

Push- vs. Pull-Concepts in Logistics Chains

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Abstract

In numerous publications on manufacturing and logistics the widespread terms „push“ and „pull“ are commonly used to characterise particular concepts of system configuration and coordination. But these publications frequently present push- and pull-ideas in a confusing way because they do not explicitly distinguish what is really meant by these terms. So it often occurs to the confused reader that some publications describe certain logistics / manufacturing contexts as a „pull“-system while other authors state the opposite. As there is no common sense of what these terms really mean and how they should be used, it is difficult to make clear statements in the scientific discussion and, as a consequence, to avoid inconsistency with other authors apparently contradicting understandings.

To shed some light on this problem, the aim of this paper is to develop a simple framework in order to classify the alternative kinds of understanding of push- and pull-concepts in the configuration and coordination of manufacturing systems or logistics chains, also known as supply chains. This framework will help to define the conceptual basis of push and pull in the scientific discussion more clearly.

I Push and Pull: Widely Used Terms in the Field of Production and Logistics

The rise of the terms push and pull can be portrayed as a process coming from the generally known discussion found in the production and inventory management literature and getting more and more used in the wider scope of logistics literature. The controversy discussion of push vs. pull systems found in publications in the field of production and inventory management in the beginning of the 80's can be seen as the starting point for an ongoing discussion on an increasingly broader field of logistics research until present times.

1.1 The Development of Push and Pull: From Japanese and Western Manufacturing-Systems to Interorganisational Logistics Chains

In 1982 Richard J. Schonberger published one of the first books dealing with „Japanese Manufacturing Techniques“ with an - at these days - astonishing subtitle: „Nine Hidden Lessons in Simplicity“. His early research can be used as a reference for the development of the terms push and pull, because he was one of the first (American) researchers focusing on the „Japanese way“ of producing consumer goods, which was supposed to be very competitive. Western companies focused on developing their planning and production processes in an automated and computer integrated way having the ideal vision of the „deserted factory“, an

automated factory which did not need workers any more to function perfectly. Therefore they heavily relied on complex technology like Numerical Controlled (NC) Machines and Mainframe Computers to cope with complexity. The Japanese way of planning and organising their production processes was so astonishing for western companies, because it turned their „world view“ upside down. Western companies believed in the control of *complexity*, whereas the first attitude of Japanese thinking was *simplicity*.

Schonberger distinguished two contrary modes of production which can be seen as the origin of the application of the terms push and pull (Schonberger 1982; Karmarkar 1990; Hall 1983):

- The western „push-production-system“ (see Image 1), which is basically founded on the „mechanics“ of Materials Requirements Planning (MRP) and the „philosophy“ of Manufacturing Resource Planning (MRP II), which also is commonly seen as the root of Computer Integrated Manufacturing (CIM) (see Table 1).

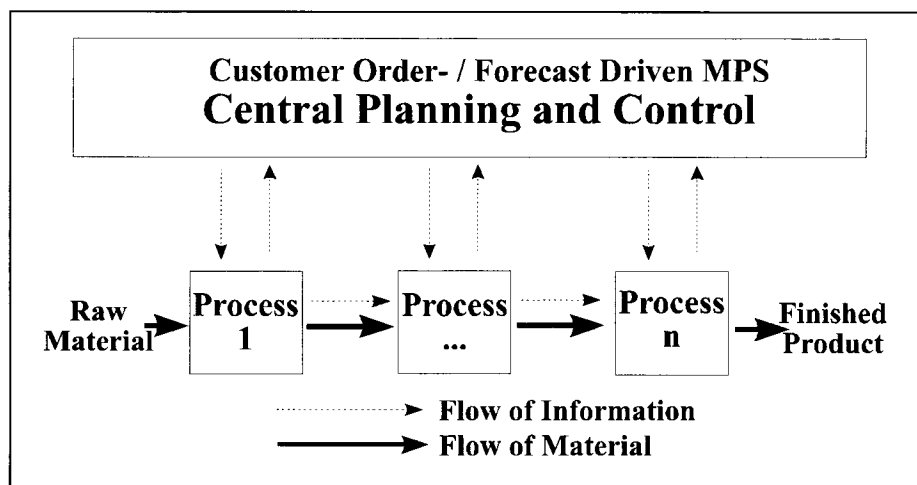


Image 1: Typical Configuration-Scheme of a Push-System

- And the Japanese „pull-production-system“ (see Image 2), which basically comprises the „mechanics“ of the KANBAN control logic in conjunction with the *principles* of the Just-In-Time (JIT) „Philosophy“ (see Table 1).

