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Impact of demand characteristics on the profitability of a purchasing strategy

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Abstract

The problem presented in this article concerns the impact of demand characteristics for consumer goods on the profitability of purchasing strategy, including the choice of both the source of supply and transport technology (deliveries in containers by sea, rail, air, and road transport). To assess the profitability of applying a specific strategy, the author developed a model to conduct simulations using the Monte Carlo approach for two demand distributions (Gaussian and Gamma), various sales fluctuations, and changes in demand during the delivery time. Calculations were carried out considering the costs of transport, storage, capital costs related to maintaining stocks, and costs of lost sales. The simulation results show that the greater the fluctuations and the lower the predictability of the demand, the greater the profitability of deliveries using air transport and local deliveries. However, concrete decisions depend on knowledge of the consequences of making these decisions and whether appropriate cost accounting is used in enterprises. The results of the calculations also indicate that the strategy of outsourcing production in low-cost countries will, in many cases, become unprofitable if production costs in these countries increase even slightly.

Introduction

Choosing a specific purchasing strategy impacts economic efficiency in a broad sense. The source of supply affects the costs of purchasing a given good – goods for sale or materials for production. If the choice of this source involves a change in the location of supplies, it also impacts the costs of logistics processes (transport, inventory, storage, transshipment) and qualitative consequences. The distance, time of transport for goods, their storage, and the conditions in which they are stored affect the quality of products and the speed of deliveries, which may further affect the possibility of achieving the required level of sales and profits.

Therefore, in the case of companies purchasing or outsourcing production in countries with lower production costs, the consequences of choosing a specific strategy should be accounted for. This means not only production costs but the broadly understood costs of logistics processes, including the costs of lost sales. Making such a decision requires knowledge of so-called "opportunity costs" that are not included in traditional accounting.

This publication presents the results of the author's research on the conditions in which it is profitable to apply a specific purchasing strategy. This strategy includes two basic decisions – the choice of a source of supply and the choice of a method of delivery (a mode of transport, transport technology,

size of deliveries, and their frequency). The author used the simulation method with the use of their own simulation model. The calculations were made based on data of costs, the parameters of logistic processes, and rates for the logistics services obtained from the logistics market in Poland and Europe.

For years, the author of this paper has been conducting research on the problems of economic efficiency in choosing sources of supply and transport technology. These decisions are interrelated (for example, production orders in the Far East may involve sea or rail transport, which is rarely used for deliveries in Europe). The conclusions that can be drawn from their studies are that the strategy of outsourcing production in "low-cost" countries often has an economic justification (Milewska & Milewski, 2017; Milewski & Milewska, 2018b).

For many years, opinions have been expressed that we could expect the retreat from globalization and return to production from the Far East to Europe. One of the reasons for this was the increasing costs of production in countries like China and the expected increase of rates for maritime transport of containers. Currently, those forecasts are being realized. In fact, the increase in transport costs occurred during the pandemic period. This raises the question of whether the retreat from the globalization strategy can now finally be realized. For some goods, however, even with several-fold increases in rates for shipping containers by sea, the purchasing strategy in "global" countries is still profitable (Milewski & Milewska, 2018a).

The problem presented in this publication is a continuation and extension of this research. The author has taken into consideration an additional factor – different demand characteristics (different demand probability distributions, different fluctuations measured by the standard deviation of demand). If the demand is volatile and its size is difficult to predict, the costs of maintaining inventories may increase and the level of logistic customer service may deteriorate.

The aim of the article and the simulations carried out is to investigate what kind of goods (value and transport susceptibility) and characteristics of demand can affect the profitability of a purchasing strategy.

Literature review

The literature commonly expresses the view that the performance of supply chains is conducive to their economic efficiency, measured both by costs and the quality of deliveries (time, punctuality). Integration with suppliers in these chains allows for a quick response to changing needs, better forecasting of demand, and lower costs (Flynn, Huo & Zhao, 2010; Danese & Romano, 2011). Their flexibility is especially important in rapidly changing demand and short product life cycles (Qi, Zhao & Sheu, 2011). Efficient and flexible supply chains are particularly important in markets where demand changes quickly and is difficult to predict, such as the clothing industry. Phenomena such as "fast fashion" and the development of e-commerce are also major challenges for logistics.

