

Production in less developed countries : a sensitivity analysis

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PRODUCTION IN LESS DEVELOPED COUNTRIES: A SENSITIVITY ANALYSIS

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ABSTRACT

In the discussion on the optimal choice of industry for less-developed countries, local production costs play an important role. The present paper focuses attention on these production costs in order to find which variables determine these costs and to analyse the sensi-

tivity of production costs with respect to these variables.

Finally, some conclusions are derived from the findings regarding the allocation of industries in less-developed countries.

INTRODUCTION

In the 1950s, Tinbergen [1] started the discussion on the international division of labour. His basic idea was to locate a certain industry where the necessary inputs of labour and capital conform with the local availability of these inputs. Thus, labour-intensive industries should be placed in labour-abundant, low-wage countries, and capital-intensive industries in capital-abundant countries (western countries). Later, a number of comments were made on this issue by Tinbergen [1] as well as by other macro-economists, e.g. Sen [2] and Hirschman [3].

The essential point in the discussion concerns how the choice of technology or industry affects the national economic objectives, i.e. economic growth and generation of employment. According to Sen, capital-intensive

technologies have the greatest effect on long-term economic growth and employment, due to the savings- and investment rate generated by these technologies. Tinbergen states that developing countries initially have to determine their own priorities between economic growth and employment creation, followed by the deduction of the preferable rate of labour intensity of industries.

Hirschman was one of the first macro-economists to introduce the micro-economic aspects of the choice of industry into the discussion. His hypothesis is that machine-paced industries have a higher relative productivity in developing countries than man-paced ones, and are therefore more favourable in these countries. Boon [4] found that the size of the market, and hence the batch-size is also an important criterion for industry selection in less-developed countries.

Although of some value for governmental policy-making in developing countries, the literature reviewed above does not, however, give directives for entrepreneurs, while the entrepreneurs have a great influence on the actual allocation of production in practice. Their aim is to find locations with maximum profit possibilities or, in other words, where costs are lowest.

Governmental influences on investments are only indirect, and that is why the entrepreneur's point of view is the basis of our research, especially the expected production costs in different countries.

PRODUCTION COSTS

Our interests are production costs in less-developed, low-wage, countries, compared with production costs in developed, western countries. For this reason, we start with a formula for the production costs in western countries.

Production costs are defined here as the sum of labour costs and capital (equipment) costs. Thus:

$$P = D_1 \cdot L_d + I_1 \cdot L_i + d \cdot C + b \cdot C/2 \quad (1)$$

P = production costs of a certain quantity of product per year;

D_1 = total number of manhours directly involved in production (the men on the machines);

I_1 = total number of manhours indirectly involved in production (e.g. maintenance, selling, buying, management and controlling);

L_d = hourly cost of direct labour;

L_i = hourly cost of indirect labour;

C = total capital invested in machinery;

d = depreciation rate per year, (linear depreciation is applied so that on average

half of the capital has been invested);
and

b = interest rate.

Working-capital costs are excluded from the formula, as generalizations of this cost type are difficult to make. Furthermore, it will be seen later that if production costs, as defined above, are higher in a particular country, it is safe to assume that the working-capital costs are also higher.

Knowing production costs in western countries, the question arises as to what happens to these production costs after production is transferred to a low-wage country where the same production technology (the same equipment) is used.

When considering production in low-wage, developing countries the following factors are of importance.

The labour productivity

Generally speaking, labour productivity in developing countries is lower than in western countries. De Beer and van de Ven [5] mention that labour productivity in these countries ranges from 30% to 80% of western productivity, and that the relative labour productivity (the local productivity compared to western productivity) is higher for product-oriented industries than for process-oriented industries.

The relative labour productivity is given by the factor p , where:

$$p = \frac{\text{labour productivity in less developed countries}}{\text{labour productivity in western countries}},$$

and $0 < p < 1$.