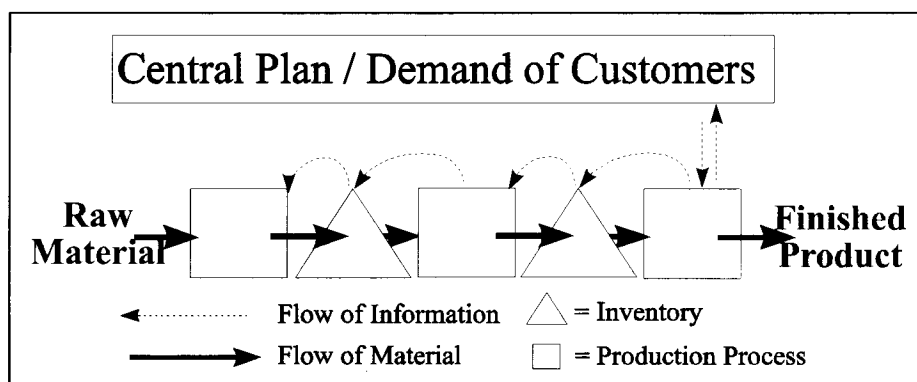


Image 2: Typical Configuration-Scheme of a Pull-System

These two contradictory concepts and philosophies of designing and controlling (intrafunctional) production processes were the starting point for an increasing and ever widening interest in the development of more complex logistics systems (interfunctional/intraorganisational and interorganisational logistics systems, see Image 3).

Dimension	Japanese „Philosophy“	Western „Philosophy“
Inventory	A liability that has to be eliminated	An asset that protects against forecast errors, machine problems, late vendor deliveries
Setups, Lot sizes and lead times	Reduce setup times to permit small lot sizes and short lead times	Accept setup times and optimise lot size with adequate analytical formulas, lead times are given as a result
Quality	Target: Zero defects, everybody is involved	Target: Some scrap is tolerated, Job of specialised quality-controller
Vendors	Partnership, few, cooperative	Adversary, many, arms length
Workers	Management by consensus, involved, committed to quality and improvement	Management by edict, not involved, committed to careful execution of plans
Focus	Reduction of Complexity	Coping with Complexity

Table 1: Japanese vs. Western Philosophy of production control

Logistics until then was rather functional oriented, like purchasing/materials-logistics, production-logistics and distribution-logistics. The problem of structuring distribution for example was already examined in 1965 by Louis P. Bucklin, who differentiated between the principles postponement vs. speculation, which are nowadays often used in combination with or as synonyms for push (speculation) or pull (postponement) issues. Therefore push and pull was also a implicit notion of logistics in the early times made explicit by production management as a specific function of logistics.

As the intrafunctional focused concepts of production control began to spread throughout the production and inventory control literature and as a result found echo in the production-managers minds, it also attracted attention of logistics professionals. Logistics thinking widened towards a more interfunctional perspective. Furthermore, the close partnership of supplier and customer favoured by the „Japanese Philosophy“ opened the narrow intrafunctional production focused thinking to a more interfunctional and interorganisational one: From the functional „vertical“ single company oriented perspective to the logistics „horizontal“ supply chain perspective (see Image 3).

By the Council of Logistics Management (CLM) Logistics is defined as „the process of planning, implementing and controlling the efficient, cost effective flow and storage of raw materials, in-process inventory, finished goods and related information from point of origin to point of consumption for the purpose of conforming to customer requirements.“ This definition

does not limit the tasks of logistics to one company, it opens the view from the interfunctional to an interorganisational perspective. In addition, this perspective is reinforced by major advances in telecommunications and information systems and by an increasingly competitive environment faced by most companies.

