

Manufacturing footprint analysis

- cost accounting approach

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Abstract

The concept of manufacturing footprint refers to positioning of production and operation activities in terms of value chain and geographical location. Companies need to analyse and design their production network from this point of view. This paper presents a cost accounting based framework for analysis of international manufacturing companies.

Keywords: manufacturing footprint, global manufacturing.

Introduction

Free trade and affordable global logistics has made changed manufacturing in many industries. Companies can consider several alternatives by factory location analysis, supplier selection as well as comparing outsourcing/insourcing options (Farell 2006). According to Holweg and Pil (2006) operating in such environment has changed the scope of analysis from value chains to value grids. Large companies have used global manufacturing as a source of competitive advantage. Today, also medium size and even smaller companies can internationalize the operations by establishing presence around the world. Drivers for the change include:

- (1) growing world population creating emerging economies (see Figure 1).
- (2) differences in labour costs and productivity
- (3) developed world-wide logistics systems
- (4) free-trade agreements
- (5) reliable and inexpensive global communication systems

Structures are changing in several industries and the optimality seems to change over the time (Ferdows 2008). Sturgeon et al (2008) studied how automotive industry footprint has evolved over and what have been the driving forces. Klier (2005) focused on supplier location in the same industry. Wæhrens, et al (2012) developed future manufacturing scenarios for Danish multinational companies. Ali-Yrkkö et al (2011) analysed how value creation is organized in mobile phone manufacturing.

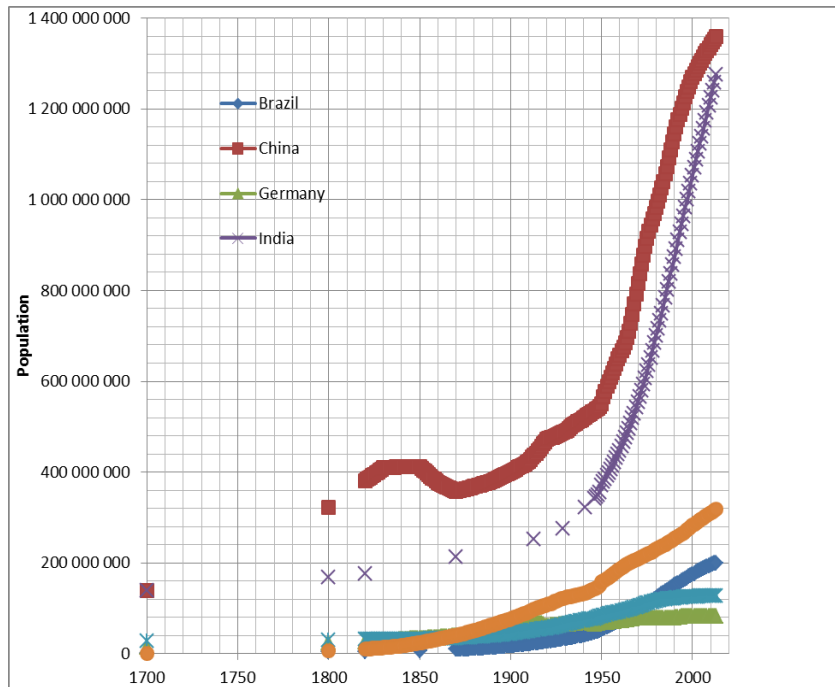


Figure 1 – World population development in selected countries (data obtained from Gapminder.com 2012).

Manufacturing footprint analysis refers to set of decisions related to manufacturing location, supply chain structure and sourcing strategies. The decision-making process involves analysis of macroeconomic trends, trade agreements, technological developments as well as traditional business analysis. The outcome of manufacturing footprint analysis defines how manufacturing is linked to markets in terms of geographical location and value creation. There is a need to have a systematic process to manage the decision making in a way which is repeatable and applicable in several different conditions and which could include different aspects into account. This need has been acknowledged by several authors. Pontrandolfo (1999) reviewed techniques used for global manufacturing. Shi and Gregory (1998) considered international manufacturing networks as a source of competitive capability. Offshoring strategies have been reviewed by Pedersen (2006) and management consulting companies such as Booz & co (Hardman & Mueller 2006). and McKinsey (Pergler et al 2008) have developed own frameworks to approach global manufacturing. This paper presents a cost account based approach on manufacturing footprint analysis and introduces some key parameters which have an effect on the result.

