On Organisation of Prospective Production/Distribution Value Added Chains in incoming Knowledge–based Economy

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ABSTRACT

Advancements of Information and Communication Technology (ICT) facilitate global sharing of valuable knowledge. This boosts the development of new technologies and changes the border between 'desirable' and 'conceivable' for the customers. According to Pine, "Mass customisation means that the consumer can get only and exactly what he wants, at a price he is willing to pay". With progress of ICT this picture becomes more and more feasible. With online access to wide variety of products available worldwide from advanced usually large multinational suppliers, the customers expect apt quality of service from conventional, often local, companies, thus strengthening global competition among producers and service providers. At the same time, the progress of ICT allows sophisticated producer to get reliable 'real-time' feedback regarding to the customer satisfaction, and facilitates manufacturing/supply management technologies with dynamic reaction on the changes in the market situation. Outdated paradigm of 'wild', i.e. uncontrolled, mass-production is hardly suitable for mature markets of incoming knowledge-based economy. Mass-customisation approach means, first of all, shifting corporate managerial focus from production efficiency to the issues of customer satisfaction. To what extent is this feasible? What are potential tangible benefits of acceptance of mass-customisation for particular company, product and market?

This paper presents generic approach and results of analysis of related problems. Prospective structure of industrial production value chain for knowledge-based economy is introduced, discussed and illustrated referring to examples of similar structures in contemporary economy.

KEYWORDS:

Strategic Planning, Product Life Cycle Management, Production/distribution value chain analysis/planning, Mass-customisation and Production Systems

1. INTRODUCTION

Industrial production is often associated with ahead of demand manufacturing of huge quantities of goods, which are delivered to the customers through sophisticated supply chain pipelines. With limited competitive pressure, unsaturated markets and inexpensive resources the businesses feel well and economies grow up rapidly until the amount of produced wealth exceeds a threshold level of what the customer really requires and is able to pay for. The overproduction results with the crisis of economy, which ultimately balances the demand and proposition, and facilitates new spiral of economic development. This outdated paradigm of uncontrollable mass-production with intrinsic phases of rapid boost ups and devastating depressions is hardly suitable for mature markets of forthcoming knowledge-based economy.

The awareness of approaching overall crisis of mass-production based economy growing since the mid 1970s has facilitated the searches for new concepts of future self-regulated organization of industrial production. With an idea that ordering should precede manufacturing, a mass-customisation, which also promises to combine best features of made-to-order goods with efficiency and low production cost of industrial processes, is an attractive concept of choice for prospective organization of the world's industry. Since mid 1980s, when Stan Davis first conceived it in "Future Perfect" (Davis, 1996), the concept is extensively discussed and spontaneously introduced in businesses, gradually changing the footprint of industrial production.

Advancements of Information and Communication Technology (ICT) made possible global sharing of valuable knowledge. This in turn, strengthens the competition among producers, boosts development of new facilitating technologies and shifts the border between the 'desirable' and 'conceivable' for the customers. According to Pine, "Mass customisation means that the consumer can get only and exactly what he wants, at a price he is willing to pay" (Pine 1993). With progress of ICT this picture becomes more and more feasible. Buying online and searching the web for something 'the most suitable' among the variety of proposed products and solutions becomes more and more popular nowadays. With online access to wide assortment of worldwide available products from advanced, usually large multinational suppliers with huge resources and sophisticated services, the customers expect apt quality of services from conventional, often local and smaller companies, thus pushing the competition among product manufacturers and service providers to the global arena.

The progress of ICT allows sophisticated producer to get reliable 'real-time' feedback regarding to the customer satisfaction, allows manufacturing/supply management technologies with dynamic reaction on the changing market requirements, and ease the penetration of mass-customisation techniques in product development, manufacturing and distribution (see Salvador F., Forza C., 2002, Pitt L., Berthon P. R., et al. 2002, Ranky P.G., 2000). Thus the knowledge facilitating substantial introduction of mass-customisation paradigm into production /distribution value chain emerges under the customer 'pull' and technological 'push' influences. The second Interdisciplinary World Congress on Mass Customisation and Personalization, which was held on 6-8th of October at Munich, Germany, has demonstrated growing interest from garments, footwear, personal computer (PC) manufacturing, automotive, construction and few other industries to the advantages of a new production paradigm (the details can be found on www.mcpc2003.com).

Acceptance of mass-customisation approach means, first of all, shifting the managerial focus from production efficiency to the issues of customer satisfaction. However, coming paradise for the customers may hide serious challenges for the producers. Knowledge based economy assumes significant investments into value chain infrastructure and business process composition. To what extent is this reasonable for the manufacturer? What are potential tangible benefits and risks of acceptance of mass-customisation for particular company, product and market? The selection of appropriate production paradigm or/and proper balancing the elements of mass-production and mass-customisation approaches in order to improve efficiency of corporate value chain requires comprehensive analysis of specific properties of the market, the product, as well as existing and innovative production/distribution processes.