Because of this development the intra- and interorganisational logistics perspective becomes a considerable topic for the strategic orientation of an enterprise. Therefore, in advanced definitions of logistics one finds the focus shifting from the core activities of transporting, warehousing, packaging and related activities to a holistic and integrated view of logistics. Logistics is becoming a specific part of the management's view and is not a functional company task any more like transport or distribution. The logistics perspective leads to viewing the own company as part of a far more complex logistics chain or logistics network (Delfmann 1995).

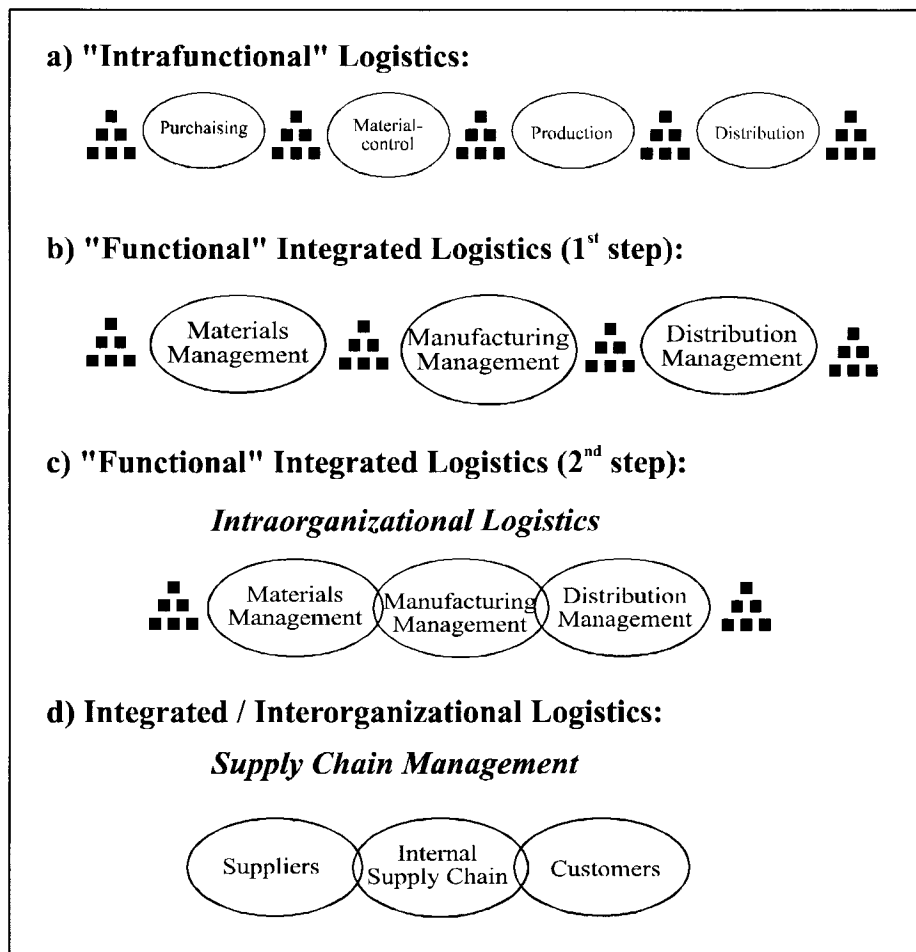


Image 3: From Intrafunctional Logistics to Supply Chain Management

Facing this development from the early definition of „logistics as a function“ to the advanced view of „logistics as a management philosophy“ it is no surprise that logistics professionals increasingly focused on cooperative (and interorganisational) logistics concepts like Supply Chain Management (SCM), Efficient Consumer Response (ECR) or Quick Response (QR).

These concepts are actually discussed in recent logistics publications, where typical descriptions of contemporary logistics systems are characterised by the notions of push/pull control logic, postponement/speculation structuring of logistics channels, direct/indirect delivery and centralisation/decentralisation of stockkeeping as alternative or complementary strategic opportunities for the design of logistics networks (Cooper/Lambert/Pagh 1997; Fernie 1994; Hammond 1993; Pfohl 1994 pp. 136-153).

