# TECHNOLOGICAL HETEROGENEITY, SCALE EFFICIENCY, AND PLANT SIZE: MICRO ESTIMATES FOR THE WEST MALAYSIAN MANUFACTURING INDUSTRY

MATHIAS BRUCH

## I. INTRODUCTION

A POSITIVE correlation between establishment size and capital intensity in the manufacturing industries of developing countries has been widely documented in the literature (e.g., World Bank [6, p. 63], Ohkawa and Tajima [3], Steel [4, p. 98]). While this may be attributed partly to fragmented factor markets with the price of labor increasing and the price of capital decreasing with the size of establishments, the coexistence of different technologies in individual industries (Nelson, Schultz, and Slighton [2, p. 114 ff.], Stewart [5]) may be of additional explanatory value. Small- and medium-scale establishments seem to employ "traditional" or "intermediate" techniques of production widely, while large-scale establishments normally make use of "modern" techniques. Thus technological heterogeneity is apparently—at least to a large extent—related to establishment size. Taking for granted a positive relationship between the "level" of technology and capital intensity, which is independent of relative factor prices, this implies that industrial production functions (interpreted as a heuristic means) are non-homothetic.[1] This, if substantiated empirically, would have important implications for the analysis of the relative contribution of small- and large-scale manufacturing establishments to employment and output creation as well as for the design of industrialization strategies.

Section II of this paper elaborates on the underlying theory and works out techniques of measurement. Section III provides a description of the data which are used in Section IV to test production functions for non-homotheticity and to arrive at estimates of relative efficiency of small and large establishments. Conclusions and recommendations for further research are given in Section V.

## II. THEORY AND TECHNIQUES OF MEASUREMENT

The concept of technical efficiency is related to the individual frontier isoquant. If, however, establishments of different size are to be compared with respect to

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[1] A production function is homothetic for any given factor input ratio, if the marginal rate of factor substitution (MRS) is constant with the level of production.

relative average efficiency, the concept of "scale efficiency" is relevant. This concept is based on a possible difference between average unit isoquants.[2] If a production function is homothetic, scale efficiency is independent of capital intensity as unit isoquants cannot intersect. If a production function is non-homothetic, then unit isoquants will intersect and relative scale efficiency of small- and large-scale establishments will depend on capital intensity as well. The latter, should it be empirically substantiated, would have important implications. First, it is an indication for the existence of size-specific technological heterogeneity in the respective industry. Second, allocational efficiency (i.e., identity of factor price ratios and the absolute values of marginal rates of factor substitution) can be simultaneously reached at different capital-labor ratios, thus making possible multiple equilibria. Third, additional capital will have a larger employment effect in small-scale establishments than if invested in large ones, even if the same factor price ratio holds for both groups. Fourth, the scale efficiency of small-scale establishments depends on their relative labor intensity; any policy measure to increase their capital intensity (like subsidized credit) will put them at a disadvantage if this is not combined with some sort of innovation or specialization. Fifth, being technologically different from large-scale establishments helps the small ones to survive and compete with the large ones even in similar product lines.

As types of production functions which allow for non-homotheticity and variable returns to scale at the same time are rather difficult to handle empirically, we decided to estimate the parameters of standard Cobb-Douglas production functions, with establishment size dummies added, as an approximation:[3]

$$\ln V = a_0 + a_1 D_1 + a_2 D_2 + b_0 \ln K + b_1(\ln K)D_1 + b_2(\ln K)D_2 + c_0 \ln L + c_1(\ln L)D_1 + c_2(\ln L)D_2 + u\,. \qquad (1)$$

The definition of the dummy variables, which is based on the number of workers per establishment, is $D_1 = 1$ for small-scale establishments and $D_2 = 1$ for medium-scale establishments with large-scale establishments as the reference group.[4] Hence the regression coefficients should be interpreted in the following way:

[2] An average unit isoquant is derived from an average isoquant (as estimated by regression techniques) by dividing all factor inputs by value added. The term "scale efficiency" has been derived from the fact that economies of scale vary with the factor input ratio when the production function is non-homothetic.