Labour cost and productivity

Labour cost has been one of the most important discussion items on global manufacturing. Low cost countries have taken a great share of labour intensive operations in electronics and textile industries to name some examples. Figure 2 presents hourly compensation in USD in selected countries. The figures are from 2011 for all other countries except two countries - India 2007 and China 2008 – where statistics handling system differs. Anyhow, the numbers show the great difference between India and China, where compensation level is below two dollars compared to US where the level is around 35

USD per hour or numbers of Germany with 47 USD and Norway 64 USD per hour. According to some estimates (Yuan 2012) the labor cost in China has more than doubled between 2007 and 2011, which gives an example of dynamic change.

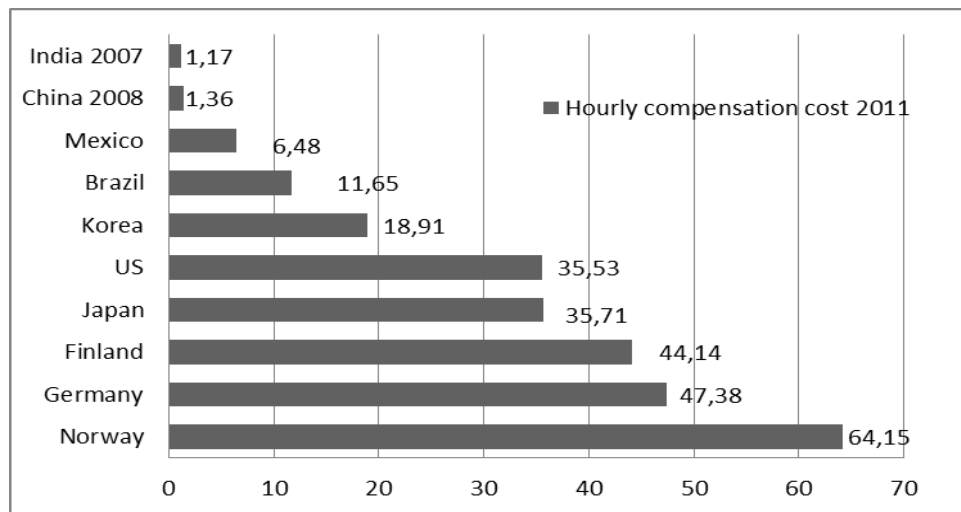


Figure 2 – Hourly compensation USD cost in selected countries (data source: US Bureau of Labor Statistics).

Manufacturing has increased its share in many low cost countries because of attractive labour cost. However, all of the mentioned more expensive countries have still manufacturing in some extent. The reason behind this is productivity, which refers to output what manufacturing produce with same labour. According to example from Sirkin et al (2011) and data from US Bureau of Labor Statistic, the productivity ratio between US and China was 100:13 in 2000 and is estimated to be 100:40 in 2015. This means that the same manufacturing output needs double amount of labour in China compared to US.

Productivity parameter is driven by capabilities and skills, which develop over the time, but any increases in labour cost will affect the number as well. In the factory level, one of the important productivity components is quality, which means less rework and reduced costs. There are no generally accepted quality metrics available but what is commonly seen in manufacturing is that production lines with shorter history may be behind the learning curve in ramp-up-to quality compared to more experienced ones. However, the life-cycle in learning curve is measured in accumulated production volume, not months or years. In terms of flexibility, work contracts are also very different around the world. Annual working hours can vary between China 2200 h, Finland 1700 h and Netherlands 1389 h (data: OECD / Onderzoeksinstituut voor Arbeid en Samenleving HIVA / Deloitte). Manufacturing labour contracts can be very different to adjust in case of capacity reduction. In many European countries workers contracts cannot be terminated before 3 to 6 months depending on contract length. Fixed term contracts such as 3-year contract with renewing options are also commonly used in China.