1.2 Push and Pull in the literature: No Evident Division

The „typical“ approach to differentiate between push- and pull-systems found in the production management literature is as follows (see e.g. Slack/Correa 1992; Spearman/Zazanis 1992):

Push systems inherently anticipate the future and attempt to finish production in advance or „just in time“ to the scheduled due date. Therefore an aggregated „Master Production Schedule“ (MPS) is disaggregated into producible units by the logic of Materials Requirements Planning (MRP). In a recurrent planning process lot sizes and the latest starting dates for job orders are automatically determined by sophisticated computer systems. Fine scheduling and production control are made by a centrally located planning staff. Start dates for job orders are computed by subtracting an established lead time from the scheduled due date. After these planning procedures have been made, the „internal“ production order is „pushed“ through the shop floor (see Image 1).

Pull systems inherently react to orders which have already been fulfilled out of stock for finished products or have to be fulfilled by the last process in the production chain. Small intermediary stocks between the production processes are constitutional part of the pull-logic. Recurrent planning procedures are substituted by the intelligent configuration of the process-structure which is product focused and flexible through cellular manufacturing. This leads to less complex planning tasks, which can be transferred to the shop floor personnel, who plans with easy to handle procedures, e.g. a KANBAN planning board (see Image 2).

With these descriptions of push- and pull-systems in mind, the control-logic of a push-system and the anticipating character of MRP-planning are inseparable connected whereas pull-control stands for a reacting production planning (Karmarkar 1990).

On the other hand the MRP-planning procedure is classified as a pull-system because it „(...) basically reacts to the master production schedule, (...). Since actual demand is a key input to the establishment of production schedules (...)“ (Coyle/Bardi/Langley 1988, p. 224-225). In this sense, pull is defined in a complete different way. Here pull means reaction to a customer-order driven MPS but not the control-logic on the shop floor.

As mentioned before the pull-concept has been transferred from the manufacturing into the broader logistics context. There, for example, the notion of pull/pull is used to explain the main fortunes of the postponement vs. speculation strategy in conjunction with supply chain integration. But it remains questionable if it is really all „pull“ or „push“ what is proposed in these logistics concepts.

Despite the differences of interpretation, all these views have at least two commonalties, which are mutually mixed up and as a result contribute to the confusion by using the terms push and pull in describing logistics systems. This inherent ambiguity of this diffuse term-usage follows from the fact, that the characterisation of logistics or manufacturing systems as push- and pull-systems commonly covers at least two “dimensions“ of meaning, which are interchangeably or simultaneously and therewith ambiguously used in the literature. These two dimensions form the basis for the framework presented in the next section.

II A Simple Framework for Classifying Push- vs. Pull-Oriented Logistics Systems

The first element or dimension of the framework consists of the understanding that the differentiation of push vs. pull can be understood as a classification of the mere *mechanism* of how material and information are transferred through the manufacturing or logistics-system respectively. These mechanisms are visualised in Image 1 and 2 by the arrows symbolising the flow of material and information.

Second, push vs. pull is often implicit interpreted as a kind of *behaviour* related with the handling of the future, guiding us to the second element of our framework described by the terms anticipating and reacting. These inherent element of the framework is also enclosed in Image 1 by mentioning the possibility of customer order driven or forecast driven MPS and also in Image 2 by the chance of a central plan or demand of customers as trigger for production. The similar can be seen in the differentiation between postponement and speculation. Whereas speculation requires forecasting and as a consequence the thorough anticipation of the future, the target of postponement is the reduction of uncertainty by reacting or postponing logistics activities until the latest possible time (Zinn/Levy 1988; Bucklin 1965).

Therefore, for a clear understanding of push and pull concepts in logistics and manufacturing, it seems to be useful to replace the terms push and pull in this second implicit adopted meaning through the explicit terms *anticipating* and *reacting*.