[3] Equation (1) is the linearized version of the Cobb-Douglas production function $V = AK^{\alpha}L^{\beta}$, where $V$=value added, $K$=capital input, $L$=labor input, $A$=intercept, $\alpha(\beta)$=output elasticity of capital (labor), $u$=stochastic error term.

[4] See Table I for the numerical definition of the dummy variables. Number of workers per establishment and value added per establishment are very closely correlated in practically all industries. For two reasons the definition of the dummy variables is not identical among industries. First, problems of multicollinearity could be very much reduced by a modification of the grouping of establishments and, second, a sufficiently large number of observations per group had to be ensured. For the latter reason only one dummy variable could be used in some industries.

| Parameter | Establishment Size | | |
|---|---|---|---|
| | Small | Medium | Large |
| Intercept ($A$) | $a_0+a_1$ | $a_0+a_2$ | $a_0$ |
| Elasticity of output with respect to capital ($\alpha$) | $b_0+b_1$ | $b_0+b_2$ | $b_0$ |
| Elasticity of output with respect to labor ($\beta$) | $c_0+c_1$ | $c_0+c_2$ | $c_0$ |

If the ratio of output elasticities with respect to capital and labor ($\alpha/\beta$) is found to differ between size groups, the production function is non-homothetic, as can be seen from equation (2):

$$MRS=(\alpha/\beta)^{-1}\cdot(K/L)\,. \tag{2}$$

If $\alpha/\beta$ increases with establishment size, $K/L$ has to increase in order to keep the marginal rate of factor substitution ($MRS$) constant. As has been argued above, in such a situation of technological heterogeneity, establishments of different size can be scale efficient, because unit isoquants intersect. Whether the scale efficient capital intensity ranges of the respective unit isoquants are empirically relevant or just have a hypothetical meaning, can be seen by comparing them with the ranges of actual capital intensities. This technique has the advantage of integrating differences in the intercept as well as in the scale elasticities and the output elasticities of capital and labor into a single concept. The equation of the unit isoquant results from the linearized version of the Cobb-Douglas function and is

$$\ln(L/V)=-\frac{1}{\beta}\ln A-\frac{\alpha}{\beta}\ln(K/V)-\frac{h}{\beta}\ln V\,, \tag{3}$$

where $h=\alpha+\beta-1$. For given values of $A$, $\alpha$, and $\beta$ value added $V$ is a "shift parameter," if $h\neq 0$. In this case, unit isoquants have to be calculated for "representative" levels of output.

## III. DATA

The estimates presented below are based on a complete set of individual establishment data for West Malaysia, which have been collected by the Department of Statistics for its *Census of Manufacturing Industries, 1973* [1].[5] This census covered 11,060 establishments of which 10,861 were included in the analysis (174 with negative value added and one small industry with only 25 establishments [MIC (Malaysian Industrial Classification) 385] were excluded). Besides giving an almost complete picture of the West Malaysian manufacturing industry in 1973, this data set on a micro-level of aggregation has several distinct advantages over published (and therefore aggregate) census data. First, there are no problems with heteroscedasticity. Second, degrees of freedom are very large. Third, there are no problems in drawing conclusions with respect to the micro-level, while an interpretation of scale elasticities, for example, which have been

5 Special thanks are due to the Malaysian Department of Statistics for making available this rather unique set of data.

TABLE I

COBB-DOUGLAS PRODUCTION FUNCTION ESTIMATES WITH ESTABLISHMENT SIZE DUMMIES FOR WEST MALAYSIAN MANUFACTURING INDUSTRIES, 1973—A SUMMARY OF RESULTS

