studies of the region, in the Department of Agricultural Economics at Ohio State University, to be completed soon. It is expected that they will provide information on other sectors of the region's economy and their potentials for growth; and characteristics of firms located in the region and capable of providing higher income.
APPENDIX A

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Quarry and Mining</th>
<th>Construction</th>
<th>Manufacturing</th>
<th>Transportation Utilities</th>
<th>Wholesale and Retail</th>
<th>Finance, Insurance and Real Estate</th>
<th>State and Local Government</th>
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<td>4.8</td>
<td>23.5</td>
<td>4.5</td>
<td>15.9</td>
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</table>

Source: Ohio Bureau of Employment

<table>
<thead>
<tr>
<th></th>
<th>Athens</th>
<th>Gallia</th>
<th>Jackson</th>
<th>Meigs</th>
<th>Vinton</th>
<th>Five Counties</th>
</tr>
</thead>
</table>

**NG** = Change related to national growth  
**IM** = Change related to industrial mix  
**RG** = Change related to regional share  
**NG** = Net relative change  
**A** = Total change

Source: Shift-share analysis for Ohio by Paul Miller and Earl Stephanson, June, 1974.
<table>
<thead>
<tr>
<th>Year</th>
<th>Athens</th>
<th>Gallia</th>
<th>Jackson</th>
<th>Meigs</th>
<th>Vinton</th>
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Source: Ohio Director of Manufacturing
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</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Total Payroll ($1,000)</td>
<td>Number of Employees</td>
<td>Total Payroll ($1,000)</td>
<td>Number of Employees</td>
<td>Total Payroll ($1,000)</td>
<td>Number of Employees</td>
<td>Total Payroll ($1,000)</td>
<td>Number of Employees</td>
<td>Total Payroll ($1,000)</td>
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<tr>
<td>Athena</td>
<td>1,768</td>
<td>8490.3</td>
<td>1,719</td>
<td>11017.1</td>
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<td>1,226</td>
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<td>1,146</td>
<td>779.2</td>
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<tr>
<td>Gallia</td>
<td>242</td>
<td>1113.9</td>
<td>438</td>
<td>3151.9</td>
<td>585</td>
<td>447</td>
<td>737</td>
<td>6215.9</td>
<td>647</td>
<td>5905</td>
</tr>
<tr>
<td>Jackson</td>
<td>2,063</td>
<td>9037.4</td>
<td>2,000</td>
<td>12817.6</td>
<td>2,188</td>
<td>13615.6</td>
<td>2,345</td>
<td>17467.5</td>
<td>2,916</td>
<td>22576.1</td>
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<tr>
<td>Meigs</td>
<td>334</td>
<td>1190.2</td>
<td>401</td>
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<td>1992.1</td>
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<td>Vinton</td>
<td>493</td>
<td>2001.3</td>
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<td>3830.7</td>
<td>711</td>
<td>5019.6</td>
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<td>Five Counties</td>
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<td>21833.1</td>
<td>5,112</td>
<td>32498.2</td>
<td>5,254</td>
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<td>5,429</td>
<td>39137.8</td>
<td>5,909</td>
<td>44935.5</td>
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</table>

Source: Ohio Bureau of Employment
APPENDIX B
MANUFACTURING FIRM QUESTIONNAIRE

RURAL DEVELOPMENT STUDY
OF FIVE COUNTIES IN SOUTHEAST OHIO

NAME OF FIRM: ____________________________________________

ADDRESS OF FIRM: ________________________________________

_____________________________________________________

CONTACT PERSON: _________________________________________

PHONE NUMBER: ________________________________

For the purpose of completing this questionnaire, "the reporting period" should be the 1974 calendar year or if you are on a fiscal year, a fiscal year ending between July 1, 1974 and June 30, 1975. Please use this "reporting period" to respond to all questions, except for those where a different period is requested. If you are a branch plant of a larger firm, please respond only for the operations of the plants at the above address.

