APPRAISING MANUFACTURING LOCATION*

Harm-Jan Steenhuis* and Erik J. de Bruijn**
* College of Business and Public Administration, Eastern Washington University, Spokane, USA
** Technology and Development Group, University of Twente, Enschede, The Netherlands

ABSTRACT
International location of manufacturing activities is an issue for managers of manufacturing companies as well as
public policy makers. For managers, the issue is relevant because international locations offer opportunities for
lowering costs due to productivity improvements. For governments the issue is important because it offers
improvement of national income due to attracting manufacturing industries with high productivity. There are
extensive theories to facilitate their decision making, which all require detailed data collection and extensive work.
This paper proposes a quick appraisal instrument based on combining the in-depth knowledge of the managers or
policy makers, using GDP as a measure of productivity and applying the concept of ‘island’ and ‘integrated’
industries.

Keywords: international operations, global supply chain, industrialization, economic development

1. INTRODUCTION
Internationalizing companies are faced with decisions regarding where to locate its manufacturing activities.
Simultaneously governments are faced with decisions on which industries to foster. Both types of decisions deal
with the same issue, the connection of manufacturing technologies and national environments, but from a different
perspective. This paper is based on research in the aircraft industry. We analyzed how companies in this sector
relocate manufacturing activities. We focussed on aircraft production in Canada, Romania and the Netherlands and
discovered that the productivity of labor is different in these countries (Steenhuis and de Bruijn, 2002). On hindsight,
management might have made the wrong relocation decisions. This paper addresses, for companies and
governments, the factors that need to be assessed to determine respectively the potential suitability of a location and
a type of industry more appropriately.

2. COMPANIES AND MANUFACTURING LOCATION
Location decisions are of paramount importance for companies. This is not only when they establish themselves but
it also occurs later in their life cycle, for example when they want to expand. As a result of the process of
globalization, companies now have to include the option of selecting an international location. This has made the
location of manufacturing activities a more complex issue. International location decisions have received increased
attention over the last decade from a range of perspectives. Initially theories were developed that showed when (in
the product life cycle) companies were moving across borders (Vernon, 1966). Lately, theories on the
internationalization process have become much more sophisticated (Melin, 1992, Elango, 1998, Fletcher, 2001). Special
attention has been put on theories that are aimed at helping companies to decide whether they should export their
products to a foreign market from their home location or whether they should invest in manufacturing facilities in the

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implications of having a foreign subsidiary, theories have been developed to determine its potential contribution to headquarters (Christmann et al., 1999), as well as to the host country (O'Donnell and Blumentritt, 1999). Theories have also been developed with regard to the costs of moving manufacturing to foreign locations (Teece, 1976, Eden and Miller, 2001). For companies which consider multiple foreign investments, the management, and choice, of locations becomes even more complicated. From an operations perspective, theories have been developed that describe which factors influence the location decision (Brush et al., 1999, Pongpanich, 1999). For multiple factories, theories are available that optimize the manufacturing locations and the logistical flows between these locations (Drezner, 1992, Verter and Dincer, 1992). In addition, different factories might have different roles (Ferdows, 1989, Shi and Gregory, 1998).

However, all these categories of theories have several limitations. The internationalization process theories are of a general scope but this might not, or not sufficiently, coincide with a particular company. For example, the choice of export versus FDI is primarily markets-oriented but for some, truly global industries a production viewpoint is more appropriate. Rather than taking the location of markets as a focus, the production activities should be taken as a focus because there is only one market; the world. An example of such a truly global industry is the aircraft industry. Based on the characteristics of the production activities it should be determined where best to locate these activities. It is also questionable whether the complexity of the location problem can be adequately quantified and covered in mathematical formulae such as is typical in the logistical or operations research approaches. Another limitation is that the decisions on where to manufacture are invariably made at a top level in the organization. Mintzberg notes that managers do not just use analysis for their decision making but rely to a large extent on intuition (Mintzberg, 1989) (pp. 56-78). Within the framework of our research, this viewpoint was confirmed. Top management of a Canadian company choose to locate its production in Romania, because one of the executives had family ties in Romania (Steenhuis, 1998). The location was determined without all kinds of theories but by an intuitive feeling that Romania would provide an appropriate environment.

In short, the available theories on international location of manufacturing have their merits but in their presented form seem to be less appropriate for use by top management. These management levels require a quick appraisal instrument that builds on their intuition, without spending (much) time on details. Once a basic decision for a location is made, the more detailed analysis can take place by staff and specialists.