This paper deals with the analysis of strategic aspects of fulfilment of social needs with industrial production. A cost-based modelling of integrated product development value chain is used in Chapters 2 and 3 for the evaluation of advantages and disadvantages of mass-customisation and mass-production approaches. Conclusions regarding expected impact of mass-customisation on organization of processes in modern industry are made based on the results of analysis of the models in Chapter 3. A structure of prospective integrated value chain, targeted to better fulfilment of customer needs with combined pre-eminent features of mass-production and mass-customisation approaches, is proposed and explained in the Chapter 4.

2. MODELLING VALUE CHAIN OF INDUSTRIAL PRODUCTION

2.1 Mass-production value chain

A product lifecycle based model of mass-production value chain (Fig. 1 below) includes the stages of market analysis and decision-making, product construction, manufacturing, distribution and marketing, as well as coping with oversupplied products.

Down-streaming arrows between the stages in the diagram of the value chain show the flow of wealth in the value chain from initial decision commencing the project, through the product construction, manufacturing and distribution, to the customer, who consumes the results of producer's efforts. Wide arrows on the left side of the diagram illustrate partial contributions (identified by C_a, C_c, C_p, C_d and C_r) to the cost of the product (C_s) from corresponding processes in the chain. Bi-directional arrows at the right side of the value chain illustrate the flow of feedback information in the form of customer orders, market analysis data, etc., which are used to control the operation of the processes.

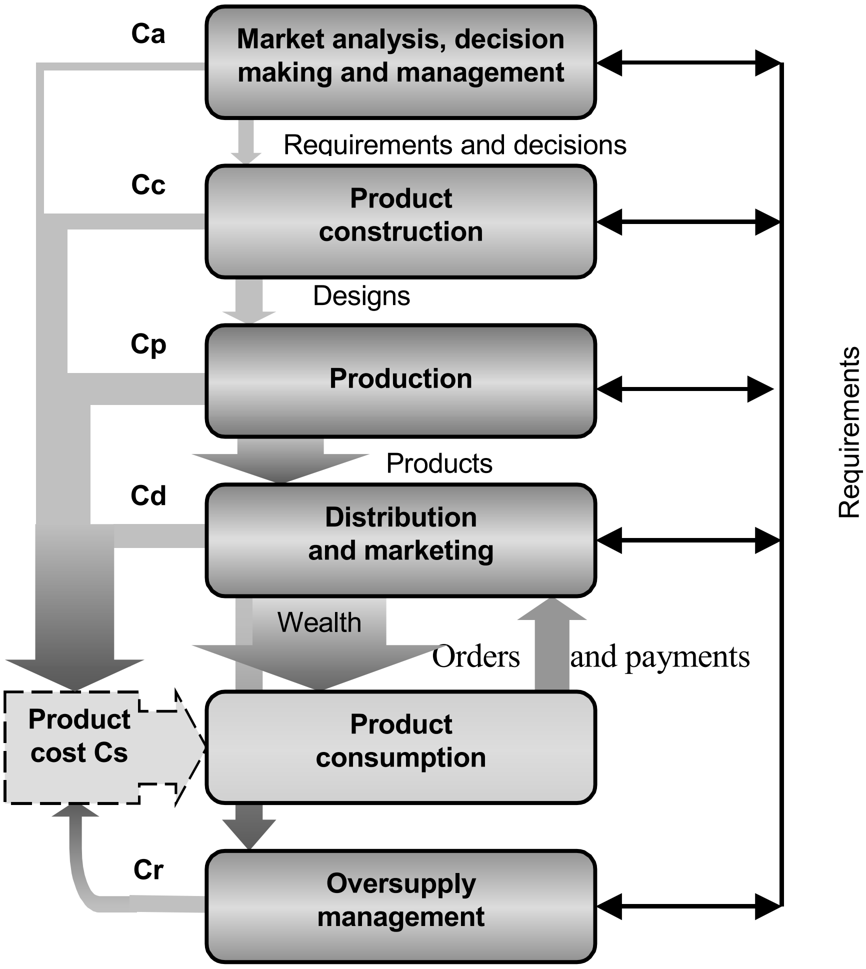

Figure 1. Structure of processes in integrated mass-production value chain.