Labour costs

Hourly labour costs are lower in developing

countries than in western countries. Taking the factor k for the relation between hourly costs of direct labour in developing countries and the hourly costs of direct labour in western countries:

$$k = \frac{\text{direct labour costs/h in less-developed country}}{\text{direct labour costs/h in western country}}$$

where $0 < k < 1$.

The hourly costs of indirect labour in developing countries are also lower, although the ratio between the hourly labour costs in developing countries and those in western countries is higher for indirect than for direct labour. For the hourly costs of indirect labour, the factor n is used, where

$$n = \frac{\text{indirect labour costs/h in less-developed country}}{\text{indirect labour costs/h in western country}}$$

where $0 < n < 1$ and $n > k$.

In countries with very low wages, such as India and Indonesia, direct workers cost about 5% of their Western colleagues, and indirect workers cost about 20% of similar workers in developed countries. In these countries, $k = 0.05$ and $n = 0.2$. For low-wage countries such as Peru and Ecuador, $k = 0.10$ and $n = 0.25$. In the middle-wage countries, e.g. Tunisia and Morocco, $k = 0.2$ and $n = 0.3$ [6]. As $n = 1$ and $k = 1$ for developed countries, a good overall estimation of the relationship between n and k is:

$$n = \exp(0.6k) - 0.83$$

The rate of interest

A risk factor is introduced to express the higher risks for foreign investments in developing countries, making the interest rate for production in developing countries: $b \cdot r$ where $r > 1$.

Equipment costs

Transport, insurance, necessary adaptations and sometimes taxes increase the cost of equipment and machinery in developing countries. This increase is given by f , where:

$$f = \frac{\text{equipment cost in less-developed country}}{\text{equipment cost in western country}}$$

and $f > 1$.

Organizational differences

Due to a less industrialized environment, to less qualified manpower and to cultural influences, a higher ratio of indirect workers to direct workers is found in developing countries [5]. The factor h is used to express this finding, where:

$$h = \frac{\frac{\text{no. of indirect workers}}{\text{no. of direct workers}} \text{ in less-developed country}}{\frac{\text{no. of indirect workers}}{\text{no. of direct workers}} \text{ in western country}}$$

Using the above-mentioned factors, the expected production costs in Less Developed Countries (P_{LDC}) can now be expressed in western production factors:

$$P_{LDC} = \frac{1}{p} D_1 \cdot k L_d + \frac{h}{p} \cdot I_1 \cdot n L_i + \left(d + b \cdot \frac{r}{2} \right) \frac{f}{p} C. \quad (2)$$

In order to facilitate the calculations, two additional relations are introduced. The first one is the relation between the cost of direct and indirect labour in the form $L_i = 1.5 \times L_d$. The value of 1.5 seems realistic for the Dutch situation (weighted average). The second relation is a more complex one. Woodward [7] states that the need for indirect workers is relatively greater for production in large series. By defining q as $q = D_1/I_1$, i.e. the number of

“directs” per “indirect”, the research indicates that q ranges from 1 for mass production to 6 for very small series.

As the present paper is mainly concerned with the comparison of production costs between developing countries and western countries, the production costs in developing countries (P_{LDC}) are expressed in terms of those of western countries (P):

$$\frac{P_{LDC}}{P} = \frac{\frac{D_1}{C} \cdot L_d \left(\frac{k}{p} + \frac{1.5nh}{pq} \right) + \frac{f}{p} \left(d + \frac{b \cdot r}{2} \right)}{\frac{D_1}{C} \cdot L_d \left(\frac{1 + 1.5}{q} \right) + d + \frac{b}{2}} \quad (3)$$

On the basis of these expressions, it is possible to compute the relative production costs (production costs in the developing countries related to production costs in western countries) for different products or industries.

Distinguishing products according to their intensity of direct labour to capital (D_1/C), Table 1 was drawn up for Dutch industry.

The relative production cost advantages of different products for any country can now be calculated by substituting the actual values for that country in eqn. (3).