*This cover sheet will be detached from the questionnaire as soon as we have verified that all questions are complete.
Type of Firm:

a. Individual proprietor (owner) / /

b. Partnership / /

c. Corporation / /

Date Firm or Branch (Plant) was Established: ____________

Reporting Period for your Plant:

a. Calendar year 1974 / /

b. Fiscal year beginning ____________ and ending ____________

SECTION I: GROSS FIRM SALES OR RECEIPTS

1. What were the total sales during the reporting period? $ ________

2. Have your total sales for the reporting period changed as compared to a comparable period five years ago (or the first full reporting period if the plant was established less than five years ago)?

   a. Increased by ____________

   b. Decreased by ____________

   c. No change / /

3. a. What was the estimated value of unfinished product(s) at the beginning of the reporting period? $ ________

   b. What was the estimated value of unsold finished product(s) at the beginning of the reporting period? $ ________

4. a. What was the estimated value of unfinished product(s) at the end of the reporting period? $ ________

   b. What was the estimated value of unsold finished product(s) at the end of the reporting period? $ ________

5. What percentage of your sales was in each of the following areas? (Give your best estimate).

   a. Township in which the plant is located (include cities and villages within the township boundaries). ____________

   b. County in which the plant is located. ____________

   c. The total in Athens, Gallia, Jackson, Meigs, and Vinton counties. ____________
SECTION II: FIXED CAPITAL STOCK

Fixed capital stock includes Land, Building(s), Machinery, Transport Equipment, Tools, and Other items which are used in the process of production and which last more than one year.

6. Give the total book value and estimated replacement cost of capital items which were owned by the firm at the beginning of the reporting period. [Replacement cost is the cost of new, identical items at beginning of reporting period].

<table>
<thead>
<tr>
<th>Item</th>
<th>Book Value ($)</th>
<th>Replacement Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machinery (office and plant)</td>
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<tr>
<td>Transport Equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tools</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other(s); please specify</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Please list the amount of new investment in capital stock during the reporting period. (New investment in capital stock is money spent on buying new items or improving old ones).

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td></td>
</tr>
<tr>
<td>Building(s)</td>
<td></td>
</tr>
<tr>
<td>Machinery (office and plant)</td>
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</tr>
<tr>
<td>Transport Equipment</td>
<td></td>
</tr>
<tr>
<td>Tools</td>
<td></td>
</tr>
<tr>
<td>Other(s); please specify</td>
<td></td>
</tr>
</tbody>
</table>
8. What was the total value of depredation on capital items during the reporting period?

<table>
<thead>
<tr>
<th>Item</th>
<th>Value of Depredation ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td></td>
</tr>
<tr>
<td>Building(s)</td>
<td></td>
</tr>
<tr>
<td>Machinery (plant and office)</td>
<td></td>
</tr>
<tr>
<td>Transport Equipment</td>
<td></td>
</tr>
<tr>
<td>Tools</td>
<td></td>
</tr>
<tr>
<td>Other(s); please specify</td>
<td></td>
</tr>
</tbody>
</table>

9. Which of the following methods was used in computing the value of depreciation for the fixed capital items?
   a. "Straight-line"  
   b. "Double declining balance"  
   c. "Sum-of-years digit"  
   d. Other, please specify

10. Did you rent or lease any of the items in question 6?
    ☐ Yes  ☐ No. If No, please go to question 12.

11. Please break down rent receipts or expenses for capital items for the reporting period.

<table>
<thead>
<tr>
<th>Rent Receipts ($)</th>
<th>Expenses ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td></td>
</tr>
<tr>
<td>Building(s)</td>
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<td>Machinery (plant and office)</td>
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<tr>
<td>Transport Equipment</td>
<td></td>
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<tr>
<td>Tools</td>
<td></td>
</tr>
<tr>
<td>Other(s); please specify</td>
<td></td>
</tr>
</tbody>
</table>
SECTION III: PURCHASED SERVICES

12. What was the cost of each purchased service used during the reporting period. [If you provide any of these services to yourself, then do not include costs if capital and labor used to provide them are included in the firm labor and capital figures].

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost ($)</th>
<th>County</th>
<th>Local*</th>
<th>Private</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid Waste Disposal Expenses</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Insurance Expenses</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Publicity and Advertisement Expenses</td>
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<td></td>
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</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sewer</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Electricity</td>
<td></td>
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<td>Telephone</td>
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</tr>
<tr>
<td>Other(s); please specify</td>
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</tbody>
</table>

*Local is defined as township, village, city, and school district in which the plant is located.
SECTION IV: PURCHASED MATERIALS

Purchased materials are items used by the firm for producing output but not produced by the firm, e.g., raw materials, packaging materials, fuel, and lubricants, etc.