As a consequence, these two elements or dimensions, the mechanics of material and information flow in a push- or pull-mode, and, the handling of the future through anticipating

or reacting, allow the development of a four-square matrix classifying four different kinds of logistics- respective manufacturing-systems. With this framework it becomes clear what kinds of manufacturing systems or, in the broader view, logistics systems can obviously be classified: Systems anticipating or reacting in either a push- or a pull-mode!

The following Table shows the essence of this framework. The four possible combinations are discussed in the following sections. It should be noted, that these four systems are theoretically developed ideal cases which in practice can be found in diverse mixed forms.*

	PUSH	PULL
ANTICIPATING	<u>ANTICIPATING SYSTEMS OPERATING IN A PUSH-MODE</u> Production to stock, activity trigger: <i>internal orders</i> derived from <i>forecast based production plans</i> , being pushed from the start till the end of production/logistics system, central planning and control of production, e.g. MRP II / DRP, forecasting methods and analytical models for logistics process optimisation are very important for operative planning	<u>ANTICIPATING SYSTEMS OPERATING IN A PULL-MODE</u> Production to stock, activity trigger: <i>internal orders</i> derived from <i>forecast based production plans</i> , being pulled step by step from the end to the start of production/logistics system central planning <i>but decentralised production control</i> , e.g. KANBAN, forecasting methods are very important for scheduling <i>end products</i> and setting the <i>frames of configuration</i> for carrying out operative routines
REACTING	<u>REACTING SYSTEMS OPERATING IN A PUSH-MODE</u> Production to order, activity trigger: <i>customer orders</i> being pushed from the start to the end of production/logistics system, central planning and control of production, e.g. MRP II, DRP tracking and tracing of production- and purchasing-status is very important for operative planning	<u>REACTING SYSTEMS OPERATING IN A PULL-MODE</u> Production to stock and to order, activity trigger: <i>customer orders</i> which have already been fulfilled by stock, „ <i>Re</i> “ <i>production of stock</i> , <i>no central planning</i> , only decentralised production control, e.g. KANBAN, shaping the environment to reduce complexity is very important

II.1 Anticipating Systems Operating in a Push-Mode

This class of logistics system can be titled „classical mass production“ or „stock production of commodities“. Products are made in advance for the anonymous customer on a prognostic basis and pushed downstream through the supply chain.

* Though „Push and Pull“ are coined by the production and inventory control literature and mainly used to classify production systems, this classification scheme is used to characterise basic characteristics of logistics systems which can also include production systems. That's why in the following the term logistics system will be used to cover all these aspects.

Commodities like dry grocery products are the typical goods which flow through this kind of system. „(...) Such products satisfy basic needs, which don't change much over time, they have stable, predictable demand and long life cycles. But there stability invites competition, which often leads to low profit margins.“ (Fisher 1997) These products have to be in place when the customers demands for it, otherwise sales will to be lost to a competitor.

The predictability and stability of demand patterns allow anticipatory planning in order to optimise lot sizes in production, packaging, stockkeeping, commissioning and transport. Analytical models explored in the area of Operations Research (OR) and especially designed for logistics problems assist to realise economies of scale in production and transportation throughout the whole supply chain. This furthermore helps to minimise the amount of stock needed in the pipeline. As a consequence the efficient flow and storage of goods depends on the intelligent application of adequate forecasting, production and transportation scheduling methods in connection with sophisticated information systems which contribute the current and accurate data. As long as the savings in costs by optimising operations by means of thorough planning in advance are higher than the costs of storage and lost sales because of missing parts, this type of configuring a logistics chain is preferable.

But this „analytical“ way of managing the supply chain has it pitfalls which should be considered. Without the claim to completeness the following exemplary pitfalls can be pointed out:

High amount of investments in hard- and software and brain power to select the appropriate planning routines. Computerised planning systems must be fed with actual and accurate Data, otherwise the slogan „Garbage in, garbage out“ will rule the output of the system.

Employees have to build up expertise in complex computer technology and planning models. The widespread way of doing this is specialisation to planning tasks and operating tasks: The division of thinking and acting.

