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Measurable economic consequences of investments in flexible capacity

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Abstract

Investments in flexible capacity are large. It is not surprising that a solid economic infrastructure is a precondition. From the strategic perspective the structural support will rest on qualitative grounds. Yet, the central problem posed in the present article is how the economic consequences of investments in flexible capacity can actually be measured. It is worked out in three steps. To begin with, the Just-In-Time concept is placed in an integral framework of goods-flow control. This is essential because it will be found that, without this analysis, there is a danger that the estimate of the positive effects will be too optimistic. Subsequently, we introduce a concrete production situation. Lastly, for the selected production situation the concrete economic consequences of a flexible capacity investment will be calculated. Our starting point is that the investment will in fact lead to an adjustment of the logistics concept. For that reason, the maximum Just-In-Time advantages can be realized. At the same time the possible misrepresentation resulting from "traditional" cost calculation will be examined.

1. Introduction

In recent years, many enterprises have been confronted with problems generated by the growing dynamics of the market. The features of the dynamic market are expressed in:

- Growth in customer-specific products (going to segmented markets, individual customers),
- High degree of modification in products or component parts (short life cycles)

Companies that fail to come to grips with these developments will soon suffer the consequences of greatly intensified competition. A high degree of adaptability is called for in selling, production and purchasing. A constant process of adaptation of these functions is called for. Adaptation problems internally and those that exist between the various functions in industry assume the form of large diversified stock (unsaleability risk) and long delivery times. Some examples can be found in Brinkman [1].

By introducing new working methods, processes and adapted logistics management, companies try to ward off the abovementioned effects. Lot size plays an important role in all of this. The last decade has seen the emergence of new logistics management concepts for which the traditional manner of determining lot sizes, e.g. Camp (Harris-Wilson) ECQ formula, is not optimal. Namely, logistic concepts such as Just-In-Time (JIT) and OPT (Optimized Production Technology), which emphatically endorse that point of view, state unequivocally that the aim has to be the reduction and, if possible, the elimination of lot sizes. In other words, the optimum lot size is one. The magic word is Technical Flexibility. Machines with short reset times do indeed enable lot sizes to be reduced without any great loss in efficiency and just-in-time han-
JIT concept can be a powerful weapon in the hands of a company determined to stay competitive in a dynamic market. Schonberger [2] speaks of "...JIT attempts to control costly resources of waste, such as
- idle inventories, which constitute waste of scarce material, resources and, indirectly, energy for basic material conversion and refining,
- storage of idle inventories, which wastes limited space,
- defective parts, subassemblies and final products, which are a waste of materials and energy."

With this last point, Schonberger means the Total Quality Control required for the proper operation of the Just-In-Time method. The positive effects of improved product quality is not part of the present article. There are also drawbacks to the advantages just mentioned. Apart from all the organizational problems following the introduction of a JIT concept into a (Western) company (for instance, see Durlinger and Wortmann [3]), considerable amounts of money have to be invested in machines capable of flexibly processing a wide range of products. To keep the JIT concept operable, resetting times have in fact to be drastically reduced. Authors like Shingo [4] have shown that, in given manufacturing environments, a certain amount of reduction of setting time can be attained with relatively simple, low-cost techniques and organisational measures. But the possibilities offered by such low-cost measures are not infinite. In this connection, it should not be forgotten that the success story of the setting-time reduction of the big presses at the TOYOTA factory, from 8 hours to 2 minutes, is spread over a period of fifteen years. If results with the introduction of the JIT concept have to be successful in less time, then structural investments in flexible capacity are a necessity.

Investments in flexible capacities are voluminous. It is not surprising that a solid economic infrastructure is a precondition. From the strategic prospective the structural support will rest on qualitative grounds. The continuity of the company is at issue because, without flexible capacity the competitive power of the company will be insufficient.

When a flexible capacity investment has to be justified, it is often done on no more than a strategie-qualitative supporting grounds. It is an argument which calls loudly to the entrepreneur to take the risk, in fact the lack of concrete financial savings in hard figures is replaced by an intuitive, strategic vision which certainly cannot afford to be wrong. The primary task of the controller is, however, to reduce the company's financial risk to reasonable proportions and keep them there. It is thus for good reasons that the controller will draw up an estimate of the concrete savings that can be made with these investments.