A computer programme has been devel-

TABLE 1

Labour intensity for some Dutch industries

Name of industry sector	Direct labour/Capital, D_1/C (h/US\$ (1983))
Clothing	0.35
Machine	0.18
Metal products	0.13
Textile	0.10
Electrotechnical	0.10
Raw materials	0.05
Oil	0.03

Source: Dutch Statistical Bureau and own calculations (1983).

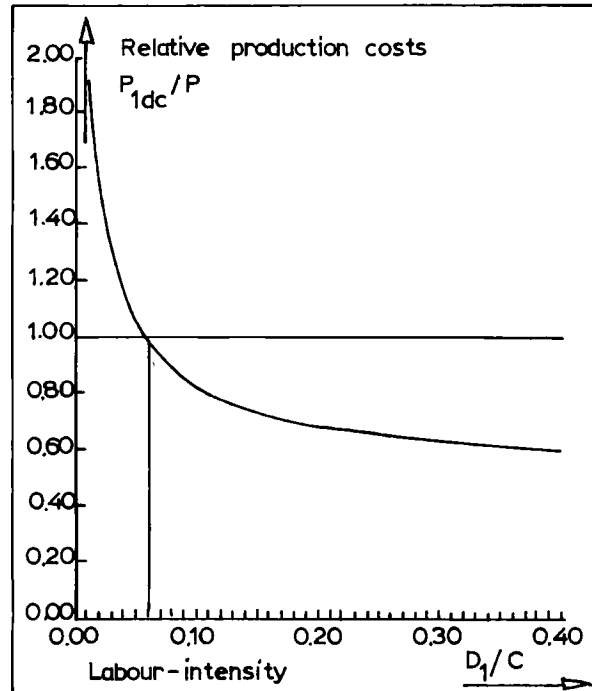


Fig. 1. An example of the relative production costs in a developing country.

oped to simplify the computational effort. Figure 1 shows the results of an example in which the following values are used:

$$\begin{array}{lll} L_d = 12 \text{ US\$} & k = 0.1 & r = 1.5 \\ d = 0.2 & n = \exp(0.6k) - 0.83 & f = 1.5 \\ b = 0.1 & q = 2 & h = 2 \\ p = 0.5 & & \end{array}$$

From Fig. 1 it can be seen that the critical value of the labour intensity for which no cost advantage can be obtained in this situation ($P_{LDC}/P = 1$) is 0.06 h/\$. To the left of this point, production in a developing country is more expensive while, to the right, production costs are lower. For the engineering industry ($D_1/C = 0.18$), for instance, the calculated production costs are 70% of those in developed countries.

SENSITIVITY ANALYSIS

Figure 1 gives a first impression of the economic effects of locating certain industries in developing countries. It is also possible to deduce from this figure the potential competition from these countries. In order to perform a sensitivity analysis, the influence of the discerned variables on the expected production cost advantages, i.e. on the shape and the position of the curves, has to be known.

The sensitivity of the relative production costs in developing countries can be analysed as a function of the direct-labour intensity, with regard to the variables mentioned in eqn. (3), i.e.

- the interest rate b ;
- the higher capital risk in developing countries r ;
- the depreciation rate d ;
- higher machine costs in developing countries f ;
- the lot sizes q ;
- the relative wage level in developing countries k ;
- the relative higher number of indirects in developing countries h ; and
- the lower relative labour productivity (with respect to western standards) in developing countries p .

Most of these variables can be considered as mutually independent; however, some are interdependent. According to de Beer and van de Ven [5], there exists a strong relationship between the batch size (expressed by the ratio q in the model) and the resulting relative labour productivity.