In supply chains and processes, disruption risks (related to demand, supply, process, and environment) significantly impact supply chain and firm performance (Parast & Nachiappan, 2021). The results of the conducted research in Chinese manufacturing supply chains indicate that supply risk and manufacturing risk management are vital for business performance, and there is a high correlation between business and manufacturing risk management performance (Kumar et al., 2018). However, the negative consequences of these disruptions can be absorbed by applying demand planning practices (Świerczek & Szozda, 2019). In textile and apparel supply chains, in particular, production and distribution planning is important because of the seasonal nature of demand, the global character of the textile and apparel supply chain, the short life cycle of apparel products, and the demand unpredictability of trendy items (Safra et al., 2019).

For years, a retreat from "off-shoring" and the return of production from low-cost countries to Europe was forecasted due to the increasingly lower effectiveness of this strategy (Moradlou & Backhouse, 2016), which is also influenced by the rising costs of logistics processes. These primarily include inventory and warehousing costs and lost sales costs, which may increase more than proportionally to the distance of shipment (Rajeev & Narendar, 2005; Boute et al., 2006; Han, Dresner & Windle, 2008; Yi, Ngai & Moon, 2011), which may be affected by distortions of information about actual demand ("bullwhip effect" – Chen et al., 2000).

So, one can ask why, in many cases, production is still located in so-called "low-cost countries"? In such a strategy, the distance and time of execution of orders is a factor that significantly hinders the effective response to changing needs, even despite good relationships with suppliers.

The predictions that the increase in transport costs (increase in energy and fuel prices), prices

(situation on the transport market), or other problems (threats arising during maritime transport) will make long-distance deliveries unprofitable (Revkin, 2008; Rohter, 2008) have not come true. However, during the Covid-19 pandemic, freight rates have increased to over 400% in some cases (UNCTAD, 2021), while delivery times have increased and the reliability of deliveries decreased. Up to this time, rates had been decreasing since 2016 (JCC, 2021).

The pandemic forced companies to change the strategies of their supply chains and has impacted trade policies in the USA and Europe (Free & Hecimovic, 2021). According to some authors, the pandemic, which caused an increase in stocks, resulted in a retreat from lean supply chains and Just-In-Time (JIT) deliveries (Brakman, Garretsen & Witteloostuijn, 2020). Although in some branches, like the fashion industry, demand volatility was observed even before the COVID-19 outbreak (McMaster et al., 2020).

The size of an enterprise (and a supply chain) is also important – larger companies, thanks to economies of scale, can not only reduce costs but also be more flexible than smaller enterprises (Srivastava & Bansal, 2013; Sukati, Hamid & Baharun, 2013). Therefore, the scale is a factor that favors both lowering production and logistics costs and increasing the level of logistic customer service. The efficiency of supply chains depends on close cooperation with suppliers. That is why big companies, although they try to find sources of supply closer to their markets, have the biggest share of their sales in countries where production costs are lower. On the other hand, they look for compromise solutions, like outsourcing in Turkey or North Africa.

However, only a small fraction of companies have implemented global strategies (Rugman & Li, 2007; Kinkel & Maloca, 2009; Rugman, Li & Oh, 2009). In companies that apply such strategies, the decision-makers do not always realize the actual effectiveness of these decisions (Platts & Song, 2010, Schiele, Horn & Vos, 2011), as indicated in the 1990s (Murray, Kotabe & Wildt, 1995; Kotabe, 1998). One reason may be that the people who make the decisions about the source of purchasing consider only the costs recorded in traditional accounting.

Even though this problem is widely described in the literature, there are no specific estimates of the actual economic benefits of applying a specific purchasing strategy. For this reason, the author of this article undertook the task of estimating them.

The model and assumptions for the calculation

To calculate the possible benefits of applying a given purchasing strategy, the author has developed a simulation model. The model recreates in detail logistics and sales processes. The model then calculates the level of stocks on a given day and the volume of sales that can be realized from this stock. The Monte Carlo method was used as the simulation method. The model randomizes the demand for particular days of the year with a given probability depending on the type of demand distribution. Inventory and sales levels are average values obtained from the simulation.

The assumptions for the simulation are presented in Tables 1 and 2.

The calculations were made for four delivery variants:

1. Sea transport in 40 containers – deliveries every 6 weeks, one delivery of 6 containers;
2. Rail transport – one delivery of 40 containers every 3 weeks;
3. Air transport – every week;
4. Local deliveries – daily deliveries.