The central problem posed in the present article is how the economic consequences of investment in flexible capacities can be measured. It is worked out in three steps.

To begin with, we placed the Just-In-Time concept in an integral framework of goods-flow control. This is essential, because it will be found that, without this analysis, there is a danger that the estimate of the positive effects will be too optimistic (Section 2). In Section 3 we introduce a concrete production situation, namely production of component parts followed by an assembly line. Customers' orders are assembled absolutely flexibly, but what we have in the manufacture of the component parts is "traditional" production in lots. It is assumed that, by investing in flexible capacity, component parts can be made directly to customers' order. It will be shown that, without adjustment of the integral logistics concept, all of the potential advantages of the investment in flexible capacity cannot be exploited.

Lastly, for the selected production situation, the concrete economic consequences of a flexible capacity investment will be examined (Section 4). Our starting point will be that the investment will in fact lead to an adjustment of the logistics concept and that, for that reason, the maximum Just-In-Time advantages can be realised. At the same time the misrepresentation resulting from "traditional" costs calculation will be examined.

2. Just-In-Time in an integral logistics concept

When an attempt is made to improve stock policy, great importance is attached to an analy-
sis of the integral goods flow (for example, see Bertrand and Wynaard [5])

A simple, yet very perceptive example of such an integral concept is the so-called Customer Order Decoupling Point (CODP) control concept [6].

Figure 1 shows an integral goods flow. Five possible decoupling points are marked in. They separate the customer-order part of the activities (on the right hand side of the decoupling point) from the activities based on forecasting/planning (left-hand side of the decoupling point). The customer order moves along the goods flow up to the decoupling point, whence it is delivered directly to the customer.

In general, the decoupling point will coincide with the main storage point. It likewise applies that, in principle, there are no stocks downstream of the decoupling point, and that upstream there are stocks only when it is economically justified. Thus the first step is the decision as to where there will be stock points in the integral chain. The choice of the position of the decoupling point is in the first instance, a process of weighing market requirements (among other things, delivery dates demanded by the customer) against throughput times in the production and distribution process. These, in turn, are decisive for investments in stocks and in the production process. The hard distinction that this control concept makes between customer-oriented activities on the one hand and activities based on planning on the other, greatly simplifies the task of illustrating how the JIT principle works.

According to the JIT control concept, there should only be production when there is an actual demand. It is in fact assumed in the present article, that the demand process in the chain is not intended for the purpose of building up stocks, but actually for handling customers' orders. This observation implies that, after the customer-order decoupling point, the Just-In-Time production has to be implemented up to, and including delivery to the customer. For instance also the physical distribution! This is an extremely important marginal condition for investment in flexible capacities and will be considered in more detail in Section 3.

The capacities after the customer-order decoupling point have to be very flexible in order to absorb the changes in mix and/or volume which

Fig 1 Five positions for the decoupling point (DP) (Source Van Hees [6])
are inseparable from customer orders in a dynamic market, without disrupting the agreed delivery times. Furthermore, in this concept, the order-acceptance function of mediation can also be applied to deal with limited flexibility beyond the customer-order decoupling point.

The importance of an integral analysis is thus demonstrated. Shifting the CODP from DP-2 to DP-3, for example (see Fig. 1) will at once affect component-part production before assembly. That department will then not be in a position to pass parts to assembly at will, but only when there is demand from assembly. This means that component-part manufacture can be faced with a build-up of stocks if the production planning is not adjusted if the integrative chain is not kept under constant observation, this effect could easily be neglected and even lead to the components factory being negatively judged on account of its holding excessive stocks! In assessing the situation, one should therefore be very careful to realise that when JIT is applied, the main stock point has to move upstream in the chain. Van Hees says that this is related to the entrepreneur's risk mentioned earlier. It is illustrated in Fig. 2.

Considerable amounts of money are invested in DP-1 in stocks of end products spread over a number of distribution points. This implies a high risk of being left with unsaleable goods. At DP-5 on the other hand, the risk lies mainly in failure to meet delivery times and in overrun of precalculation costs of the project. Finally, the entrepreneur's risk related to the fixed assets will also be increased because of investments in (costly) flexible capacities when the decoupling point is shifted upstream.