Small batch production (mostly process-oriented industries) results in a lower relative labour productivity than large-batch production (or product-oriented industries). Thus, small batches are characterised by a low ' p ', and by a relatively big number of direct workers, by a high ' q ', whilst large batches

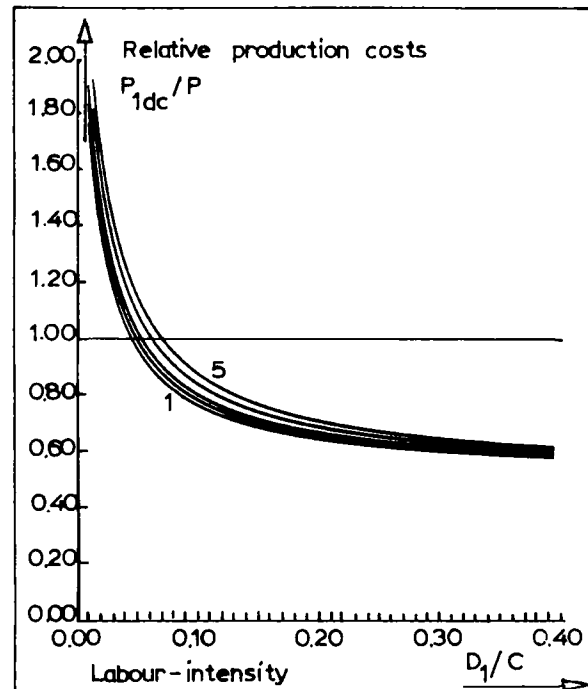


Fig. 2. Sensitivity of the relative production costs to the interest rate (b).

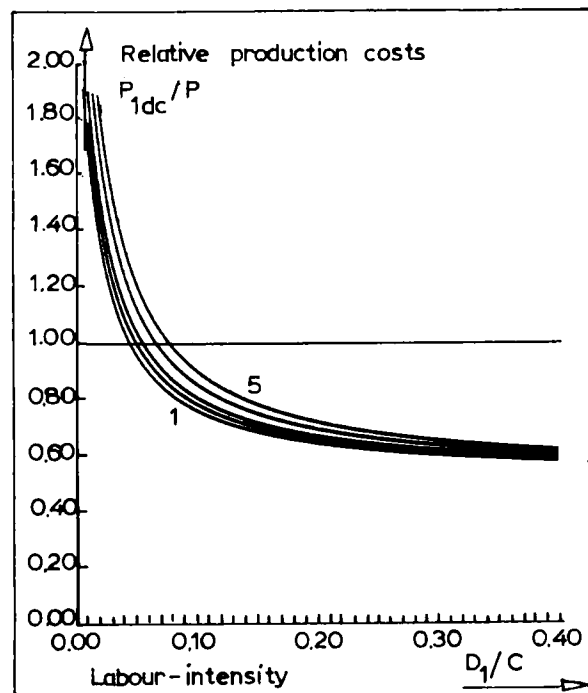


Fig. 3. Sensitivity of the relative production costs to higher risks (r).

have a higher ' p ' and a low ' q '. In the computer programme, the authors varied the values of the variables used in the example of Fig. 1 by factors of 1/2, 3/4, 1/1, 3/2 and 2/1. The resulting sensitivity analysis is shown in Figs. 2–9 inclusive. The curves in the figures are numbered 1 to 5, indicating the increase in the variable concerned.

THE INTEREST RATE AND HIGHER RISKS IN DEVELOPING COUNTRIES

It appears from Figs. 2 and 3 that neither the absolute rate of interest in developed countries, b , nor the relative rate of interest in developing countries, r , really matters; neither the position nor the shape of the curves is strongly influenced by these variables.

This conclusion is of importance in developing countries in the discussion regarding governmental measures to direct private investment into more labour-intensive industries by artificially increasing the capital costs. It is evident that such measures do not have any effect.

DEPRECIATION RATE AND HIGHER MACHINE COSTS

The influence of the depreciation rate (d) is a bit bigger (see Fig. 4), especially regarding the less labour-intensive industries. The critical point moves slowly to the right as the depreciation period decreases. Poor maintenance or tropical conditions therefore can be the reason for the textile industry ($D_1/C = 0.10$) to lose its advantage.

The same may be said about the higher costs of machinery in less-developed countries (see Fig. 5). If machine costs become three times higher in less-developed countries than in developed countries, then the minimum labour-intensity required increases to 0.14 h/\$.