The first three options concern procurement in "low-cost" countries and the fourth supply from suppliers located closer ("local suppliers"), offering more expensive products.

To identify factors that may affect the profitability of the application of a given strategy, it was assumed that simulations would be carried out for four groups of products – office supplies, cheap electronic products, expensive electronic products, and clothing. These groups of products are characterized by a different value (sale and purchase price) per item, weight, and volume, which impacts the number of products that can be transported in each load unit or means of transport (pallet, container, truck, plane). The consequence being the differing levels of unit costs for logistics processes – transport and storage.

It was assumed that the costs of inventories both in the warehouse and "in transit" depend on the adopted purchasing strategy – in the case of the "global" strategy, the costs are higher (20% of the value of a product) because the costs of damage, theft, and so on, in longer distribution channels.

The simulations were carried out for four demand variants:

1. Normal distribution (Gaussian distribution) of daily demand – standard deviation of 5% of the average daily demand;

Table 1. Assumptions for calculations (own assumptions, based on market prices)

An assortment	Office products	Electronic (Lower Value)	Electronic (Higher Value)	Garment
Value of a commodity [$/pellet]	2073	8712	426 667	80 000
Volume [m^3/pcs.]	0.0031	0.0119	0.0006	0.0093
Weight [kg/pcs.]	0,80	1.00	0.20	0.77
Items per pellet	415	108	2133	200
Purchase price ("global") [$/pcs.]	2.35	44.47	115.00	230.00
Purchase price ("local") [$/pcs.]	4.50	71.97	176.00	348.00
Selling price [[$/pcs.]	5.00	80.86	200.00	400.00
Warehousing costs [$/pellet/day]	13.48	13.48	13.48	13.48
Warehousing costs [$/pellet]	1.35	1.35	1.35	1.35
Inventory costs (global deliveries)	20%	20%	20%	20%
Inventory costs (local deliveries)	10%	10%	10%	10%

2. Normal distribution (Gaussian distribution) of daily demand – standard deviation of 30% of the average daily demand;
3. Gamma distribution – standard deviation of 3% of the average daily demand;
4. Variable average demand during the delivery period.

The first three options relate to a situation where the average demand and demand over a given period (throughout the year) is constant and predictable. However, there are difficulties in predicting what the demand will be on a given day.

The fourth variant assumes that the demand may change in the period between placing an order and a delivery. In the case of longer deliveries, especially when sea transport is involved, there is a high risk of lowering the level of customer service.

To ensure comparability, it was assumed that for all product groups in the first strategy (sea transport) and for the first variant of demand (Gaussian distribution), the profitability for all product groups amounts to approximately 11%. Such an assumption made it possible to assess the degree of impact for individual strategies and the characteristics of the demand on this profitability.

The freight rates in individual modes of transport are presented in Table 2.

Table 2. Costs of transport (own assumptions, based on market prices)

Mode of delivery	Costs [$]
Maritime	2 000
Maritime (increase of freight rates)	4 000
Rail	15 000
Air	25 000
Local suppliers	150

In the case of sea transport, the cost of delivery from a port to a receiver was accounted for, which is almost as much as the cost of delivery by sea route.

Influence of the purchasing strategy on the level of logistic customer service

Using the model, the first simulations were carried out for the impact of a specific purchasing strategy on the level of logistic customer service, measured by the availability of goods in stock.

The simulation results are presented in Table 3 and Figure 1.

Table 3. Results of the simulations – impact on the customer service (availability of stocks) – average values (own calculations)

Strategy of a delivery	Demand distribution			
	Maritime	Rail	Air	Road (local suppliers)
Gauss – Lower St. Dev.	**99.82%**	96.73%	99.42%	99.73%
Gauss – Higher St. Dev.	98.73%	96.29%	99.15%	**99.21%**
Gamma Distribution	97.07%	93.80%	98.70%	**99.99%**
Changes of demand during lead time	98.15%	96.25%	95.08%	**100.00%**

If the demand has a normal distribution and demand fluctuations are small (Variant 1 – standard deviation = 5% of average sales), the level of customer service is very high in almost all modes of transport – over 99%, except for deliveries by rail at 96.73%. The high level of service in air and road transport seems obvious and requires no comment. The equally high quality of deliveries in maritime transport may come as a surprise. However, this seems to confirm the results of the author's research on the impact of the size of the delivery batch on