13. Please give a break down of purchased materials for the reporting period.

<table>
<thead>
<tr>
<th>Purchased Materials</th>
<th>Cost During Reporting Period ($)</th>
<th>Estimated Inventory, Beginning of Period ($)</th>
<th>Estimated Inventory, End of Period ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Materials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging Materials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel &amp; lubricants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other(s); please specify</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

14. Do you own a source(s) of material input(s), e.g., a quarry, such that some material(s) does not have to be purchased and hence, not included in question 13? / / Yes, / / No. If No, go to question 16.

15. Please list the input(s) from this source(s) during the reporting period.

<table>
<thead>
<tr>
<th>Material Input</th>
<th>Estimated Value ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td></td>
</tr>
</tbody>
</table>
16. What percentage of your purchased materials comes from the following areas: (Give your best estimate).

a. Township (to include cities and villages) in which your plant is located? _______%

b. The county in which your plant is located (to include township)? _______%

c. Total in Athens, Gallia, Jackson, Meigs, and Vinton counties (to include county in which plant is located)? _______%

SECTION V: EMPLOYMENT

17. What was the average number of persons employed by your plant during the reporting period? _______

(In calculating the average include all persons who worked during or received pay for any part of a calendar month regardless of type of work performed. Average = Summation of employment for the 12 months in the reporting period/12.)

18. Please break down the average employment in question 17 into the following categories:

<table>
<thead>
<tr>
<th>Category</th>
<th>Total Number</th>
<th>Average Hourly Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managers</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>Professional and Subprofessional</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>Office workers (secretarial, clerical, etc.)</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>Total production and related workers</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>Skilled production and related workers</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>Semi- and unskilled production and related workers</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>

*Examples of some categories of workers are:
Professional and subprofessional: architects, engineers, chemists, physicists, geologists, economists, subprofessional technicians, laboratory assistants, etc.

Office workers: bookkeepers, cashiers, stenographers, secretaries, office machine operators, etc.

Production and related workers: includes working foreman, and non-supervisory workers (including lead men and trainees) engaged in fabricating, processing, assembling, inspection, receiving, storage, handling, packing, warehousing, shipping, trucking, hauling, maintenance, repair, janitorial, watch men services, record keeping (as directly related to production) and other services closely associated with the above production operations.

Skilled production and related workers: mechanics, machine repairmen, electricians, radio technicians, etc.

19. What fringe benefits do most of your production workers receive?
   a. Social security /
   b. Other retirement programs (please specify) /
   c. Life insurance /
   d. Housing /
   e. Health insurance /
   f. Discounted purchases of company products /
   g. Other fringe benefits (please specify): 
   h. No fringe benefits /

20. What percentage of your production workers are covered by collective bargaining agreements? __________%

21. Approximately how many production workers had been with the firm for less than six months at the beginning of the reporting period? _______(number)

22. What was the approximate number of white production workers at the beginning of the reporting period? _______(number)

23. What was the approximate number of production workers who were under 24 years of age at the beginning of the reporting period? _______(number)

24. What was the approximate number of production workers over 35 years of age at the beginning of the reporting period? _______(number)

25. What is the total number of production workers who quit working during the reporting period? _______(number) (A "quit" is a termination of employment initiated by the employee for any reason except to retire, to transfer to another establishment of the same firm, or for services in the Armed Forces. Include a person who fails to report after being hired (if he is counted in the total employment figure) and an unauthorized absence if on the last day of the month the person has been absent more than 7 (seven) consecutive days).
26. How many production workers were laid off during the reporting period? 
   ________ (number) [A "layoff" is suspension from pay status (lasting or 
   expected to last more than 7 (seven) consecutive calendar days without 
   pay) initiated by the employer without prejudice to the worker for such 
   reasons as: lack of orders, model change over, termination of seasonal or 
   temporary employment, inventory taking, introduction of labor saving 
   devices, plant break down, shortage of materials, etc.]