The analytical thinking and its comprehensive way of implementation by OR-Methods and computerised information systems leads to a „black-box“ thinking. The operative staff does not understand the complex way things are planned and scheduled and rely on the expertise implemented in the system. Information and planning systems become an institution which can handle complexity right, something like an „oracle“: All is accepted, nothing questioned.

As a quintessence it can be stated that this kind of production/logistics system configuration can be effective and highly efficient but is subject to rigidity. Once set in place it will remain this way until inefficiencies arise because of bad planning and/or changed realities in the systems environment. But even in the sector of commodities supply changes can occur.

II.2 Anticipating Systems Operating in a Pull-Mode

This kind of logistics system configuration pulls the material flow downstream through the supply chain, triggered by an upstream step by step information flow on the basis of an anticipated future demand pattern.

The commodity's standardised character and the continuity and stability of demand enable the installation of operative routines, which reduce the complexity of the planning and control procedures in logistics chains. As a consequence, the demand pattern and the typical characteristics of a commodity can be interpreted as enabling factors for configuring the whole logistics channel like a chain of repeating self-contained order cycles or logistics segments which control their processes by a standardised set of rules or routines (Schwegler 1995 pp. 259-266).

Determined amounts of repetitive operative tasks are assigned to production/logistics segments (e.g. work groups in cellular manufacturing) which are arranged in order to the product flow. Immediately following segments maintain direct relation to each other by an intermediary buffer. Each segment is responsible for its output which is input for the following segment. The trigger for activity in a segment is an order placed by the following segment. The transfer of materials is predetermined by fixed lots. By this arrangement visibility and transparency is achieved throughout the whole value added chain. In manufacturing, for example, this is done by installing KANBAN production systems, which consist of producing and buffering components controlled by simple cards representing a fixed lot size (see Image 2).

Forecasting provides the basis for configuring and controlling the pull oriented logistics system. First the segmentation of the logistics channel has to be tailored to specifics of the product structure and to capacity requirements of the customer demand. Second the anticipated demand rate is the input for determining the size of the intermediary buffers between the segments and the lot size which has to be reproduced when an order is placed. The techniques of determining these operative control parameters, which are crucial to

maintain the pull control logic, are not new and widely known as Reorder Point Techniques (ROP) discussed in every logistics and production management textbook.

By reconfiguring the „classical mass production system“ into this „anticipating pull system“ the pitfalls incurred by the internal complexity of computerised planning procedures, can occasionally be overcome. To achieve this one has to remind the principles of the „Japanese Philosophy“ as outlined in Table 1. The reconfiguration of logistics chains needs a complete different way of awareness concerning the implementation of logistics tasks. It is not enough to accept problems as given, the task is to ask for complexity reduction. Only by this desire for simplification the segmentation into order cycles and the control of operative tasks by standardised routines in logistics chains will be possible.

II.3 Reacting Systems Operating in a Push-Mode

This kind of logistics system configuration pushes the material flow downstream through the supply chain, triggered by an information flow based on a customer's order. By only reacting to a customer's order this system tries to reduce the uncertainty of stockkeeping on the level of finished products.

Innovative, very sophisticated high priced products, like an CNC lathe or a Porsche sports car are the kinds of products which are pushed through this push controlled chain. Characteristic elements of these products are high value, fast innovation rates, a reasonably short product life cycle and as a result a high uncertainty regarding demand patterns. This uncertainty is expressed by the risk or costs of excess supplies or of supply shortage. Furthermore the length of and dependability on lead time are further crucial factors for this supply chain configuration.

Here the strategy of designing the supply chain is completely different than the strategies of the so far discussed, anticipation-based supply chain configurations. The efficiency regarding optimal capacity utilisation through the whole supply chain was the main target whereas in designing a supply chain for innovative products the most important goals are responsiveness and flexibility.