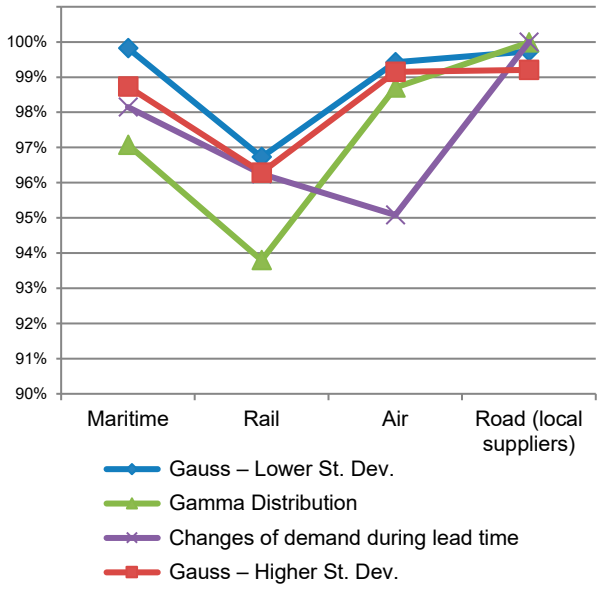

Figure 1. Results of simulations – impact on Logistics Customer Service

the level of Logistic Customer Service (Milewski, 2019), that increasing the delivery batch and reducing the frequency of deliveries helps to reduce the risk of stock depletion.

However, when the fluctuations in demand are greater (Variant 2 – 30% of average sales), the level of service decreases in this mode of transport (to 98.73%) and even more than in other modes of transport.

Even more service deterioration would occur if it were not "Normal" but Gamma distribution (Variant 3), which is more unstable than Gaussian (down to 97.07% for maritime and 93.80% for rail). There was also a visible decrease in air transport.

Lower levels of service also occurred in the case of changes in daily and total demand during the delivery period (Variant 4). Interestingly, the lowest level occurred not in sea and rail transport, but in air transport.

On the other hand, the local purchasing strategy represents the highest level of service, regardless of how volatile and predictable the demand is.

Influence of purchasing strategy on profitability

The high levels of service offered in individual modes of transport (delivery strategies) do not always have to result in the high profitability of given strategies.

The results of the simulation for the impact of choosing a procurement strategy on the company's profitability are presented in Table 4 and Figures 2–5.

Table 4. Results of the simulations – impact on profitability (own calculations)

Strategy of a delivery	Demand distribution				
	Maritime	Maritime (increase of freight rates)	Rail	Air	Road (local suppliers)
			Office products		
Gauss – Lower St. Dev.	**11.45%**	9.57%	8.53%	–2.44%	7.09%
Gauss – Higher St. Dev.	**9.44%**	7.56%	8.17%	–3.42%	6.33%
Gamma Distribution	**7.22%**	5.27%	6.08%	–8.19%	5.63%
Changes of demand during lead time	4.08%	2.16%	4.84%	0.53%	**6.38%**
			Electronic (Lower Value)		
Gauss – Lower St. Dev.	11.49%	11.05%	**13.92%**	11.18%	10.49%
Gauss – Higher St. Dev.	10.29%	9.84%	**13.74%**	11.04%	10.22%
Gamma Distribution	12.07%	11.60%	**13.90%**	7.02%	10.00%
Changes of demand during lead time	7.74%	7.28%	12.28%	**13.94%**	10.17%
			Electronic (Higher Value)		
Gauss – Lower St. Dev.	11.58%	11.57%	**15.47%**	12.98%	11.90%
Gauss – Higher St. Dev.	10.57%	10.56%	**15.36%**	12.97%	11.77%
Gamma Distribution	10.60%	10.59%	**15.30%**	11.82%	10.89%
Changes of demand during lead time	9.07%	9.06%	14.34%	**15.76%**	11.69%
			Garment		
Gauss – Lower St. Dev.	11.16%	11.09%	**14.82%**	12.39%	12.87%
Gauss – Higher St. Dev.	10.11%	10.04%	**14.71%**	12.36%	12.70%
Gamma Distribution	11.02%	10.95%	**14.83%**	11.60%	12.65%
Changes of demand during lead time	6.85%	6.77%	12.74%	**14.25%**	12.65%