The strategic appeal to taking the entrepreneurship risk referred to in the introduction is thus certainly justified. The question is however, whether concrete effects can be discovered which support such strategic intuition. It is for this purpose that a concrete production situation is examined.

3. Concrete production situation

An industrial enterprise manufactures a great variety of end products. It consists of a number of component part factories and an assembly line. In the interests of simplicity we shall concentrate on the combination of one components factory plus an assembly line. The customer-order decoupling point is positioned beyond the components factory.

In the components factory in question, work includes heavy pressing on a traditional roughly 2000-ton press. Hundreds of different semifinished products are pressed from about thirty different raw materials. In addition, the factory carries out various cutting activities with considerable overcapacity. The pressed semifinished parts are assembled on the assembly line together with several parts from other components factories. The possible combinations are practically unlimited. It could be said that the heavy pressing work of the components factory divides the product range into 100 main types (semifinished product). Depending on customer orders, the main type is processed on the assembly line to a practically unique, customer-specific product. There are in fact thousands of types of end products.

The components factory centres on the big press. As the resetting times are considerable, a lot size rule is followed, based on Campbell's EOQ formula, which determines the lot size by comparing the costs of holding stocks of semifinished product with the costs involved in resetting the press. Given this lot size, the internal cost price of the semifinished product can be determined.

The structure of this cost price is as follows:

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Fig. 2 Entrepreneurs risk and the location of the decoupling point (Source: Van Hees [6]).
- The material value (to be paid to suppliers): 30%
- The fixed part of the added value (fixed man capacity, depreciation, etc.): 60%
- The variable part of the added value (energy): 10%

Sales have greatly increased in past years thanks in part to extension of the already wide range of end products. Further growth is, however, impossible without building a new assembly line, as assembly is already being done in three shifts. However, no substantial further growth is expected in the market that is served, so that the company has reconciled itself to the fact that it will not serve a (relatively small) part of that market.

The growth of sales has also had its effect on the component-parts factory. Capacity problems arose with regard to the 2000-ton press. This has led to contracting part of the work out (10%). The price charged by the supplier charges amounts of 110% of the internal price. Growth has also brought the regular need to work overtime in the event of breakdowns.

The delivery time agreed with the customer is longer than the throughput time of the assembly process, but not so long that one can simply shift the decoupling point to DP-4 (see Fig 1). This would mean that the Camp lot size used for the 2000-ton press would have to be dropped in favour of working with flexible customer-order lot sizes (lot size 1!). The ratio of setting time to production time would then become so unfavourable, that serious efficiency losses would occur. In addition, the work contracted out would have to increase considerably.

In order to be sure that every customer order can be handled in the present-day situation considerable safety-buffer stocks of every main type (semi-finished) are held at the main stock point. The aim is reducing as far as possible the risk of being unable to start assembly because of waiting for production of components. Such a situation could endanger delivery times as agreed with the customers. Safety-buffer stocks are the standard means of compensating for uncertainty.

The characteristic problem of this production situation is that the total number of main types that will be bought is known (namely the maximum number that assembly can process), but not how many of what type. In other words, component-part manufacture has no problem with volume flexibility, but does have one with flexibility of the mix. Problems with reference to volume flexibility (for example, see Bertrand [7]) will not be considered in the present article.

Because of its long resetting (setup) times, the traditional press is a thorn in the flesh of production management, which suggests replacing it by a very flexible heavy press. Management claims that, after the investment, Just-In-Time can deliver on call by assembly. In other words, after making the investment there is no need to work in the component-parts factory on the basis of the fixed Camp lot size. It also claims that contracting out will no longer be necessary and that overtime will be a thing of the past. This could bring savings. The number of operators needed for the new press is the same as for the old one. The space the new one will occupy remains unaltered. There are no savings here.

The flexible heavy press is an investment involving millions. The controller has his doubts. The concrete expenditures involved in the acquisition of the flexible press are evident to him. But how does one determine the concrete yield from such an investment in flexibility?

The concrete savings involved in this investment will be considered in detail in Section 4. However, before we can do that we must first make an emphatic distinction between an investment in flexible capacity without and one with adjustment in the logistics concept. Let us assume that the stock in the initial situation, that is before the investment in flexible capacity, comprises 3 kinds:

- a quantity of raw material in stock due to purchasing-order sizes,
- a quantity of work in process stock in component-parts production. This stock depends on the throughput time of parts production,
- a quantity of semi-finished product stock at a decoupling point where, on the one hand its function is that of a buffer stock and, on the other, is itself caused by the lot size in component-part production.