Logistics costs and performance

Several cost effective alternatives are available for global transportation. Use of standardized sea container and intermodal logistics has reduced cost of non-bulk transportation over the last 50 years remarkably. Container shipping price estimation has become more complex due to extensive use of surcharges such as Suez Canal transit, piracy, heavy weight, war risk or congestion to name some (Slack et al 2011).

Figure 3 below shows total freight rates including both base rate and surcharges to selected destinations. Stopford (2009) has estimated that a roundtrip of 14 000 miles can vary between 648 USD and 360 USD depending on ship sizes between 1200 TEU and 11 000 TEU containers. Large container ships such as Emma Maersk can have a capacity exceeding 14 000 TEU and carry the cargo in 30 days between Asia and Europe by having a crew of 13 people. For manufacturing company, the logistics service network between the logistics hubs of the world has created a reliable and cost effective way to deliver goods from manufacturing to point of consumption. In most cases, long haul transportation cost represents a minority in the overall logistics costs.

Arvis, et al (2012) have compared logistics conditions in countries around the world by using a survey. They have developed a Logistics Performance Index which gives an overall score [1..5] for each country by combining aspects from customs, infrastructure, internal shipments, logistics competencies available, tracking/tracking and timeliness of logistics. Not surprisingly, the top ranks are taken by small countries which have central logistics hubs such as Singapore, Hong Kong, Germany and the Netherlands. (Table 1).

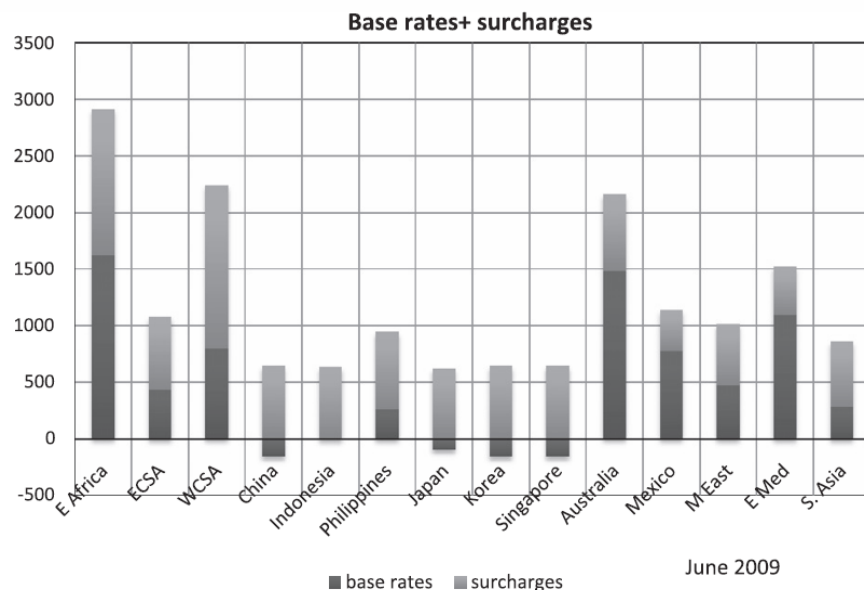


Figure 3 – Container freight rates to selected destinations (Slack et al 2011).

Table 1 – Logistics performance index ranks for selected countries (data from Arvis et al 2012).