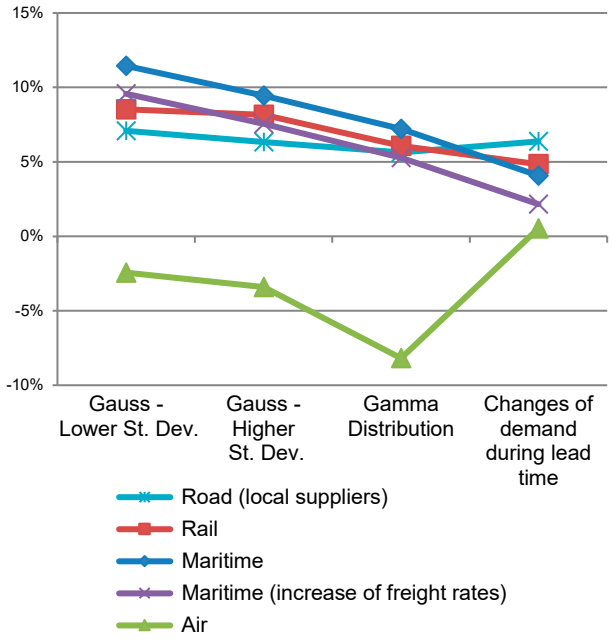

Figure 2. Results of simulations – impact on Profitability (office products)

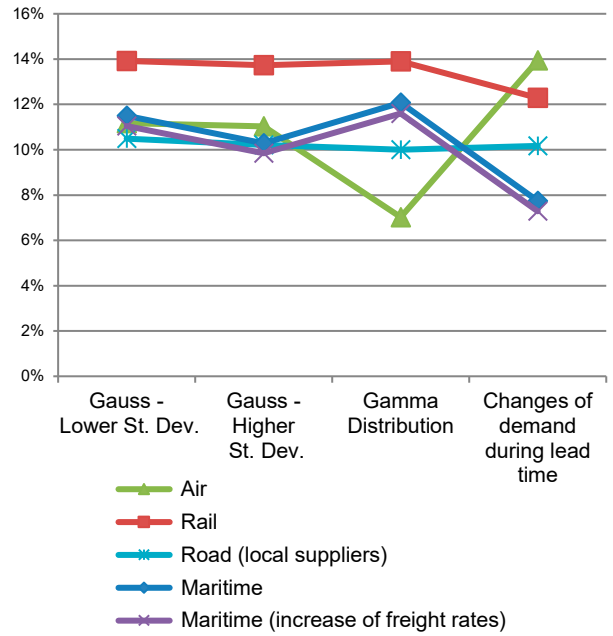

Figure 3. Results of simulations – impact on Profitability (Electronic – lower value)

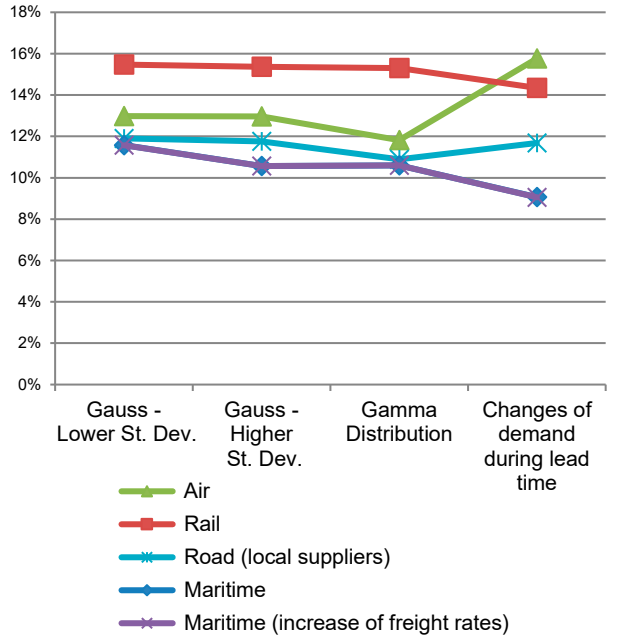

Figure 4. Results of simulations – impact on Profitability (Electronic – higher value)