After investment in flexible capacity without adjustment of the logistic concept, the customer-
order decoupling point remains located beyond the component-parts factory, which means that a safety-buffer stock is still required at the decoupling point. The safety stock can perhaps be cut down a bit because the throughput time in the component-parts factory is reduced. We will not continue with this line of enquiry here. In any case the decoupling-point stock will shrink because the lot size stock will disappear. The quantity of work in process in the component-parts factory will also decrease thanks to the shortening of the throughput time brought about by the investment in flexible capacity, thus in fact yielding an economic benefit. On the other hand, the quantity of raw material will increase as the offtake from the component factory has become smaller, causing build-up of raw material stocks. This can, of course, be avoided by adjusting the purchasing order quantities, but this possibility is independent of the investment in flexible capacity. (Observation even if the size of purchasing order quantities can be cut down, the upshot can be a discount loss on quantity, a negative economic consequence in this case.)

Let us now assume that the production management guarantees that the total throughput time of component-part production and assembly, irrespective of the mix, will be shorter than delivery time to the customer. In other words, thanks to the investment, the logistics concept can be adjusted by shifting the CODP to DP-3 (assembly to customer order) to DP-4 (producing and assembling to customer order; see also Fig 1). What is the effect on stock size in this case?

The old decoupling-point stock of semifinished product now disappears entirely. The quantity of work in process is reduced in the component-parts factory just as in the preceding situation. Here, too, stocks of raw materials increase, a process which cannot however be completely prevented by adjustment of purchasing order quantities. This is because, just as in the old situation, buffer stocks have to be maintained at the decoupling point, as the component-parts factory must be able to start when the customer order comes in. The conclusion is that a flexible investment that goes along with an adjusted logistic concept yields the greatest saving. In the next section, in which the yield from the situation will be discussed in detail, the starting point will be that the investment does lead to the adjusted situation in which assembly to customer order is further adjusted to a situation with both component-part production and assembly to customer order.

4. Economic consequences of a flexible capacity investment

In our case, seven economic consequences can be indicated. First of all the decoupling-point stock of semifinished products disappears. It was, on the one hand, set up from buffer stocks in order to be able to carry out customer orders in assembly at any time and, on the other, because components manufacture supplied parts in fixed lot sizes. These effects are dealt with in Sections 4.1 and 4.2, respectively.

We have also seen that the quantity of work in process had dropped in the component factory owing to the cut in throughput time. This will be dealt with in Section 4.3. Since stock disappear, there is less need for storage space, see Section 4.4. The production management guaranteed that overtime and contracting out work would no longer be needed in the new situation. These effects will be dealt with in Sections 4.5 and 4.6. Last of all, it must be assumed that smaller stocks represent less risk of unsaleables and this will be discussed in Section 4.7.

4.1 Reduction of safety-buffer stock

In the traditional approach, the safety-buffer costs are calculated by multiplying an interest percentage by the internal cost price of the article in stock. In principle there is always a safety buffer and the standard safety-buffer stock level will be included in our considerations. In our case it would mean that the savings on the buffer stocks of semifinished pressings per type can be calculated according to the following formula:

\[ \text{savings} = \text{standard safety stock} \times \text{internal cost price} \times \text{interest percentage} \]

A number of marginal notes must be made to this calculation. For instance, we cannot be certain that the buffer stocks will disappear entirely.
As the main stock point is shifted, the buffer stocks of pressed semifinished product are in fact no longer required. However, it may in view of the total throughput time from the date of customer order to delivery, be necessary to lay in buffer stocks of raw material. It must be borne in mind that, if a customer order comes in and there are no stocks of raw materials, the total throughput time of the process is extended by the delivery time of that raw material. Shifting the same buffer stocks upstream does, however, have a positive effect, as the number of types contained in it drops from a hundred (semifinished) to thirty (raw material). Thus, the safety buffer stock can be reduced per type of stock item, since aggregated patterns of demand arise [8].