| MIC | Industry | Definition of Dummies (No. of Workers) | | Deviation from Coefficient for Reference Group (LSE) | | | | | | Number of Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Production Elasticities of | | | | Intercept | | |
| | | | | Capital | | Labor | | | | |
| | | $D_1$ | $D_2$ | $D_1$ | $D_2$ | $D_1$ | $D_2$ | $D_1$ | $D_2$ | |
| 311–2 | Food | 1– 9 | 10–49 | – | + | + ** | ++ ** | – ** | – – ** | 2,992 |
| | | 1–19 | 20–99 | – – * | – * | ++ ** | + * | – – | – | |
| 313 | Beverages | 1–19 | | – * | | + * | | + | | 72 |
| | | 1–49 | | – * | | + o | | + | | |
| 314 | Tobacco products | 1– 9 | 10–49 | – – ** | – o | – | + | ++ * | + | 158 |
| 321 | Textiles | 1–19 | 20–99 | – – * | – | + o | ++ o | ++ * | + | 238 |
| 322 | Wearing apparel | 1– 9 | 10–49 | – o | – – o | + o | ++ * | – | – – * | 209 |
| 323 | Leather and leather products | 1–19 | | – o | | + o | | – | | 52 |
| 324 | Footwear | 1–19 | | + | | – | | + | | 168 |
| 331 | Wood and cork products | 1– 9 | 10–49 | – – | – | + ** | ++ ** | – ** | – – ** | 996 |
| | | 1–19 | | – | | + ** | | – ** | | |
| 332 | Furniture | 1–19 | | – * | | + * | | + | | 852 |
| 341 | Paper and paper products | 1– 9 | 10–49 | – – * | – | ++ | + | + | ++ | 150 |
| 342 | Printing and publishing | 1– 9 | 10–49 | – – ** | – * | + * | ++ * | ++ * | + | 467 |
| | | 1–19 | 20–99 | – – ** | – * | ++ | + | ++ ** | + ** | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 351 | Industrial chemicals | 1–49 | | + * | | – | | – | | 53 |
| 352 | Other chemical products | 1– 9 | 10–49 | – – ** | – o | + | ++ * | + | – * | 279 |
| 355 | Rubber products | 1–19 | 20–99 | – | – – | + * | ++ * | – | – – * | 556 |
| 356 | Plastic products | 1– 9 | 10–49 | – ** | – – ** | + ** | ++ ** | + | – | 296 |
| 361 | Ceramics | 1–19 | | – o | | + o | | + | | 48 |
| 362 | Glass and glass products | 1–19 | | – * | | + | | + * | | 34 |
| 369 | Other non-metallic products | 1–49 | | – | | – | | + | | 330 |
| 371–2 | Basic metals | 1–49 | | – * | | – o | | + | | 195 |
| 381 | Metal products | 1– 9 | 10–49 | – – * | – * | + * | ++ * | – | – – o | 1,474 |
| 382 | Non-electrical machinery | 1– 9 | 10–49 | – – ** | – * | ++ ** | + * | – – o | – | 845 |
| 383 | Electrical machinery | 1–49 | | – * | | – | | + * | | 107 |
| 384 | Transport equipment | 1–49 | | – * | | + | | + | | 171 |
| 390 | Other manufacturing | 1–19 | | – | | + o | | – | | 119 |

Source: Author's calculations based on data from [1].

Notes: 1. +(–)=the deviation from the coefficient of the reference group ($D_1=D_2=0$) is positive (negative).
++(– –)=the positive (negative) deviation is larger than the one for the other alternative group.

2. **=deviation statistically significant at the 1 per cent level.
*=deviation statistically significant at the 5 per cent level.
o=deviation statistically significant at the 10 per cent level.

estimated on the basis of aggregate census figures, is limited by the fact that the individual observations consist of several establishments of different size. Fourth, and most importantly, the data set used is so detailed that it allowed variables to be defined more in line with theoretical demands. Thus labor input could be based on full-time worker equivalents adjusted for overtime hours.[6] Capital input was revised to include rented equipment, using appropriate conversion factors for the various types of capital goods. Value added is defined residually as usual.