Because of the fact that the specification of the product can differ up to a very considerable level, concerning the customers desire and the kind of product offered, the planning and controlling processes in the supply chain as carried out in purchasing, production and distribution are subject to a relatively low rate of standardisation compared to the so far

discussed supply chain configurations. As a result it can be stated, that handling complexity is far more important than reducing it and therefore it can be stated that computer based planning and scheduling methods are crucial for controlling the materials flow in order to meet customers requirements.

II.4 Reacting Systems Operating in a Pull-Mode

This kind of logistics system configuration pulls the material flow downstream through the supply chain, triggered by an upstream step by step information flow reacting to a customer's order.

Basically all the remarks made in section II.2 about „*Anticipating Systems Operating in a Pull-Mode*“ are also valid here, except the element of anticipation. But this is only a half-truth, because anticipation is, as a matter of principle, always inherent in logistics systems being pull controlled. Remind the fact, that anticipation of future demand is needed to determine the size of the intermediary buffers between the logistics segments. This is also the case for configuring the self contained order cycles being represented by the logistics segments. Information, based on anticipation, is needed to determine the entrusted tasks and the capacity requirements per order cycle in order to build an intelligent and efficient modular chain of standardised segments.

The necessity for standardisation to ensure an decentralised controlled flow of goods on a routine basis, without the control of a central planning and coordination system, is inherent in the pull control logic as such (Karmarkar 1990 p. 91). So if a pull system is build on a mere reactive pattern of order fulfilment, one has to pay attention to this anticipatory element of pull controlled logistics systems.

For high priced, cost intensive and innovative products the concept of the value added-chain can help to make a first step in structuring the supply chain into pull controlled logistics segments. If the range of end product is wide, due to the customer's individual demand, modularization of parts and components can be a viable solution. „Few“ modulated parts and components are used in combination to build many different models of customised end products. This leads to a reduction of uncertainty on lower level components. As the value of the product rises during its way through the supply chain it is a useful strategy to keep stock only at low levels in the value creation process, to avoid high storage costs and the possibility

of keeping the wrong end product. In logistics this concept is well known as the so called the strategy of „value added postponement“.

II.5 Putting it all Together

As stated before, these four alternative configurations do not exclude each other from being applied in the same logistics chain.

To illustrate this, imagine a segmented logistics chain, the last segment being reactive on a customer order basis operating a push controlled mode and the preceding being reactive operating in a pull mode triggered by the demand of the last segment. This last segment could be an assembly line, which produces the customer specific end products by assembling components and parts pulled out of preceding buffers. Contributions in the logistics literature coined the terms Postponement vs. Speculation for the division of such segments by defining the „order penetration point“, the point where the logistical process is determined by a customer's order.

Another aspect is, that it is important to make clear on which level of aggregation the analysis is focused. For example by structuring production processes the focus is on the internal „micro“ structure of logistics segments. By structuring complete logistics chains the relationship between these segments is subject of a „macro“ analysis. But even this differentiation can not be seen as independent tasks.

III Conclusions for Further Research

The above analysis of Push vs. Pull configurations of logistics systems reveals a brief insight into the complex problems of configuring and coordinating logistical tasks throughout the whole logistics chain. The mechanics of control named Push and Pull and the way of handling the future described as Anticipating and Reacting were the elements of a simple framework which defined the view of the study.

Many factors which also play a very important role, like the influence of power or the impact of modern information and communication technology on interorganisational logistics chains, were not discussed because of the limited scope of this short paper. This is also the reason why the role of changing the philosophy in conjunction with changing the control concept was only addressed in an rudimentary way.

Nevertheless, the presented framework can be used as a tool for a structured analysis of real supply chains in order to initiate a project of logistics restructuring. Furthermore the framework seems to be suitable and valuable for an ongoing theoretical analysis of logistics chains, which can lead to an interesting extension of the scientific scope.

Interesting problems which could not be dealt with in the scope of this paper are, for example, the question of who should take the responsibility of anticipation in a logistics chain. Another question results directly from the presented framework: At which position in the supply chain is the adequate place for changing from anticipation to reaction and from push to pull et vice versa? Further research activities are needed to expand the presented framework or to develop more detailed frameworks to support the shaping of adequate supply chains.

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