27. Please estimate the number of all employees who reside:
   a. In the township (to include cities and villages) in which the plant is 
      located? _______ (Number)
   b. In the county in which the plant is located? _______ (Number)
   c. In the total of Athens, Gallia, Jackson, Meigs, and Vinton counties? 
      _______ (Number)

28. What is the estimated total number of production workers hired since January 
    1, 1970? _______ (Number)

29. Of the production workers hired since January 1, 1970, about how many were 
    due to expansion of operations as opposed to normal turnovers? _______ (Number)

30. Of the production workers you have hired since January 1, 1970, what 
    approximate percentages fall into each of the following categories (at the 
    time they were hired):

    | Job Related Experience | No Job Related Experience |
    |------------------------|---------------------------|
    | Had no previous formal training and had |   |   |
    | Had vocational-technical training and had |   |   |
    | Had participated in some government man-
      power training program and had |   |   |

31. Of your total production workers at the end of the reporting period, what 
    percentage have participated in one or more formal on-the-job training 
    programs since January 1, 1970? _______ X

32. Of the production workers who have participated in formal on-the-job 
    training programs since 1970, what approximate percentage was unskilled 
    and/or semi-skilled at the time they participated in their first program? 
    _______ X
33. Please give a break down of formal on-the-job training (OJT) programs since January 1, 1970, into the following categories:

<table>
<thead>
<tr>
<th>Financed By Your Firm Only</th>
<th>Financed By Government Only</th>
<th>Jointly Financed By Your Firm and Government</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of total production workers (question 23) who participated in OJT programs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of semi- and/or unskilled production workers who participated in OJT programs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SECTION VI: FORMAL EDUCATION

We would like to have some information on the formal education of your production workers. We realise that it may be difficult in some cases to furnish such information in any specific format, so we will appreciate any attempt to give approximate answers in this section.

34. What is the approximate average years of school completed by your production workers? ___________

35. When hiring production workers, what do you consider the ideal or best (considering trade-offs between skills and cost) formal school levels for new production workers?
   a. Less than high school graduate. [ ]
   b. High school graduate, general program. [ ]
   c. High school graduate, vocational program. [ ]
   d. Post high school vocational or technical program. [ ]
   e. Post high school general training [e.g. 2 year associate degree]. [ ]
   f. Other(s); please specify. ________________________
36. Approximately what percentage of your production workers had achieved your ideal equivalent level of formal school training or more as of the end of the reporting period (include evening classes, correspondence courses, on-the-job training, and other programs of which you are aware that are used by your production workers to attain equivalency)?
TABLE C-1. Regression Results for Fitting an Alternative Version of Model I-1 to the Sample

Model: $\ln O = \ln A + \alpha_1 \ln F + \alpha_2 \ln I + \alpha_3 \ln P + \alpha_4 \ln MP + e_i$

<table>
<thead>
<tr>
<th>Constant</th>
<th>$\ln F$</th>
<th>$\ln I$</th>
<th>$\ln P$</th>
<th>$\ln MP$</th>
<th>$R^2$</th>
<th>F</th>
<th>No. of Obser.</th>
</tr>
</thead>
<tbody>
<tr>
<td>.18</td>
<td>.18**</td>
<td>.51***</td>
<td>.18***</td>
<td>.18**</td>
<td>.95</td>
<td>153</td>
<td>35</td>
</tr>
<tr>
<td>(.09)</td>
<td>(.04)</td>
<td>(.07)</td>
<td>(.09)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** = Significant at $\alpha = .01$
** = Significant at $\alpha = .05$
* = Significant at $\alpha = .10$

Standard errors are in parentheses.
One tailed t test was used to test for significance.
P = Sum of skilled, unskilled, and office workers.
MP = Sum of managers and professionals.
TABLE C-2. Regression Results for Fitting an Alternative Version of Model II-1 to the Sample

Model:  \( \ln o = \ln q + \gamma_1 \ln F + \gamma_2 \ln I + \gamma_3 \ln P + \gamma_4 \ln MP + \gamma_5 \left( \frac{MP}{F} \ln F \right) + \gamma_6 \left( \frac{MP}{I} \ln I \right) + \gamma_7 \left( \frac{MP}{P} \ln P \right) + e \)