3. GOVERNMENTS AND MANUFACTURING INDUSTRIES

Governments face similar issues as companies albeit from a different perspective. Their concern is which type of industries they should foster. A driving force is that the technologies, as a part of the industries, have a (major) impact on economic development (Sharif, 1986, Technology Atlas Team, 1987b). As with international manufacturing location decisions for firms, this area has attracted widespread attention. The linkages between technology, and specifically manufacturing technologies, and economic development and growth have been extensively explored from a variety of viewpoints.

For the industrialized nations, it is primarily an issue of sustaining economic development. This can be accomplished through innovation (Porter, 1990). For example in the US and Japan there is tremendous effort to innovate through cooperative research centers (Aldrich and Sasaki, 1995). Another approach is to focus on cluster development (Porter, 1998).

For the industrially developing countries there are several routes to upgrade their technology base. First, it can select a bottom-up strategy: to upgrade from distribution point via manufacturing base towards R&D capabilities (Dahlman et al., 1985, Hayami and Ruttan, 1985, Habibie, 1990). Second, it can opt for a leapfrog strategy (Sharif, 1989). Third, industrially developing countries can especially learn from the application of technologies that have been established in the developed countries. In this regard, numerous theories have been developed. Some, primarily technology-oriented theories, are aimed at assessing technologies (Sharif and Sundararajan, 1983, Sharif, 1986, Technology Atlas Team, 1987a). In particular, there are theories which address the technology gap with developed countries (Technology Atlas Team, 1987c, Klein and Lim, 1997). A viewpoint of ‘using’ foreign companies is expressed in theories that investigate the role of foreign direct investment (Nogueira and Nogueira, 1995, O'Donnell and Blumentritt, 1999, Glass and Saggi, 1999). Lastly, there are theories aimed at acquiring technology and how the technology should be transferred (Raz et al., 1983, Raz and Assa, 1988, Siemsen, 1988, Scarso, 1996).

The theories for technology assessments require a considerable amount of input, detail and expertise (Bowonder and Miyake, 1988, Ramanathan, 1988, Panda and Ramanathan, 1996). In addition to this, there are numerous technologies and it is practically impossible to analyze them all. Also, similar to the discussion on intuition for managers, policy makers are led by external influences, for example the ‘prestige’ that a certain industry carries with it. This motive
frequently turns out to be extremely expensive. Indonesia invested heavily in the prestigious aircraft industry without gaining a foothold (Cohen, 2000, Steenhuis and Bruijn, 2001). Governments, therefore, would benefit from a quick appraisal instrument that helps focus their attention on certain technologies, without being required to spend a large amount of time on all the details. Once a choice for a technology or industry is made, the more detailed analysis can take place.

4. PRODUCTIVITY

The discussion in the previous sections illustrated that companies need to determine attractive locations and governments need to decide which industries are attractive. An appraisal method, which allows companies and governments to quickly distinguish between attractive and unattractive locations or industries, would be instrumental for this purpose. Companies frequently use the labor cost per hour as a reliable indication to determine the attractiveness of a location. However, this is much too simplistic, and does not provide a reliable indication. Labor cost per hour is only a part of the total picture. Labor productivity levels are also important because this gives a more accurate measurement of the total cost involved. For governments, the choice of attractive industries is also related to productivity (Porter, 2000), because the drive for innovation is a drive for productivity improvements. Porter states: “Economic development seeks to achieve long-term sustainable development in a nation’s standard of living, adjusted for purchasing power parity. Standard of living is determined by the productivity of a nation’s economy, which is measured by the value of the goods and services (products) produced per unit of the nation’s human, capital, and physical resources “(Porter, 2000) (p. 19).

In other words, both a company looking for an international manufacturing location and a government looking for technologies (industries) are concerned with productivity. Porter argues that the productivity of a nation’s economy is measured by the value of the goods and services produced per unit of input. The GDP per number of people employed is good proxy for the productivity of a nation. It shows how much value, in goods and services are produced per working resident of that country. This leads to the observation that for companies it is not necessary to examine all locations and also that governments don’t have to assess all type of industries. An assessment of its GDP per number of people employed provides a first insight into the productivity of a country’s labor force.

\[
\text{Productivity}_A = \frac{\text{GDP}}{\text{number of people employed}}
\]

Where, Productivity\(_A\) stands for the productivity of the residents of country \(A\).