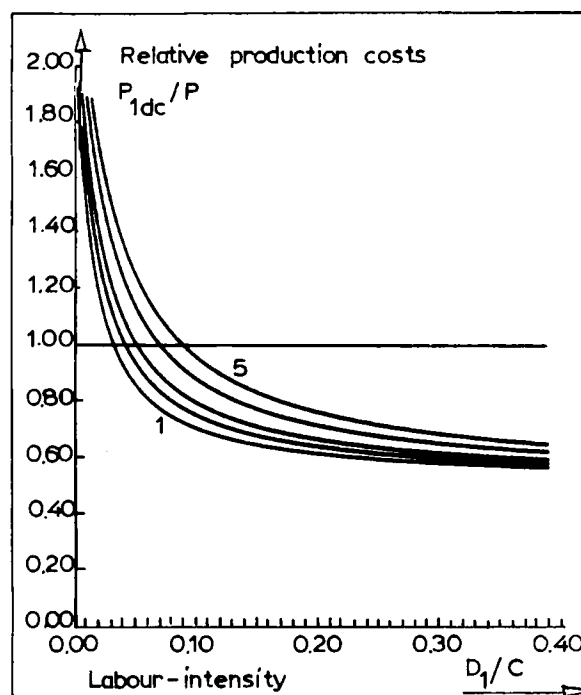


Fig. 4. Sensitivity of the relative production costs to the depreciation rate (d).

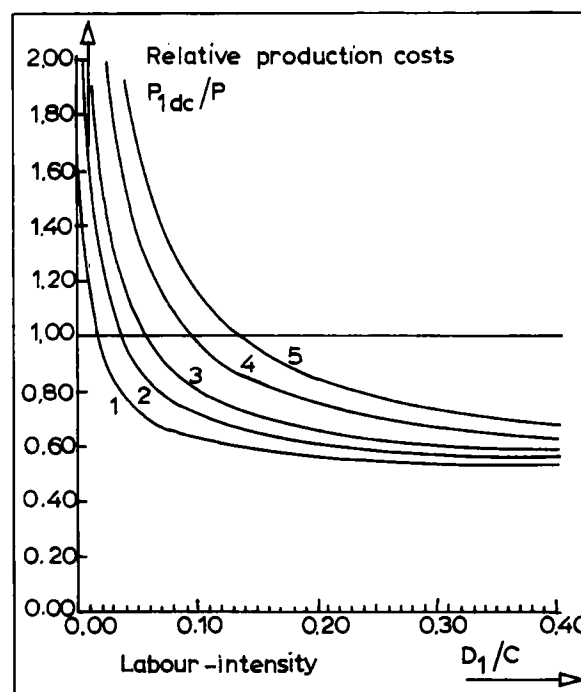


Fig. 5. Sensitivity of the relative production costs to the higher machine costs (f).

LOT SIZE AND LOWER WAGES

As seen earlier, the batch size influences the direct/indirect ratio q . Figure 6 shows that the influence of the batch size on relative production costs indicated by this ratio is rather small.

Figure 7 shows that the production costs, at 5% relative wage costs (line 1), can be reduced by some 50%. The critical point is situated at a labour intensity of 0.045 h/\$. Increasing the relative wages from 5% to 20% (curve 5), the highest relative advantage will be about 20%, while the critical point moves to a labour-intensity of 0.10 h/\$. However, most industries (see Table 1) are still profitable in this case, but the margin has strongly narrowed.