The above savings calculation suggests that buffer stock in raw materials is cheaper than that in semifinished products. The cost of raw materials is of course lower. The question is whether the argument is correct. Money (capital) is invested in safety-buffer stock. Capital is not gratuitous; the company, for example, has built up a bank debt for its capital and has to pay interest on it. The crucial point is thus the extent to which that debt will drop if the buffer store is shifted. We are faced here with a decision calculation in a going-concern situation. We therefore try to calculate the concrete savings. This means that we must ask ourselves how much the expenditure and production will really be diminished if the buffer stocks of semifinished product disappear. Verderveken [9] observes that, with regard to labour, machines, overheads, etc., a lower bank debt cannot really be obtained as the result of lowering stocks. His conclusion is unequivocal. The real effect is on the material value and, perhaps, energy. All other expenditures remain unaffected if buffer stocks disappear. On the other hand, this can be traced back to expenditure incurred in the past (acquisition of machine) and hence no longer subject to influence, on the other, because savings on hours worked will be so marginal that no actual reduction, for example, in personnel can be achieved. The real expenditures on salaries thus remain unchanged and the savings are calculative fictions. It could be observed at this point that real savings can indeed be achieved by working variable hours of overtime. This, however, is not the case. As the work is in fixed lot sizes and one is always obliged to supply as many items as assembly can process at a maximum (purely mix flexibility), overtime and contracting out is inevitable in the stable situation. In the new, post-investment situation, overtime and contracting out will be things of the past as the result of pure increase in capacity thanks to decreasing the resetting time and not because of reduction in safety-buffer stock. Savings on overtime and contracting out are dealt with in Sections 4.5 and 4.6. The real savings on interest costs will have to be calculated by the following formula:

\[ \text{savings} = \text{difference in buffer-store level} \times (\text{materials value} + \text{energy}) \times \text{interest percentage} \]

It should be noted that, as regards the expenditures which can be influenced, it makes little difference whether it is raw material or semifinished stocks that are kept. The only thing which can be influenced is, of course, energy! The real savings are thus mainly brought about by reduction of buffer stocks in the chain, but not by shifting them.

In addition, there is a further observation to be made about the interest percentage applied in these calculations. The assumption is that the liquid means made available will be used to diminish the (short-term) bank debt. This is a real assumption, though one could also consider using this capital for other purposes. Once cannot always be certain in advance of getting an interest percentage on short-term bank debts! The company's financial management will pronounce as to how the released liquid means are to be used. It is on this basis that the concrete savings that can be obtained with said available means will be determined. This article will now restrict itself to the question of how much liquid means will become available by investment in flexible capacity.

The above calculation is an example of so-called money-flow calculation, see [9–11]. In general, sceptics note that, "although the costs of labour, machines, etc., cannot be influenced im-
mediately, the effect must come in the long run. This argument is correct in principle, but it is precisely this long-term situation which is so unpredictable. In fact, the wish to invest in flexible capacities is because future offtake is uncertain and difficult to forecast in a dynamic market. It is thus extremely doubtful, in anticipation, and whether the “long-term” situation in which the calculative savings are to be obtained will ever occur.

That all costs are variable in the long term is certain. But was it not J. M. Keynes who in this context once remarked, “In the long run, we will all be dead”? In view of the investment of millions of guilders in flexible capacity, that is a statement which should make one thoughtful, for more than one reason.

**Conclusion.** Two misrepresentations in calculating the proposals to cut buffer stocks are:
- valuation of interest expenditure at the full internal cost price instead of value of materials and variable energy costs, because of which the estimated savings are too optimistic,
- failure to realise that it can be necessary to maintain buffer stocks at the new main stock point. Because of the above valuation, the difference between buffer stock in the old and new main stock points may be less favourable than the costs approach would lead one to believe.

**4.2 Reduction of lot size stocks**

The same valuation problem is encountered in the savings calculation for a reduction of lot size stocks in semifinished product. Here too, one will be inclined to valuate at internal cost price instead of taking the material value and the variable energy costs. There is yet another problem that occurs in lot size stocks which has been described in detail in an article by Van der Veeken [9].

If the aim is to use nothing, but real economic effects and not calculative results as the basis for the decision-taking, then changes in payments in which the outside world is involved have to be estimated.