Country	Year	LPI Rank	LPI score	Customs	Infra-structure	Intern. shipments	Log. Compet.	Tracking & tracing	Timelines
Singapore	2012	1	4.13	4.10	4.15	3.99	4.07	4.07	4.39
Hong Kong, China	2012	2	4.12	3.97	4.12	4.18	4.08	4.09	4.28
Germany	2012	4	4.03	3.87	4.26	3.67	4.09	4.05	4.32
Netherlands	2012	5	4.02	3.85	4.15	3.86	4.05	4.12	4.15
Japan	2012	8	3.93	3.72	4.11	3.61	3.97	4.03	4.21
United States	2012	9	3.93	3.67	4.14	3.56	3.96	4.11	4.21
United Arab Emirates	2012	17	3.78	3.61	3.84	3.59	3.74	3.81	4.10
Australia	2012	18	3.73	3.60	3.83	3.40	3.75	3.79	4.05
Korea, Rep.	2012	21	3.70	3.42	3.74	3.67	3.65	3.68	4.02
South Africa	2012	23	3.67	3.35	3.79	3.50	3.56	3.83	4.03
China	2012	26	3.52	3.25	3.61	3.46	3.47	3.52	3.80
Brazil	2012	45	3.13	2.51	3.07	3.12	3.12	3.42	3.55
India	2012	46	3.08	2.77	2.87	2.98	3.14	3.09	3.58
Mexico	2012	47	3.06	2.63	3.03	3.07	3.02	3.15	3.47
Russian Federation	2012	95	2.58	2.04	2.45	2.59	2.65	2.76	3.02
Nigeria	2012	121	2.45	1.97	2.27	2.60	2.52	2.35	2.92
Iraq	2012	145	2.16	1.75	1.92	2.38	2.19	1.86	2.77

Value added analysis in global production

Value creation along the supply chain may be very different when comparing products. Figure 4 illustrates examples of value chain of three commodity products: shirt, shoe and mobile phone. The chosen products are made by taking the advantage of global manufacturing footprint. The cost structures of all products show how important share is covered by R&D, product administration and retail activities. Competitive cost has been enabled by using global manufacturing footprint, in practice low cost countries for labour intensive operations and efficient logistics.

Companies want to ensure their strategic positioning in the value chain. For this reason non-core competence related manufacturing operations have been outsourced or moved to low cost countries. Value-add aspects are important for nations as well, and we have seen export restrictions of scarce raw materials in order to add value in local industry. Chinese case of rare earth metals used in battery manufacturing and permanent magnet applications is a good example of this type of approach.