## IV. RESULTS

The coefficients of Cobb-Douglas production functions with establishment size dummies added were estimated for the individual industries on the three-digit level of the Malaysian Industrial Classification (MIC).[7] As can be seen from Table I, the hypothesis that production functions are homothetic could be rejected for almost all industries.[8] While deviations in the intercept between size groups are positive as well as negative, a striking uniformity was found for deviations in the elasticities of output with respect to capital and labor: For smaller establishments the output elasticity of capital is lower and the output elasticity of labor is higher than for large-scale establishments.[9] This pattern of differences implies that the unit isoquants of small-scale establishments are located more in the labor-intensive part of factor space, while those of the larger establishments are located more in the capital-intensive part. Thus unit isoquants differ in such a way that the same *MRS* will be realized at a lower capital-labor ratio in the groups of smaller establishments than in the group of large-scale establishments. This, however, is not necessarily a dualistic phenomenon, as is suggested by the results for those industries for which three size groups were distinguished. As can be seen from Table II, the ratio of output elasticities ($\alpha/\beta$) increases from small to medium-sized to large establishments in five out of twelve such industries.

Industrial production functions being non-homothetic, unit isoquants will intersect, with the above-mentioned implications for scale efficiency. These points of intersection may, however, correspond to either such high or such low capital-labor ratios that they are irrelevant. Thus, a way must be sought to get an idea of the practical relevance of switches in scale efficiency. For this purpose,

6 Unfortunately adjustments for human capital differences were not possible.

7 The MIC (1972) is broadly comparable to the International Standard Industrial Classification.

8 In order to economize on space, only a summary of the results is given in Table I. The regressions are all statistically significant at the 99 per cent level. $\bar{R}^2$s are always higher than 0.76 with the only exception of industrial chemicals, where $\bar{R}^2=0.69$. The complete results are available from the author upon request.

9 Statistically significant exceptions are the industrial chemicals and the basic metals industries. For these two industries an approximation of size by the number of workers may be misleading.