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1 The term productivity is defined in various ways. A practical and sound operational definition of productivity is by in’t Veld (Veld, 1992):

\[
\text{Productivity}_{\text{real}} = \frac{\text{Output}_{\text{real}}}{\text{Input}_{\text{real}}} = \frac{\text{Output}_{\text{norm}}}{\text{Input}_{\text{norm}}} \times \frac{\text{Output}_{\text{real}}}{\text{Output}_{\text{norm}}} \times \frac{\text{Input}_{\text{norm}}}{\text{Input}_{\text{real}}}
\]

which is reformulated by in’t Veld as:

\[
\text{Productivity}_{\text{real}} = \text{Productivity}_{\text{norm}} \times \text{effectivity}_{\text{real}} \times \text{efficiency}_{\text{real}}
\]

If productivity comparisons at different locations are made, then the norm productivity is constant. That leaves two terms, the effectiveness of operations, i.e. is the company able to produce the good according to the specifications, and the efficiency of the operations, i.e. how much does it cost to produce? The distinction between effectiveness and efficiency can also be worded as effectiveness is concerned with doing the right thing whereas efficiency is concerned with doing things right.

2 There are three measurements for national income that can be used. The gross national expenditure (GNE), the gross national product (GNP), and the gross domestic product (GDP). GNE measures national income as equal to the sum of expenditures on consumption, investment, government production, and net exports. GNP measures national income as equal to the sum of all factor incomes earned plus the depreciation plus (to get the valuation at market prices) indirect taxes minus subsidies. GDP measures national income as equal to the sum of all values added in the economy or the values of all final goods produced in the economy. An important difference between GDP and GNP is that GDP measures output located in a certain country whereas GNP measures output owned by citizens of a country (but these citizens could be living abroad). For the argument in this paper the GDP is the most appropriate measurement of national income.
Comparing these figures for (aircraft production activities in) Romania, Canada and the Netherlands shows that (based on numbers provided by (World Development Report, 2000)):

- Productivity_{Romania} = $34,027/11 = $3,093 per person employed
- Productivity_{Canada} = $634,898/16 = $39,681 per person employed
- Productivity_{Netherlands} = $393,692/7 = $56,241.71 per person employed

Therefore, the productivity of Romania versus Canada versus the Netherlands can be determined as: 1:12.8:18.2

It is attractive to re-locate production activities from country B to country A if:

\[
\frac{Productivity_A}{Average \ wage \ rate_A} > \frac{Productivity_B}{Average \ wage \ rate_B}
\]

When production activities for global products are re-located internationally the value of the output (the produced aircraft part) is the same regardless of the production location, i.e. it is determined by the international market.

As a result: productivity x input value (input cost from a company perspective) = constant

Where input value = number of hours x (cost per hour).

If we continue with the comparison of the three countries, the labor cost per hour of Romania versus Canada versus the Netherlands compare as 1:5:7. But the lower labor cost in Romania does not make up for the difference in productivity, or in other words, the number of hours required for producing aircraft parts in Romania is much higher than in Canada or the Netherlands. In particular:

\[
\text{productivity}_{Romania} \times \text{input value}_{Romania} = \text{productivity}_{Canada} \times \text{input value}_{Canada} = \text{productivity}_{Netherlands} \times \text{input value}_{Netherlands}
\]

Number of hours = 64 x number of hours_{Canada} = 127.4 x number of hours_{Netherlands}.

The number of hours to complete a certain task in Romania versus Canada versus the Netherlands can therefore be calculated as: 127.4:2:1.

Therefore, under these theoretical considerations, i.e. labor productivity is uniform within a country, it is judged to be unattractive to re-locate aircraft manufacturing activities from Canada or the Netherlands to Romania. It is unattractive because due to higher productivity levels it is cheapest to produce in the Netherlands and it is most expensive in Romania.

The previous conclusion was strictly based on an ideal theoretical situation, as has been specified. A problem with the approach is that the use of GDP per number of people employed is an oversimplification for the productivity level. The issue at hand is that productivity is not evenly distributed across a nation and industrial sectors. This can be explained by the following example.

If perfect information and markets would exist, then, at an individual level the income earned is directly related to the productivity of an individual. This can be seen from a simple comparison of two production employees who are performing the same task. The completion of the task has a fixed value for the company, independent on who performs the task.

\[
\text{value output} = c \times \text{value input}
\]

Where \( c \) is a constant portraying the difference in input costs (input value) and output value to the company. Assuming that people can freely move, this means that

\[
\text{value input}_i = \text{value input}_j
\]

Where \( i \) and \( j \) stand for two different employees. This is the case because if the value of the people’s input is different, the person with the higher productivity would move to another job where the pay would be higher.