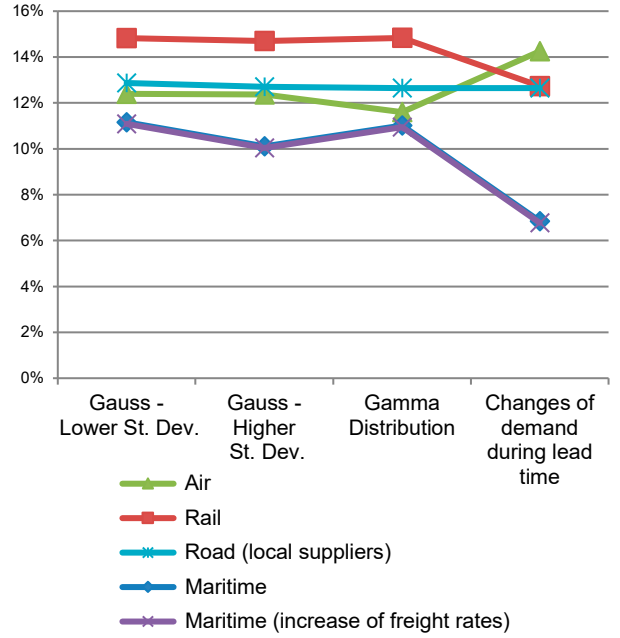

Figure 5. Results of simulations – impact on Profitability (Garment)

It was assumed that the costs of purchasing goods from low-cost suppliers amount to (depending on the product) about 50% of the selling price, and from local suppliers to 90%.

One transport option was included in the local procurement strategy in the calculations. The adopted transport costs are based on the rates applied in road transport, which has the biggest share in Europe. Of course, the model can account for the use of different modes of transport. However, the impact of changing the mode of transport is relatively small. For example, if we assume that in the "local purchasing" strategy, transport costs would be 20% lower, then for the first variant, Gaussian distribution and 5% of standard deviation, the profitability will increase from 7.09% to 7.49%. Similar, and therefore minor, changes were obtained for the remaining distributions. The benefits of changing the mode

of transport could be even smaller if worse quality parameters in rail or inland transport are considered. For this reason, the simulations did not consider as many transport options as the "global strategy".

As expected, the greatest benefits in the cheapest goods (office supplies) in the first three variants of demand occurred in maritime transport, which explains its popularity. However, if there is a risk of a change of demand during the time of delivery (option four), a local source of supply turns out to be the best strategy, which can be explained by the high share of logistics costs in the price of low-value goods.

One can observe the impact of the increase in freight rates in maritime transport. However, it is not big – profitability drops from 11.45% to 9.57% in the case of Gaussian distribution and small demand fluctuations. The reason is the low level of rates for the transport of containers by sea in intercontinental relations. Thus, even their several-fold increase may not have a large impact on the profitability of the purchasing strategy. The increase in freight that has taken place recently (resulting from the Covid-19 pandemic) should not have a major impact on the purchasing strategy of companies.

The use of air transport to transport cheap office supplies is unprofitable – in the first 3 variants of demand, there is a loss rather than a profit, which seems to confirm the views expressed in the literature that air transport is most suitable for the transport of expensive goods. It is worth noting that fluctuations in daily demand have a greater impact on the profitability of air use than in other modes of transport (a decrease from –2.44% to –8.19%).

However, in the last variant of demand, when there is a risk of change in demand during delivery, the profitability of using air transport increases sharply and is already positive (0.53%), although it is still lower than in other modes of transport. In this variant, it is most advantageous to produce locally.

In the case of cheaper electronic products, for the first three variants of demand (Gaussian and Gamma), the best option is "global" using rail transport (profitability above 13%). However, when the demand may change during the delivery (the fourth option), it is best to deliver by air. Moreover, this is also the case with other products.

Importantly, the highest profitability of local supply does not occur in the case of expensive electronic goods but in the case of medium-value clothing. It can be commented on that the profitability of the purchasing strategy is the result of various factors, such as the physical parameters of the transported loads, including their dimensions, which is an important factor in transport and storage costs.

The results of the simulations carried out by the author show that the profitability of using a given source of supply and a mode of transport is influenced by many different factors. However, at least to some extent, they confirm the classical laws of transport economics regarding "the modal split" –that air transport is best suited for the transport of high-value goods for which demand is difficult to predict.