As the lot size stocks of semifinished goods are to be found in the middle of the logistic chain and not at the purchasing or selling sides of the firm, one has to determine whether the altered lot size policy will also lead to changes in the pattern of payments on both sides of the firm. In this case the offtake and payment patterns for finished products do not change. We can therefore restrict ourselves to the purchasing side of the company. The payment-pattern changes, due to a delayed increase in expenditure, to the amount of the purchasing value of the materials to be acquired are ordered in smaller quantities and paid for in accordance with this order pattern. Van der Veeken summarised this in Fig. 3, in which he assumes that the delayed expenditures are shown in the company’s bank debt.

Note that there is no mention of smaller purchasing order quantities! We have, in fact, seen that buffer stocks of raw materials will certainly be required, but no argument is put forward in justification of reducing the purchasing order quantities in the new situation. There are no such arguments in fact. The possibility of cutting down the purchasing may well exist, but that is quite unconnected with investment in flexible capacity!

The real economic effect of the disappearance of lot size stocks of semifinished goods is therefore nil.

This conclusion will strike the reader as quite incredible.

Stocks disappear and yet there is no economic effect! Considerable effects can be achieved, but these have to be attributed to a different positive effect of the investment in flexible capacity, namely a reduction in throughput time, and with it, a reduction in the amount of work in process. It is namely the case that a change in lot size can only lead to a change in the payment periods. A change in throughput time, achieved as a result of lot size adjustment, can lead to an actual reduction in the volume of work in process. For example, Bertrand [7] mentions, like several other authors, the favourable effect that shortening the throughput time can bring about. This is discussed in Section 4.3.

**4.3 Reduction in throughput time**

Computer simulation permits one to calculate what happens when the lot sizes are reduced or, as in the present case, these sizes are determined by actual customer demand. A condition for this is, of course, that a realistic package of customer
orders and reliable resetting and processing times are available.

With the aid of such a simulation, the length of the new throughput time in the component-parts factory can be calculated and from that information the amount of work in process can be determined as well. The average throughput time is also dependent on the priority rules that are applied. We assume that these will remain unaltered. Up to now we have assumed that this work in process will be less than in the old situation, but we cannot be certain of that. The effect on the work in process is namely determined for the most part by the loading degree of the new machine (resetting plus production in relation to the full time available) In the new situation there are two changing variables which are related to the loading degree, hence the resetting time, on the one hand, is drastically reduced, thus lowering the loading degree and, on the other, the work is done with small, customer-order-dependent lot sizes, which increases the degree of loading.

For the sake of simplicity, let us assume that we have found from the simulation that the work in process will decrease. Again we are faced with the question, "What are the concrete savings which are concerned in this reduction of work in process?"

The total of stocks held by the company becomes smaller, which means that the company's requirements of capital will be reduced. Here too, internal cost prices does not provide precise insight. Just as in the case of the buffer stocks, our point of departure will have to be that only the expenditures on energy and material can ensure less need for capital. The costs approach in this case too, suggests a higher calculatively fictitious economic consequence.

4.4 Reducing storage space requirement

In most companies, part of the accommodation costs are allocated to each department by means of the costs allocation sheet in the departmental budget. This is usually based on a rate per square or cubic metre of space used by the department.

Accommodation costs are fixed in most cases. Reduction of these costs for a production department because it needs less room is a calculative saving. The rate per unit space is not the appropriate instrument for determining the real savings related to accommodation.

In principle there are two conceivable situations. In the one, the company is not short of space and any eventual redundancy will hardly be suitable for a different purpose, in which case there are no concrete savings to be expected. The situation is different where the company is faced with a shortage of space. In our case, however, it is not a hypothetical situation, because sales have risen sharply in recent years. A shed may well have to be (or already has been) hired in the present situation because the storage capacity has simply become inadequate. In this case too, the rate per square metre or cubic metre does not provide a correct picture of the gain to be expected when the shed is no longer needed. The real gains are namely determined by all the expenditures involved in renting the shed. The co-
tal of costs involved will, in most cases, be more than the space concerned, multiplied by the rate, since it is usually impossible to rent the space strictly required.

The costs rate per unit space is in both cases inappropriate for determining real savings on space. Where space is not a bottleneck factor, the gain suggested is too optimistic, where a bottleneck does exist, it suggests too low a gain.