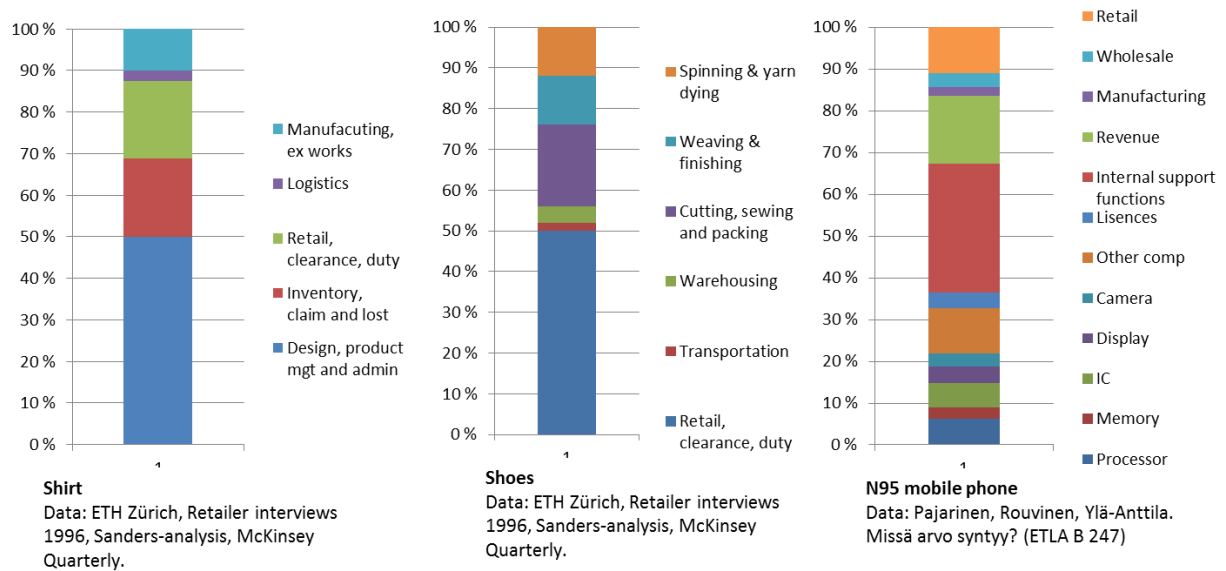


Figure 4 – Value analysis of three products: shirt, shoes and mobile phone.

Value chain structure

Global value chain structure is shaped by dispersed manufacturing. Placing manufacturing units around the globe has impact on how every day supply chain management operates.

- (1) Sourcing strategies. Part of manufacturing footprint is to set strategy for supply. Some components may be purchased locally and feeding only the nearby factory. In case of more complicated components, a centralized global feeding factory could support all the regional factories and achieve high performance. In order to improve flexibility, resiliency and competition, many companies prefer dual sourcing. For project businesses such as offshore, marine, oil and gas, nuclear related large scale infrastructure projects, governments set targets for content of local sourcing, this requirement could range between 20 – 40 % and could shape company's global supply chain.
- (2) Distribution strategies. Each manufacturing site needs to be connected to distribution center. In case of merge-in-transit or project based business involving a great number of manufacturing sites, direct delivery from vendors to distribution centers take place. Finding an optimal solution between centralized and decentralized structure is an important decision what managers need to take. Centralized factory structure should enjoy higher volumes and reduced manufacturing costs. The inventory levels should be also lower due to risk pooling described by Zinn et al (1989). However, distribution costs are most likely increased due to longer distances.
- (3) Postponement strategies and strategic safety stock location define the response time of a value chain (Graves et al 2000). Inventory located downstream in the value chain is probably more expensive from inventory holding cost point of view, but managing material flow from upstream safety stocks takes longer time. Product and process design on postponement improves the performance (Feitzinger & Lee 1997).

Cost model

The following cost accounting type of model proposes some key parameters that should be used in analyzing manufacturing footprint decisions. Country specific features should be recorded for each option and three values, the current, projected in 3 years and worst case scenario for risk analysis. The following cost elements and drivers should be included in comparing different location alternatives for manufacturing.

- Materials costs based on globally sourced materials as well as local sourced components.
- Labour cost and productivity
- Annual depreciation based on investment and fixed assets
- Inventory holding cost caused by average number of inventory holding days due to transportation delay, on-time-delivery performance and quality performance by suppliers and own manufacturing.
- Transport cost for both inbound and outbound logistics
- Country specific customs / taxation on import
- Other remarkable cost items such as energy price or quality costs, which might cause large deviations from original plans.
- Expected production volume
- Expected product life-cycle in production

Production volume

Consider the following example on the effect of production volume to factory selection. There are two manufacturing alternatives (1) western factory and (2) low cost country. The labour cost for the first one is 44 USD per product unit and 10 USD in low cost country. Non-varying cost is 40000 USD and same for both. Figure 5 shows that in smaller volumes (< 500), cost difference is not very much, but by increasing volume it goes up to 60% in favor for low cost country. This example does not include transportation costs to customers, but it shows how low cost manufacturing becomes more attractive on higher volumes when fixed costs are high or when share of material costs are low.