**TABLE II**

PRODUCTION ELASTICITIES OF CAPITAL AND LABOR FOR MANUFACTURING ESTABLISHMENTS OF DIFFERENT SIZE—WEST MALAYSIA, 1973

| MIC | Definition of Dummies (No. of Workers) | | Production Elasticities of | | | | | | $\alpha/\beta$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Capital ($\alpha$) | | | Labor ($\beta$) | | | | | |
| | $D_1$ | $D_2$ | $D_1=1$ | $D_2=1$ | $D_1=D_2=0$ | $D_1=1$ | $D_2=1$ | $D_1=D_2=0$ | $D_1=1$ | $D_2=1$ | $D_1=D_2=0$ |
| 311–2 | 1– 9 | 10–49 | 0.320 | 0.395 | 0.354 | 0.848 | 0.972 | 0.520 | 0.377 | 0.406 | 0.681 |
| | 1–19 | 20–99 | 0.334 | 0.365 | 0.474 | 0.889 | 0.857 | 0.355 | 0.376 | 0.414 | 1.335 |
| 313 | 1–19 | | 0.208 | | 0.681 | 1.162 | | 0.642 | 0.179 | | 1.061 |
| | 1–49 | | 0.247 | | 0.704 | 1.098 | | 0.571 | 0.225 | | 1.233 |
| 314 | 1– 9 | 10–49 | 0.419 | 0.537 | 0.680 | 0.425 | 0.601 | 0.568 | 0.986 | 0.894 | 1.197 |
| 321 | 1–19 | 20–99 | 0.216 | 0.315 | 0.452 | 0.601 | 0.635 | 0.483 | 0.359 | 0.496 | 0.936 |
| 322 | 1– 9 | 10–49 | 0.278 | 0.271 | 0.406 | 0.783 | 1.019 | 0.520 | 0.355 | 0.266 | 0.781 |
| 323 | 1–19 | | 0.208 | | 0.799 | 0.600 | | 0.113 | 0.347 | | 7.071 |
| 324 | 1–19 | | 0.234 | | 0.116 | 0.874 | | 1.068 | 0.268 | | 0.109 |
| 331 | 1–19 | 10–49 | 0.276 | 0.312 | 0.324 | 0.877 | 1.015 | 0.445 | 0.315 | 0.307 | 0.728 |
| | 1–99 | | 0.289 | | 0.296 | 0.967 | | 0.331 | 0.299 | | 0.894 |
| 332 | 1–19 | | 0.261 | | 0.462 | 0.760 | | 0.531 | 0.343 | | 0.870 |
| 341 | 1– 9 | 10–49 | 0.216 | 0.330 | 0.392 | 0.873 | 0.713 | 0.699 | 0.247 | 0.463 | 0.561 |
| 342 | 1– 9 | 10–49 | 0.168 | 0.381 | 0.665 | 0.803 | 0.810 | 0.499 | 0.209 | 0.470 | 1.333 |
| | 1–19 | 20–99 | 0.231 | 0.337 | 0.876 | 0.802 | 0.737 | 0.727 | 0.288 | 0.457 | 1.205 |
| 351 | 1–49 | | 0.800 | | 0.229 | 0.018 | | 0.463 | 44.444 | | 0.495 |
| 352 | 1– 9 | 10–49 | 0.414 | 0.591 | 0.806 | 0.434 | 0.809 | 0.174 | 0.954 | 0.731 | 4.632 |
| 355 | 1–19 | 20–99 | 0.319 | 0.267 | 0.364 | 0.831 | 1.175 | 0.524 | 0.384 | 0.227 | 0.695 |
| 356 | 1– 9 | 10–49 | 0.287 | 0.271 | 0.760 | 0.792 | 1.019 | 0.205 | 0.362 | 0.266 | 3.707 |
| 361 | 1–19 | | 0.055 | | 0.461 | 1.132 | | 0.710 | 0.049 | | 0.649 |
| 362 | 1–19 | | 0.822 | | 1.113 | 0.064 | | 0.056 | 12.844 | | 19.842 |
| 369 | 1–49 | | 0.244 | | 0.288 | 0.868 | | 0.917 | 0.258 | | 0.314 |
| 371–2 | 1–49 | | 0.375 | | 0.522 | 0.757 | | 0.604 | 0.495 | | 0.864 |
| 381 | 1– 9 | 10–49 | 0.293 | 0.318 | 0.529 | 0.764 | 0.854 | 0.390 | 0.384 | 0.373 | 1.356 |
| 382 | 1– 9 | 10–49 | 0.188 | 0.285 | 0.497 | 1.012 | 0.808 | 0.463 | 0.186 | 0.353 | 1.073 |
| 383 | 1–49 | | 0.312 | | 0.576 | 0.444 | | 0.608 | 0.703 | | 0.947 |
| 384 | 1–49 | | 0.108 | | 0.267 | 0.816 | | 0.899 | 0.132 | | 0.297 |
| 390 | 1–19 | | 0.265 | | 0.404 | 0.688 | | 0.397 | 0.385 | | 1.018 |

Source: Same as Table I.