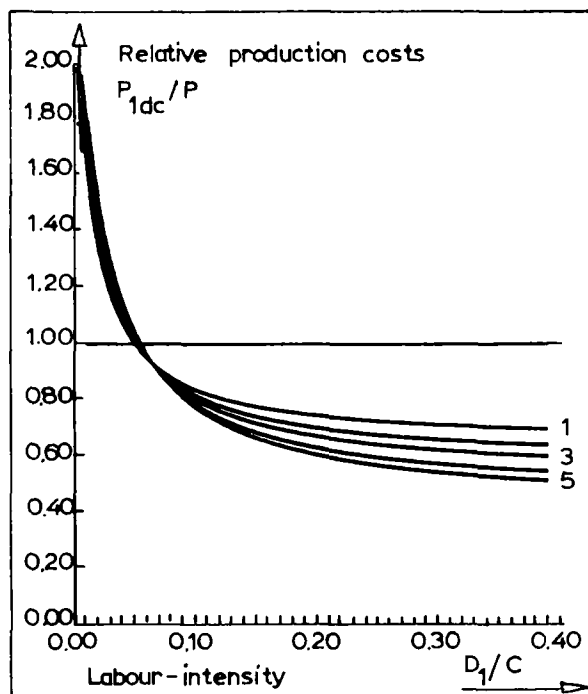


Fig. 6. Sensitivity of the relative production costs to the lot size (q).

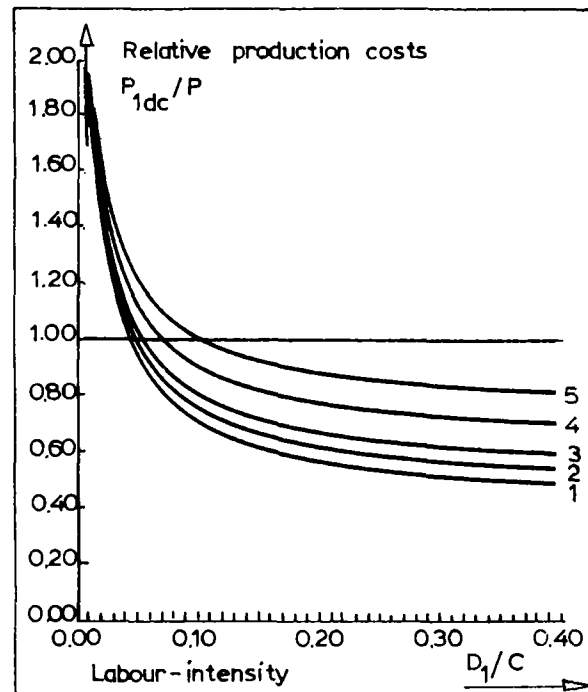


Fig. 7. Sensitivity of the relative production costs to the lower wages (k).

INDIRECT LABOUR AND RELATIVE LABOUR PRODUCTIVITY

The big influence of the greater need of indirect personnel (h) can be seen from Fig. 8. When $h = 4$ (i.e. a 4 times higher ratio of indirects per direct than in developed countries), no cost advantages can be obtained.

Figure 9 shows that the effects are even stronger for variations in the productivity of labour, p . Even when capital costs are 50% higher in developing countries, local production is nearly always profitable when productivity equals western standards (line 5). At this productivity level the costs of production will be less than 40% of western costs for technologies with a labour-intensity greater than 0.1 h/\$. However, when productivity falls to 25% of that in developed countries

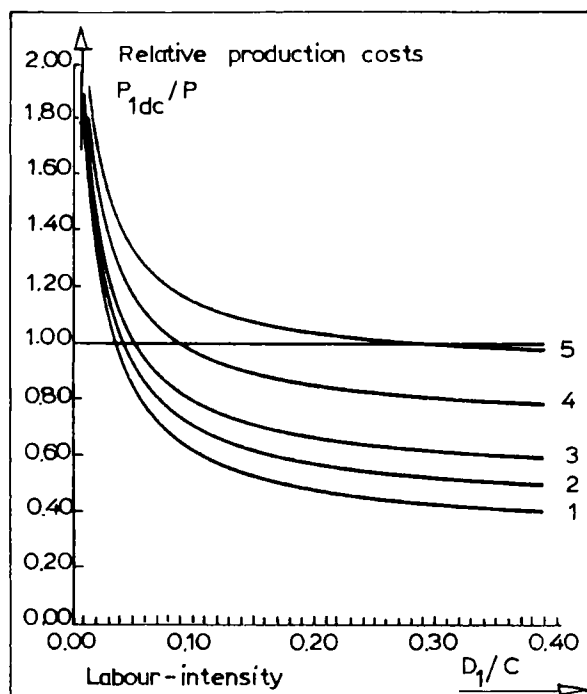


Fig. 8. Sensitivity of the relative production costs to more indirects (h).