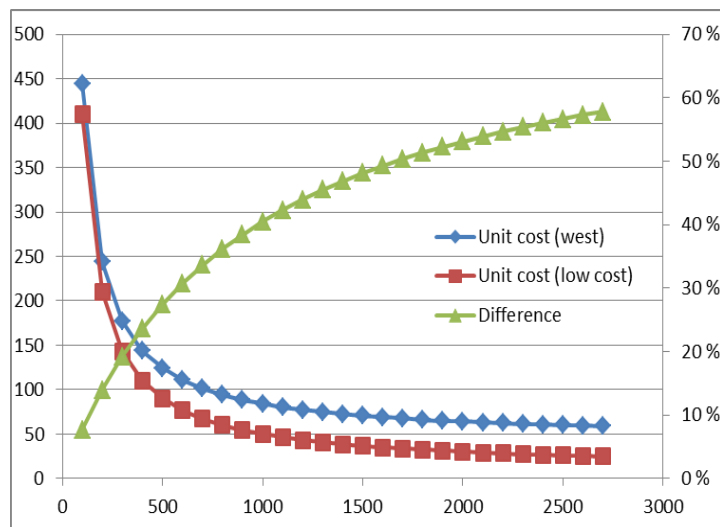


Figure 5 – Low cost manufacturing becomes more attractive in high volumes.

Product life-cycle

Life cycle of production in terms of volume has also impact. Figure 6 below illustrates demand of a product first going up in ramp-up phase. Manufacturing costs remain high in all footprint solutions due to low volumes and high percentage of factory depreciation and other fixed costs as well as components. Solving quality related matters with R&D is a typical concern in this phase. When demand exceeds certain point, the cost difference becomes obvious between two manufacturing options. In this phase the manufacturing should be moved to volume factory, which could be centralized global feeder factory or regional factory close to local markets and preferably in low cost country. The final part, the ramp-down, should be planned ahead and moved to special organization to be able to care a high mix of low volume products. This could be a service organization within a company or external supplier specializing old generation products.

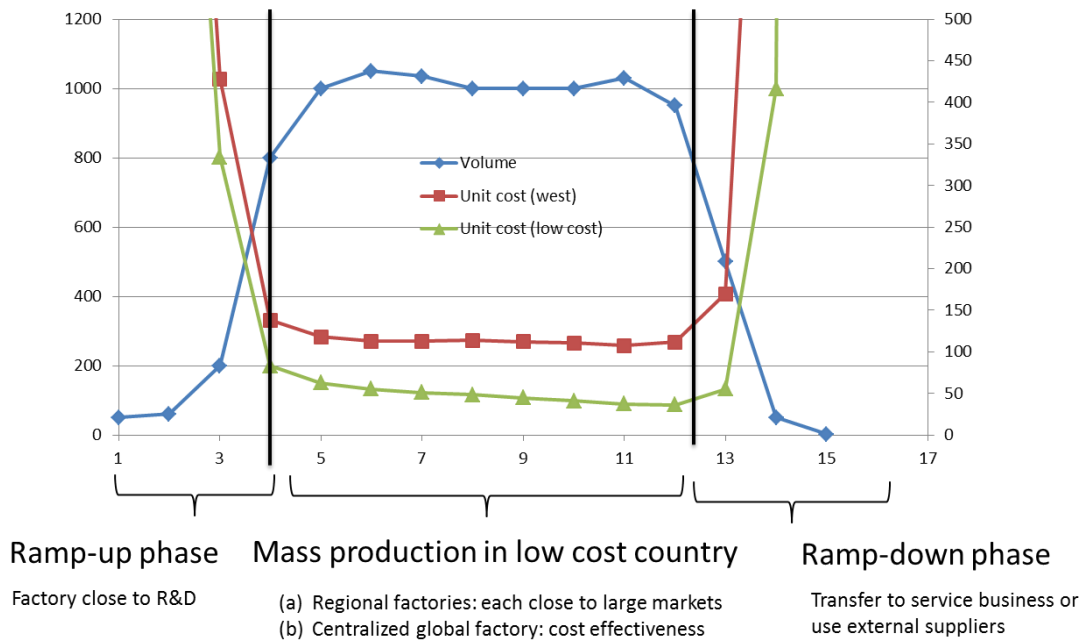


Figure 6 –Factory type optimality changing as function of product life-cycle.