TABLE III

SCALE-EFFICIENT RANGES OF CAPITAL INTENSITY FOR MANUFACTURING ESTABLISHMENTS OF DIFFERENT SIZE—WEST MALAYSIA, 1973

| MIC | Definition of Dummies (No. of Workers) | | Scale-efficient Capital-Intensity[a] Ranges of Cobb-Douglas Unit Isoquants | | | Arithmetic Mean ($\bar{x}$) and Standard Deviation($s$) of Micro Capital-Intensities | | | | | | Scale-efficient Establishment Size Group[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $D_1=1$ | | $D_2=1$ | | $D_1=D_2=0$ | | |
| | $D_1$ | $D_2$ | $D_1=1$ | $D_2=1$ | $D_1=D_2=0$ | $\bar{x}$ | $s$ | $\bar{x}$ | $s$ | $\bar{x}$ | $s$ | |
| 311–2 | 1– 9 | 10–49 | 0–0.00 | 0.00–60.13 | 60.13+ | 14.42 | 23.58 | 25.59 | 46.66 | 51.33 | 58.74 | 10–49; (50+) |
| | 1–19 | 20–99 | 0–0.00 | 0.00–68.95 | 68.95+ | 15.41 | 27.24 | 32.54 | 47.61 | 60.28 | 68.85 | 20–99; (100+) |
| 313 | 1–19 | | 0–0.02 | | 0.02+ | 8.75 | 6.01 | | | 33.68 | 37.56 | 20+ |
| | 1–49 | | 0–0.10 | | 0.10+ | 10.95 | 11.94 | | | 44.67 | 42.86 | 50+ |
| 314 | 1– 9 | 10–49 | n.e. | 0– 0.00 | 0.00+ | 7.21 | 9.41 | 4.30 | 4.78 | 5.96 | 11.76 | 50+ |
| 321 | 1–19 | 20–99 | 0–2.25 | 2.25–25.07 | 25.07+ | 13.84 | 38.48 | 15.96 | 31.83 | 33.78 | 74.16 | (1–19); 20–99; 100+ |
| 322 | 1– 9 | 10–49 | n.e. | 0– 5.71 | 5.71+ | 12.45 | 26.60 | 8.81 | 11.45 | 7.72 | 4.97 | (10–49); 50+ |
| 323 | 1–19 | | 0–0.13 | | 0.13+ | 7.80 | 7.68 | | | 10.77 | 4.51 | 20+ |
| 324 | 1–19 | | 33.68+ | | 0–33.68 | 6.23 | 6.52 | | | 9.11 | 8.49 | 20+ |
| 331 | 1– 9 | 10–49 | n.e. | 0–20.38 | 20.38+ | 10.02 | 21.44 | 20.21 | 24.35 | 27.30 | 26.73 | 10–49; 50+ |
| | 1–99 | | 0–3,820 | | 3,820+ | 15.99 | 24.40 | | | 30.91 | 23.27 | 1–99 |
| 332 | 1–19 | | 0–5.21 | | 5.21+ | 9.32 | 11.23 | | | 10.72 | 9.01 | (1–19); 20+ |
| 341 | 1– 9 | 10–49 | 0–0.16 | 0.16– 3.66 | 3.66+ | 16.37 | 47.99 | 17.05 | 23.15 | 34.99 | 39.90 | (10–49); 50+ |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 342 | 1– 9 | 10–49 | 0–1.08 | 1.08– 8.61 | 8.61+ | 17.36 | 19.04 | 18.83 | 11.83 | 22.69 | 15.63 | (10–49); 50+ |
| | 1–19 | 20–99 | 0–0.33 | 0.33–13.55 | 13.55+ | 18.68 | 17.06 | 17.89 | 10.73 | 24.53 | 16.86 | (20–99); 100+ |
| 351 | 1–49 | | 423.8+ | | 0–423.8 | 99.00 | 251.0 | | | 304.9 | 401.6 | 50+ |
| 352 | 1– 9 | 10–49 | n.e. | 0– 7.63 | 7.63+ | 12.23 | 28.01 | 17.43 | 27.76 | 33.53 | 39.52 | (10–49); 50+ |
| 355 | 1–19 | 20–99 | n.e. | 0– 0.00 | 0.00+ | 14.57 | 22.24 | 33.99 | 38.30 | 31.39 | 38.70 | 100+ |
| 356 | 1– 9 | 10–49 | n.e. | 0–27.62 | 27.62+ | 25.59 | 46.61 | 26.16 | 22.23 | 35.22 | 22.01 | 10–49; 50+ |
| 361 | 1–19 | | 0–2.08 | | 2.08+ | 4.20 | 4.35 | | | 19.67 | 31.45 | (1–19); 20+ |
| 362 | 1–19 | | 0–1,468 | | 1,468+ | 12.43 | 11.93 | | | 150.8 | 244.2 | 1–19 |
| 369 | 1–49 | | 0–21.58 | | 21.58+ | 18.99 | 81.51 | | | 39.96 | 71.66 | 1–49; 50+ |
| 371–2 | 1–49 | | 0–11.92 | | 11.92 | 23.69 | 54.80 | | | 70.47 | 57.09 | (1–49); 50+ |
| 381 | 1– 9 | 10–49 | n.e. | 0–18.05 | 18.05+ | 11.36 | 22.01 | 15.74 | 18.78 | 31.77 | 40.21 | 10–49; 50+ |
| 382 | 1– 9 | 10–49 | 0–1.50 | 1.50– 3.41 | 3.41+ | 18.19 | 19.32 | 12.71 | 13.28 | 18.01 | 22.57 | 50+ |
| 383 | 1–49 | | 0–0.06 | | 0.06+ | 24.66 | 18.97 | | | 27.42 | 25.39 | 50+ |
| 384 | 1–49 | | 0–0.00 | | 0.00+ | 9.63 | 10.35 | | | 24.22 | 15.83 | 50+ |
| 390 | 1–19 | | 0–5.97 | | 5.97+ | 11.81 | 16.44 | | | 16.98 | 13.05 | (1–19); 20+ |