Therefore
\[ \text{hours} \times \text{wage}_i = \text{hours} \times \text{wage}_j \]

A result of this is that although for the company the cost of getting the task done is fixed, for the individual workers it might make a big difference in the wages they earn because these wages are directly related to their individual productivity level.

Perfect information and markets don’t exist in practice and as a consequence there are differences in the value of the input. This might for example occur because workers can not move freely, or do not want to move. A specialized shop floor worker may not be able to find another job because the job that he or she does is so narrowly defined that it is not needed in a different location or industry. As a result of this phenomena it means that

\[ \text{value}_{\text{input}_i} \neq \text{value}_{\text{input}_j} \]

and this means that

\[ \frac{\text{value}_{\text{output}_i}}{\text{value}_{\text{input}_i}} \neq \frac{\text{value}_{\text{output}_j}}{\text{value}_{\text{input}_j}} \Rightarrow \text{productivity}_i \neq \text{productivity}_j \]

For practical, not ideal situations, the key is therefore to get access to those workers (or on a more aggregated scale those activities) in a nation for which the productivity level is high compared to the income level. In other words, find the group of production activities \( i \) in country \( A \) for which the productivity is higher than the average productivity level in country \( A \).

\[ \text{productivity}_{A,i} > \text{productivity}_{A,A} = \frac{\text{GDP} _{A}}{\text{number of persons employed}_{A}} \]

In the particular instance of aircraft parts production in Romania it is likely that the productivity for those activities is higher than the national average. Due to the involvement in aircraft production activities over the last couple of decades (although not at world competitive standards) operators have become trained and research showed that foreign expatriates qualified them as almost as productive as operators in Canada or the Netherlands (Steenhuis, 2000). However, they do require more hours of work to complete a similar task as in Western countries (Steenhuis and de Bruijn, 2002).

For managers and governments it is a difficult task to distinguish the different productivity levels because this requires detailed in-depth knowledge. It includes for example knowledge about all the micro-economic factors that determine national competitiveness, see e.g. (World Economic Forum, 1999), or the technology factors that determine national competitiveness, see e.g. (Roessner et al., 1997).

A short-cut to circumvent the need for detailed and in-depth knowledge can be made. Not all types of industries fit well with every country. The aircraft industry is an industry that is tightly connected to the overall business environment. It requires a for example a minimum level of infrastructure for transportation and communication and skills for manufacturing as well as managing. To build up the aircraft industry in an industrially developing country is extremely difficult and expensive because the overall environment in such a country is lacking (Steenhuis and Bruijn, 2001). It can therefore be concluded that the aircraft industry is an ‘integrated’ industry, i.e. it is very dependent on the overall environment. This explains why the aircraft industry is, until the present date, not successful in Romania. Even though the productivity of manufacturing workers may be relatively high compared to the productivity of workers in Romania overall, the Romanian environment is not productive enough, compared to world standards, for aircraft manufacturing.

Not all types of industries are integrated industries. There are also examples of what can be designated as ‘island’ industries, i.e. industries that are rather independent of their overall environment (for example less dependent on a minimum level of infrastructure for transportation and communication and skills for manufacturing as well as
management). An example of this is the software industry. For the software industry to be successful you need good programmers, and some hardware and software. In other words, it can operate almost anywhere in the world. This explains why the Indian software industry is world competitive.

5. LOCATION & TECHNOLOGY APPRAISAL

With the use of GDP and the concept of island and integrated industries, companies and governments hold the key to a quick appraisal method that uses the intimate knowledge they already have or have easy access to. Companies searching for international manufacturing locations can use GDP per number of people employed as a proxy for the productivity of a country’s labor force and use this data with their intimate knowledge about their industry. If the company’s manufacturing industry is primarily an integrated industry, then it is theoretically attractive to re-locate production to another country if this country’s productivity is higher than at the original location. Therefore, relocating manufacturing to industrially developing countries, which typically have a lower productivity, is usually not a good option for companies in integrated industries, considered from the production viewpoint. This conclusion is in line with the observation that most of the foreign direct investment is aimed at industrialized countries rather than at industrially developing countries (Ferdows, 1997).