Although this simulation assumes that "local purchasing" is the most expensive option, the differences between the profitability of purchasing strategies decrease with the value of goods and the costs of delivery processes. Therefore, it is supposed that the increase in production costs and the resulting increase in the value of products and delivery costs should increase the profitability of shifting the sources of purchase closer to Europe. Further simulations were carried out to confirm this.

The results of these simulations for individual products are presented in Figures 6–9. It turns out that even a small increase in production costs (5%) in the countries in the Far East has a significant impact on the profitability of the purchasing strategy. The increase in profitability is more than proportional to the change in the cost of production. The greater the problems with predictability, the lower the profitability, and losses may even occur (Figure 6). In this case, in almost all variants of demand for all types of products, it would be most advantageous to move production from Asia to Europe.

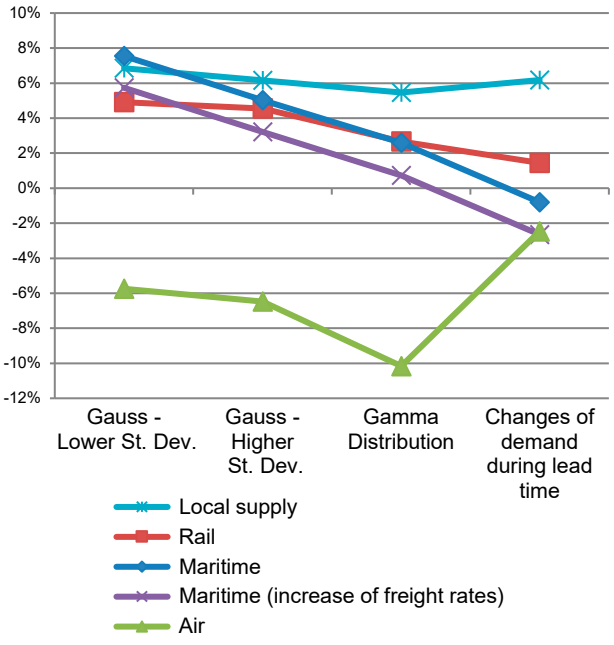

Figure 6. Results of simulations ("increase of production costs") – impact on Profitability (office products)

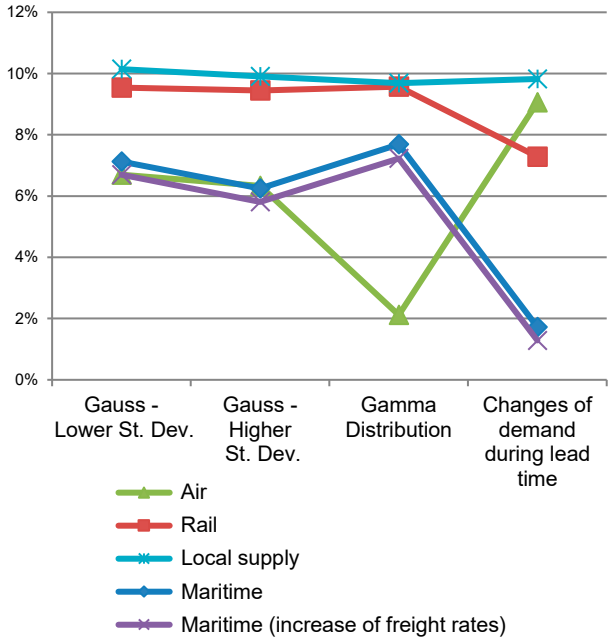

Figure 7. Results of simulations ("increase of production costs") – impact on Profitability (Electronic – lower value)

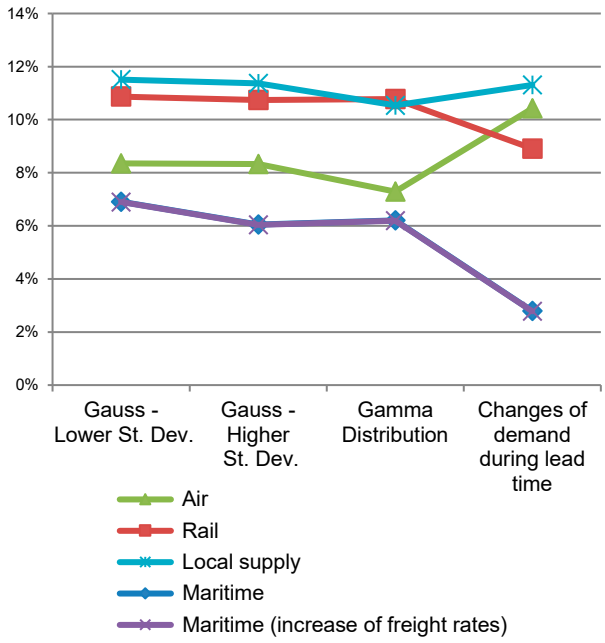

Figure 8. Results of simulations ("increase of production costs") – impact on Profitability (Electronic – higher value)