Sources: Same as Table I.

Note: n.e.=not scale efficient independent from capital intensity.

[a] Capital per man-day.

[b] An establishment size group is regarded as scale efficient, if the scale-efficient capital-intensity range of its Cobb-Douglas unit isoquant overlaps with its actual capital-intensity range (as given by $\bar{x}+/-0.5s$); it is given in parentheses if $\bar{x}$ is not an element of the scale-efficient capital-intensity range.

scale efficient capital intensity ranges were calculated and compared with the actual values pertaining to the respective size groups.[10] Thereby the relevant range of actual values was defined as $\bar{x}+/-0.5s$, where $\bar{x}$ is the arithmetic mean and $s$, the standard deviation of actual capital intensities on the micro-level. The necessary information for a comparison of scale efficient and actual ranges of capital intensities is contained in Table III. With the exception of the glass industry (362), large-scale establishments as a group are scale efficient in all industries. In nine out of twelve industries, for which three size groups were distinguished, the medium-scale establishments are scale efficient as well; in four cases, however, the arithmetic mean of the actual capital intensities is not an element of the scale efficient range on the unit isoquant. Small-scale establishments were found to be scale efficient in only seven out of twenty-four industries and in only two of them the arithmetic mean of actual capital intensities is an element of the scale efficient range. This means that, in the majority of industries, establishments at the lower end of the size spectrum on an average use both more capital and more labor per unit of value added than larger establishments actually do or would do, if they employed techniques with the same capital-labor ratio. Large-scale establishments are the only scale efficient size group in those industries, where the type of product mostly requires the application of modern techniques (industrial chemicals, non-electrical and electrical machinery, and transport equipment), where scale economies are relevant (beverages, tobacco, and rubber), or where small-scale establishments are mostly cottage-type activities (leather and footwear).

## V. CONCLUSIONS

The most important result of this paper is that for the majority of industries, technological heterogeneity has been found to exist in such a way that there is a switch in scale efficiency: Small- and medium-scale establishments tend to be scale efficient at lower capital-labor ratios than larger establishments. Very small-scale establishments are scale efficient only to a very limited extent. These findings have important implications for the contribution of manufacturing to employment and output creation in developing countries: A reallocation of resources to very small-scale establishments is likely to have a significant employment effect but also to be rather costly in terms of output losses. In many industries such a trade-off may not occur if the reallocation is in favor of the not so small- and medium-scale establishments. The scale efficiency of these establishments depends, however, on their use of labor-intensive intermediate techniques of production. This also can be regarded as an important factor for their continuing coexistance with larger establishments.

The findings of this paper raise a number of questions which have not yet been adequately dealt with, despite the increasing amount of literature on the

[10] In the calculation of unit isoquants the arithmetic mean was used to determine the "representative" level of value added of a size group.

development of small-scale industry. When we regard the existence of technological heterogeneity as a result of unequal intra-industrial technological diffusion (Nelson, Schultz, and Slighton [2, pp. 114 ff.]), we have to seek the determinants of such a process. Here, problems of access to finance, information, services, and markets as well as differences in entrepreneurial ability come to mind. Further, when the extent of technological heterogeneity is likely to diminish with a rising level of economic development, we need to determine the likely consequences for industrial structure and the relationship between small-scale and large-scale manufacturing establishments.

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