4.5 Reduction in overtime

In our case, the production management guaranteed that overtime would not be necessary in the new situation. Overtime is about 35% dearer in most cases. The effect on the cash flow is, however, more than is suggested by that 35%, as overtime, in contrast to regular hours of work vary roughly in proportion to production volume. The real effects can thus be calculated from the variable man-hour rate, plus the extra-allowance factor for overtime. Here the situation is not so misleading. This is because the investment in flexible capacity actually provides more productive hours within regular working time, so that more expensive, irregular overtime is no longer necessary as a whole.

4.6 Reduction in work contracted out

The production management claimed, as we know, that there would be a reduction, not only in work contracted out, but in overtime as well. The semifinished contracted-out product is 10% dearer than the internal cost price. This means that a saving of 10% per semifinished part contracted could be achieved. From the strategic perspective this is correct. In that case namely, we assume that the factory has yet to be put up and that all the expenditures required for production have still to be incurred. This problem can be compared to a make/buy decision. However, that is not the case in the present instance. The real yield which can be achieved with contracted-out work is far higher than 10%. One should ask oneself how much extra work it would cost to produce that work internally. Just as in the case of the buffer stocks discussed in Section 4.1, extra expenditure is incurred only in relation to material and energy. The outgoing cash flow for work contracted out is reduced by far more than 10%. In Fig. 4 we see at the left-hand side the internal cost-price structure. At the right-hand side we see the (variable) invoicing of the work contracted out. Comparison between the two amounts indicates that the real effect (= reduction of outgoing cash flow) is ±63% of every invoice for work contracted out! Here the costs approach wrongly suggests a much lower effect.

4.7 Reduction risk of unsaleables

There has been no discussion of the risk of unsaleables in buffer stocks of semifinished goods and lot size stocks of semifinished goods. One could imagine that part of these items could become useless through wastage or technical ageing. In view of a dynamic market, the risk of technical ageing is always present. In the new situation this risk no longer exists for semifinished items, and advantages are thus to be gained here, too. In the light of the foregoing considerations, it will come as no surprise that the internal cost price gives a distorted picture of the financial returns in this case as well. From a structural perspective, all that is involved is lower expenditure on material and energy.

5. Summary

It was shown that there are about seven different economic effects to be distinguished, all of which are involved in an investment in flexible capacity. We have shown that such an investment only generates all the suggested Just-In-Time advantages if the customer-order decoupling point can really be moved upstream as a result of that investment. Otherwise stocks are only moved internally in the company. Bringing
about far slighter effects that the costs approach suggests and doing less than justice to potential advantages which can be achieved thanks to flexible capacity.

An investment in flexible capacity which really results in shifting the customer-order date coupling point upstream has shown that seven types of savings are possible. One can also be misled the same number of times as well. The reader may rightly observe that some of the misrepresentations are more or less trivial, for example in practice, space saving will seldom lead to majorated yield calculations.

One cannot fail to note that the costs approach promises too optimistic a result in many cases. The "tendency to misrepresent" will therefore be great for the most part among the innovative forces within the organisation. In fact, it is almost as if investment in flexible capacity, as sketched out here, can practically never be justified economically! But this is not altogether so. If the old press is worn out and it is thus correct to speak of an unavoidable replacement investment, the picture will be much rosier for flexible capacity. In addition, a great deal more can be earned in the area of contracting out, overtime, etc., than is suggested in the costs approach.

When investing in flexible capacity it should be realised that the "proof of the flexibility pudding" is the market. The customer will make his choice out of many types and a reliable, if possible, short delivery time. It will not matter to him at all if he gets his goods delivered on these conditions, either from stock or by way of flexible capacity. (Possible improvements in quality achieved by flexible capacity are not taken into consideration.)

Better than that, if there is a manufacturer who produces in lots, that is with stocks, but by good management of these stocks can offer the same delivery performance as the flexible manufacturer, the conventional producer can possibly be even cheaper. Such good control of (lot size) stocks, however, requires insight into the handling of an integral logistic concept, as the present article has illustrated. Furthermore, Camp's Economic Order Quantity is not a suitable instrument in this context with which to determine the lot size, as the costs approach fails because of the calculative misrepresentations which ensue.

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