Risk and sensitivity analysis

Due to dynamic and changing nature of parameters, a sensitivity or risk analysis should be conducted for each strategic model attribute (Pergler 2008). Figure 7 presents an example how labour cost and share of labour cost in total cost structure parameters affect the total cost. The plateau part is probably optimally located in a high volume – low cost factory. The mountain part of the figure could fit in high-mix low-volume type of factory located closed to R&D.

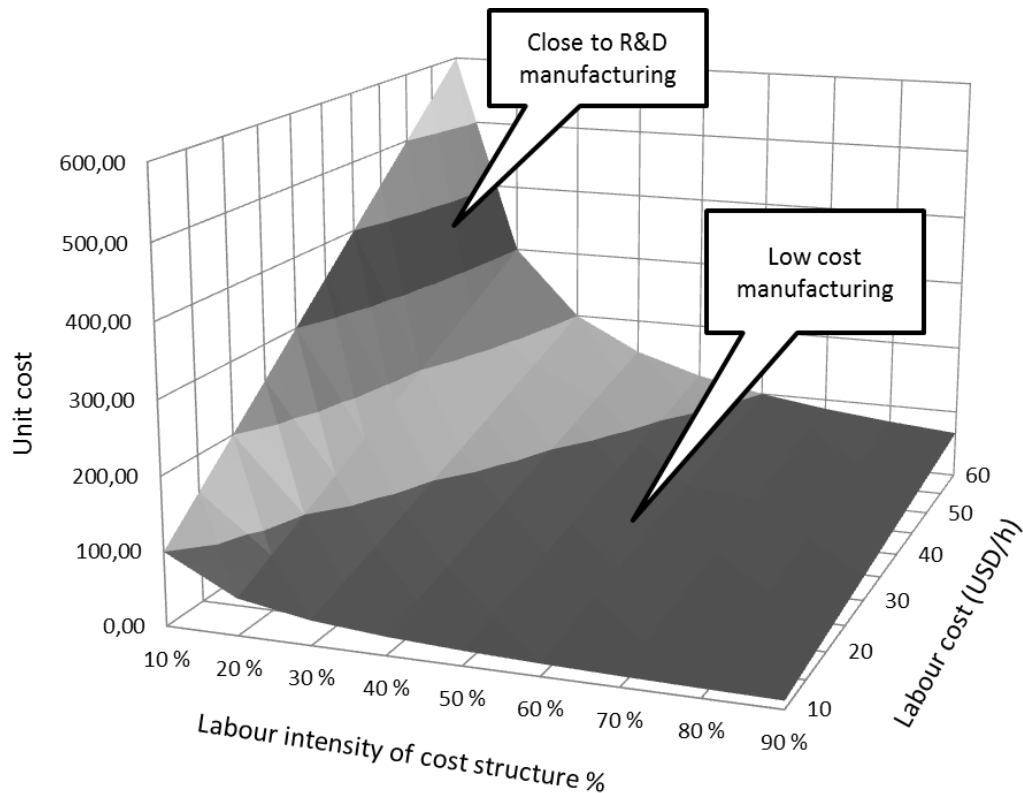


Figure 7 – Sensitivity analysis of labour cost and labour intensity of cost structure.

Conclusions

The simple examples from cost model show some aspects how features of manufacturing alternatives could be evaluated when making manufacturing footprint decisions. A systematic model and data collection is needed in order to check optimality, time-frame and risk of decisions. The examples presented from the literature and model show that there are several trade-off situations which need balancing.

- (1) Location: Low cost manufacturing and customer demand location
- (2) High volume centralized manufacturing and decentralized regional factories with fast delivery
- (3) Flexibility of proposed footprint and effectiveness of manufacturing – Demand change due to life-cycle; uncertainty in cost parameters
- (4) Product life-cycle related uncertainties – length and volume

Literature in supply chain management has presented optimization approaches for network design (Graves 2000). For manufacturing footprint and operations, similar mathematical programming type of approach should be introduced based on cost models.

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