<table>
<thead>
<tr>
<th>Constant</th>
<th>( \ln F )**</th>
<th>( \ln I )**</th>
<th>( \ln P )**</th>
<th>( \ln MP )</th>
<th>( \frac{MP}{F} \ln F )</th>
<th>( \frac{MP}{I} \ln I )**</th>
<th>( \frac{MP}{P} \ln P )**</th>
<th>R²</th>
<th>F</th>
<th>No. of Observ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>.18</td>
<td>.20 (.1)</td>
<td>.57 (.05)</td>
<td>.26 (.08)</td>
<td>.10 (.07)</td>
<td>.01 (.03)</td>
<td>-.006 (.002)</td>
<td>-.03 (.01)</td>
<td>.97</td>
<td>126</td>
<td>35</td>
</tr>
</tbody>
</table>

*** = Significant at \( \alpha = .01 \)
** = Significant at \( \alpha = .05 \)
* = Significant at \( \alpha = .10 \)

Standard errors are in parentheses.
Two tailed t test was used to test significance of interaction coefficients.
One tailed t test was used for all other coefficients.
P = Sum of skilled, unskilled, and office workers.
MP = Sum of managers and professionals.
TABLE C-3. Regression Results for Fitting an Alternative Version of Model II-2 to the Sample

Model:  \( \ln y = \ln K + B_1 \ln F + B_2 \ln I + B_3 \ln P + B_4 \ln MP + B_5 (\ln^{MP} F) \ln F \\
+ B_6 (\ln^{MP} I) + B_7 (\ln^{MP} P) + V \)

<table>
<thead>
<tr>
<th>Constant</th>
<th>( \ln F )</th>
<th>( \ln I )</th>
<th>( \ln P )</th>
<th>( \ln MP )</th>
<th>( \ln^{MP} F )</th>
<th>( \ln^{MP} I )</th>
<th>( \ln^{MP} P )</th>
<th>( R^2 )</th>
<th>( F )</th>
<th>No. of Obser.</th>
</tr>
</thead>
<tbody>
<tr>
<td>.12</td>
<td>.28***</td>
<td>.54***</td>
<td>.16**</td>
<td>.12*</td>
<td>.07*</td>
<td>-.03*</td>
<td>-.10**</td>
<td>.96</td>
<td>103***</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>(.09)</td>
<td>(.06)</td>
<td>(.08)</td>
<td>(.08)</td>
<td>(.05)</td>
<td>(.02)</td>
<td>(.04)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** = Significant at \( \alpha = .01 \)
** = Significant at \( \alpha = .05 \)
* = Significant at \( \alpha = .10 \)

Standard errors are in parentheses.
A two tailed t test was used to test significance of interaction coefficients.
One tailed t test was used for all the other coefficients.
P = Sum of skilled, unskilled and office workers.
MP = Sum of managers and professionals.
TABLE C-4. Regression Results for Fitting an Alternative Version of Model II-3 to the Sample

Model: \( \ln O = \ln V + C_1 \ln F + C_2 \ln I + C_3 \ln P + C_4 \ln (MP) + C_5 (\ln MP \ln F) + C_6 (\ln F)^2 \\
+ C_7 (\ln MP \ln I) + C_8 (\ln I)^2 + C_9 (\ln MP \ln P) + C_{10} (\ln P)^2 + u \)

<table>
<thead>
<tr>
<th>Constant</th>
<th>( \ln F )</th>
<th>( \ln I )</th>
<th>( \ln P )</th>
<th>( \ln (MP)^2 )</th>
<th>( \ln (P)^2 )</th>
<th>R²</th>
<th>F</th>
<th>No. of Obser.</th>
</tr>
</thead>
<tbody>
<tr>
<td>.30***</td>
<td>.50***</td>
<td>.26***</td>
<td>.05**</td>
<td>.05*</td>
<td>.95</td>
<td></td>
<td></td>
<td>132 35</td>
</tr>
<tr>
<td>(.7)**</td>
<td>(.04)</td>
<td>(.08)</td>
<td>(.02)</td>
<td>(.03)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** = Significant at \( \alpha = .01 \)  
** = Significant at \( \alpha = .05 \)  
* = Significant at \( \alpha = .10 \)

Standard errors are in parentheses.  
P = Sum of skilled, unskilled and production workers.  
MP = Sum of managers and professionals.  
A two tailed t test was used to test significance of interaction coefficients.  
One tailed t test was used for all other coefficients.
BIBLIOGRAPHY