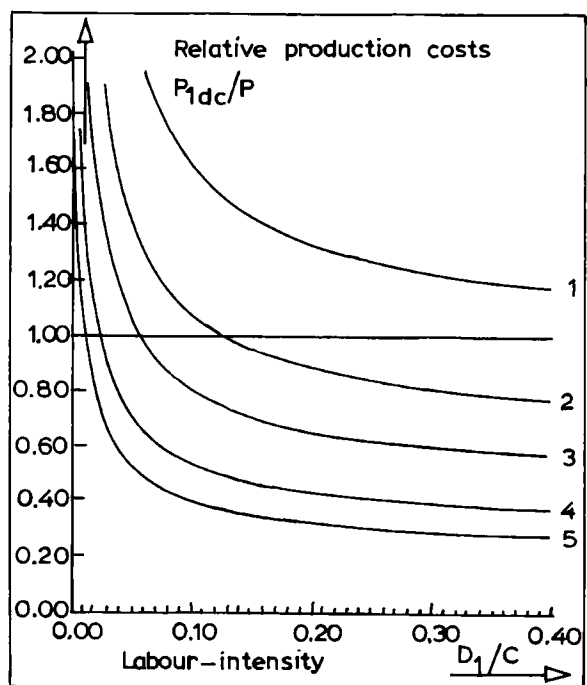


Fig. 9. Sensitivity of the relative production costs to lower labour productivity (p).

(curve 1), no industry whatsoever will obtain advantages in developing countries; even for the very labour-intensive clothing industry ($D_1/C = 0.35$) local production will cost 20% more, as indicated by figure 9.

The great influence of the labour productivity on relative production costs is also important with regard to the batch size: the larger the batch size, the larger the relative labour productivity, as shown in the foregoing. This batch size effect can also be deduced from Fig. 9. Moving from curve 1 to curve 4, which can be interpreted as going from smaller to larger batches, yields an increase in relative labour productivity from 25% to 75%.

CONCLUSIONS

Considering production in developing countries, the local labour productivity appears to be the most decisive factor for the choice of industry. This labour productivity is closely related to the characteristics of the production involved: product-oriented production has a significantly higher relative labour productivity than a process-oriented industry in developing countries.

Since the possibilities for product-oriented production are greater for large-scale production, investors in developing countries should try to choose technologies based upon larger batches. The markets for these products can be local, regional or international, depending on the size of the country.

Further research is needed in order to quantify the relationship between production characteristics (batch size, number of extra indirects, etc.) and labour productivity in developing countries. In this respect, studies on variations in labour productivity between similar production systems in different developing countries are important.

In determining the location of industries in low-wage developing countries, the relative costs of labour are far less important than labour productivity. The sensitivity analysis showed that variations in the very-low wage costs are of little importance for location.

For middle-wage countries like Tunisia and Morocco, however, the wage rate becomes more important. It has been shown that, for these countries, the minimum labour productivity required is around 40% of that of western countries, if it is to be possible to produce at lower cost.

The higher ratio of indirect/direct workers has a great influence on the possible production costs advantages. Next to labour productivity we found this ratio to be most important. This leads to the conclusion that further research is necessary in order to trace the different causes of this higher ratio and to discover ways to lower this ratio. One possibility could be substituting local management by western (imported) management, other possibilities are training, changing the infrastructural constraints, etc.

Finally, in the authors' opinion, the sensitivity analysis presented here shows that the discussed economic literature about labour-intensive industries in developing countries

has the danger of oversimplifying micro-economic reality. Even labour-intensive industries can be advantageous in under-developed countries only if a number of rigorous conditions is satisfied.

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