In case the company’s manufacturing industry is primarily an island industry, then it might be advantageous to re-locate manufacturing activities as long as the productivity in this particular area of production is higher than the national average. In other words, for island industries, it is theoretically beneficial to re-locate to low-cost labor countries as long as there is imbalance between the productivity of those activities and the incomes generated with those activities.

$$\text{productivity}_{A,i} > \text{productivity}_{A,i} = \frac{\text{GDP}_{A}}{\text{number of persons employed}_{A}}$$

This only makes sound business sense though if the imbalance is likely to continue for a long time, e.g. there is limited opportunity for people to move away from the specific activities because they are so specialized that they won’t easily find other job opportunities. It means that

$$\text{productivity}_{A,i} > \text{productivity}_{A,i} = \frac{\text{GDP}_{A}}{\text{number of persons employed}_{A}}$$ \text{will remain on the long-term.}$$

It also makes business sense if the imbalance will solve itself in a higher overall productivity, i.e. the new location’s higher productivity will sustain itself, but only if the home location’s productivity is not likely to improve as much. Therefore in the long-term the new location (in country A) is more attractive than the original location (in country B).

$$\text{productivity}_{A,i,new} > \text{productivity}_{B,i,new} > \text{productivity}_{A,old}$$

In conclusion, this means that for integrated industries, there is a good case to move them to higher productivity locations. Integrated industries are more appropriate for industrialized countries although moving integrated industries away from industrially developing countries will not allow the industrially developing countries to develop technologically. Island industries are particularly suited to be relocated to cluster areas, since these areas have higher productivity levels, or to locations where there is an imbalance between productivity and income.

Governments that are searching for manufacturing industries can use GDP/number of people employed as a proxy for the productivity of their country’s labor force and use this with their intimate knowledge about the composition of the GDP. In case the industry is an integrated industry, it is attractive to nurture this industry, from an economic development standpoint, when the average productivity levels in this industry are higher than that in the country overall. However, in this case, which is probably true for many industries for developing countries, one has to consider whether these productivity levels can be reached since the local environment might be impeding such productivity levels. If the industry is an island industry, then it makes sense to attract the industry if the average productivity level in the industry is higher than that in the country.

Overall then, it can be concluded that island industries are particularly appealing to the industrially developing countries in raising their national income levels although these industries contribute little to the overall technological development level. This explains the phenomena that industrially developing countries have extreme difficulty to
catch-up with the level of industrialized countries. They need their overall economic and technological position to improve but although island industries offer economic improvement, their technological impact is limited. Hence, for overall improvement integrated industries are attractive. However, the integrated industries are dependent on the environment and hence, the low level of development in industrially developing countries impedes optimum productivity levels for these industries. The industrially developing countries are therefore caught in a very difficult situation.

6. CONCLUSIONS
Both governments and companies are constantly searching for productivity enhancement. For companies this is the case when they have to decide where to manufacture their goods. For governments this is the case when they want to decide which industries to stimulate. Although many theories exist that can support the decision making of both government and of industry, these are invariably very detailed and require expert knowledge outside of the immediate area of expertise. The GDP/number of people employed measurement and the concept of island and integrated industries are used to give companies and governments a quick assessment of potential locations respectively industries.

For companies that are looking for international manufacturing locations this method is based on the following steps.
- Determine whether the industry is an island or integrated industry.
- Collect GDP figures for attractive locations.
- Estimate whether the average productivity level, in the potential host country, warrants moving production activities in the case of integrated industries, or;
  - Estimate whether productivity levels for the particular types of activities, in the potential host country, warrants moving production activities in the case of island industries and whether this will be a long term productivity difference.

For governments that are looking for industries, this includes the following steps.
- Determine how the national industries contribute to the GDP
- Collect information on whether the industry is an island or integrated industry.
- Estimate whether the industry will raise the overall level of productivity in the case of integrated industries, or
  - Estimate whether the productivity levels for this particular industry are higher than the national average in the case of island industries.

By executing those steps and using the calculation methods as has been discussed an indication can be obtained to judge the suitability of a location for a specific type of industry, or to select a type of industry for a specific industrial setting.

Integrated industries fit well with the industrialized countries and less with industrially developing countries. Island industries on the other hand can be facilitated and developed in both industrially developing countries as well as industrialized countries.

REFERENCES
Roessner, J. D., Porter, A. L. and Newman, N. (1997), 1996 Indicators of technology-based competitiveness of nations, Technology Policy and Assessment Center, Georgia Institute of Technology, Atlanta, Georgia.