In fact, the benefits of "local production" would be even greater. The model calculates the costs of lost sales, resulting from the fact that there is no product in stock that is on sale. A longer sales planning horizon is associated with the risk of erroneous forecasts regarding the volume of demand for a given good and customer preferences, resulting, for example, from a change in fashion. It is easier to react to these changes when production is located closer to the market.

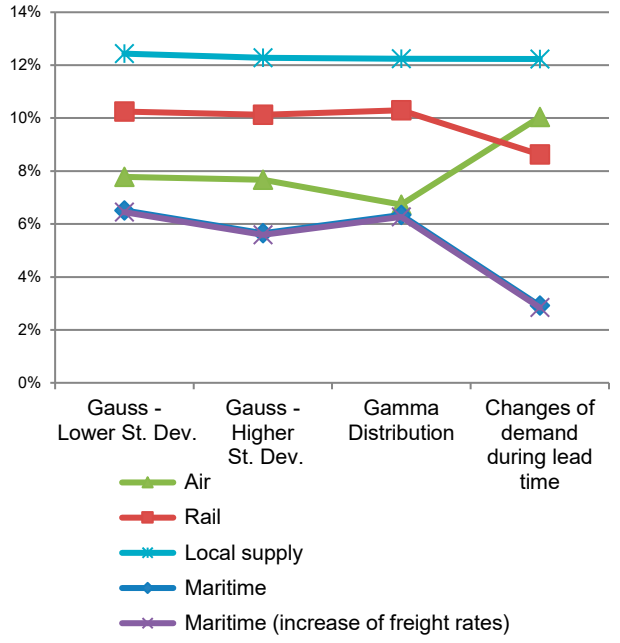

Figure 9. Results of simulations ("increase of production costs") – impact on Profitability (Garment)

Summary and conclusions

When choosing a purchasing strategy, various factors should be accounted for: production and distribution costs, the value of goods, the parameters of goods transported (weight, volume, packaging), and the characteristics of the demand. According to the research conducted and presented by the author, the type of probability distribution of demand (Gaussian or Gamma) and its variability and predictability are very important factors in the effectiveness of choosing a strategy.

The calculations confirmed the assumptions that the profitability of purchasing strategies in low-cost countries drops significantly (more than proportionally) with a decrease in the predictability of demand for a given good and its value and in transport susceptibility resulting from the parameters of the goods transported.

In response to the above conclusions, the author proposes to conduct further research on the characteristics of the demand for various product groups and the economic calculation of the costs of logistics processes. This is because traditional accounting does not account for "opportunity costs" – the costs of capital tied up in inventories and the costs of lost sales, which may be the reason for using a purchasing strategy in low-cost countries.

However, this strategy does not have economic justification in many cases, even when considering the costs included in the model built by the author.

The costs of logistics processes often constitute a small share of the total costs, and the differences in production costs in different parts of the world are significant.

Additionally, large companies can negotiate much lower rates for logistics services, make frequent and regular deliveries, and meet demand efficiently, which may be relatively less volatile and more predictable for them due to economies of scale.

The model and calculations did not account for other factors such as the social effects (and costs) of reallocating production to low-cost countries. This issue should be the subject of separate research.

A significant "return of production" to Europe, which has been forecasted for years, would have to be caused by an increase in total costs, including both production costs and costs of processes of deliveries of goods. A significant factor may also be customer requirements regarding delivery time or adapting products to individual customer requirements. However, in practice, the final decision is made by the managers responsible for implementing these strategies. The rationality of making these decisions depends on the knowledge of their effects and information about all the costs that result from them.

It should be considered that the decisions about the location of production, like in Asia, are caused by lower costs, greater flexibility of suppliers and even more advanced technologies. Long-term production reallocation processes in low-cost countries such as China may result in the development of technologies in these countries that may not be available yet in Europe.

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