Introduction of a new product in mass-production value chain begins with the market analysis and taking the decision to develop a product for specified market niche. The analysis, usually carried out within a comparatively limited period of time prior to the commencement of the product design, identifies potential customers; specifies the product in terms of customer requirements; evaluates market capacity in terms of estimated price and amount of the product items (N_s) to be sold; evaluates associated expenses, profit and project timeframe. The decision regarding the project is usually based on the outcomes of the feasibility study and results with approval of a sort of a business plan, which addresses in details all aspects of operation of prospective value chain. Necessary resources and investments are usually planned in advance, and every deviation from the plan results, as a rule, with extra expenses and lost profits. Then, the product is designed according to the requirements and produced in volume (or at the rate) sufficient to cover the estimated market capacity. The production assumes that corresponding, in terms of capability and capacity, production line, or more generally, integrated supply/manufacturing chain is designed, developed and deployed. The product produced in mass is stored in stock (obsolete in modern economy), or/and delivered in suitably large chunks through the distribution chain and sold. All aforementioned processes contribute with corresponding cost elements into integrated product cost C_s.

The customer compares product price with proposed wealth and purchases the product. The flow of payments associated with the orders reimburses the expenses of the producer(s) and keeps the business flying. The flow of the wealth passing by the consumption to the process of 'Oversupply management' in the diagram reflects the fact that in reality not all manufactured products reach their customers, as it was planned and desired. Therefore, extra cost element C_r should be added to account for the contribution of lost value to the product cost.

The management, presented in the process of "Market analysis, decision making and management" is limited mostly to administration and general coordination of the processes in the value chain. The interfaces between the "Product construction", "Production", "Distribution and marketing " and "Oversupply management" in mass-production are typically well defined, the processes are self-manageable, and once started run to the end, producing intended result(s). The opportunities for external control are usually very limited and the intervention in the flow of the process execution may cause unpredictable results or significant losses.

This organization of integrated product development and distribution, presents classical example of vertically organized industry inherited from primitive fabrication of pre-historical times and proven by the practices of a mankind. This type organization still can be found almost everywhere from archaic individual manufactures somewhere at the suburbs of industrial world to modern multinational corporations in well developed countries.

2.2 Model of mass-customisation based value chain

Mass-customisation based value chain is represented by a somewhat less complex compared to its mass-production counterpart structural model (see Fig. 2 below). The process of 'Analysis and management' is supposed to be carried on continuously, based on close and enduring interaction with integrated product development processes over the production/distribution value chain and the customer. It is also suggested, that mass-customisation makes use of more advanced, extended and manageable process of the product development:

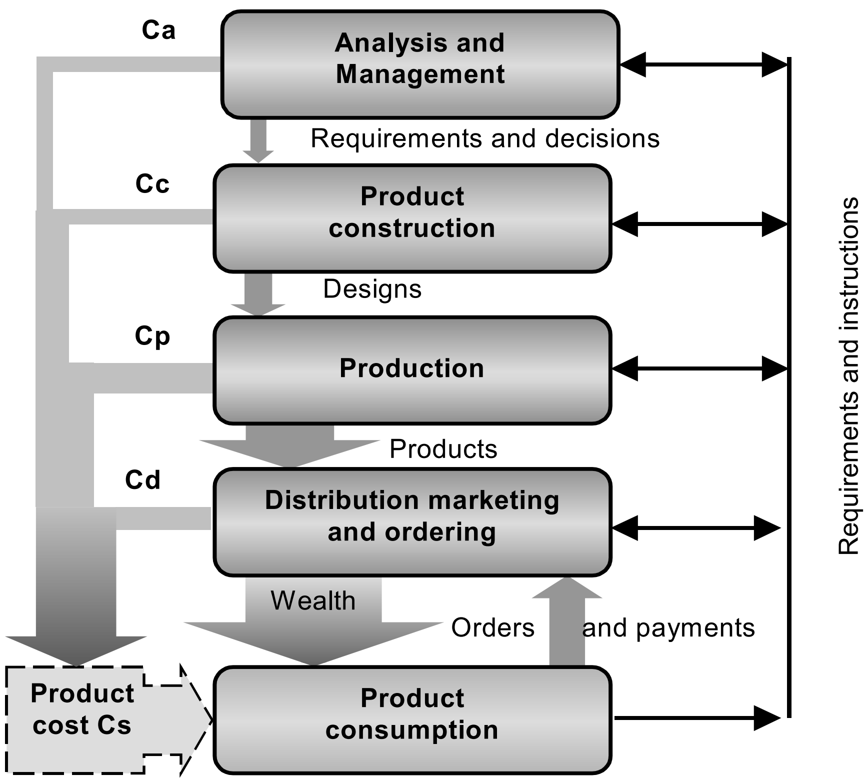

Figure 2. Structure of processes in integrated mass-customisation based value chain.

- The ‘Product construction’, should perhaps integrate some elements of market analysis and decision-making. The product, for example, could be designed initially as a result of one continuous design effort, as it is in the case of mass-production, and later on gradually modified and redesigned according to changing market requirements. Or, alternatively, a whole family of related products can be designed in one act, allowing simple switching between available designs in the following process of production of customized products.

- ‘Production’ in mass-customisation paradigm assumes extra flexibility combined with efficiency of manufacturing processes, allowing production at adequately low price variable quantities of diverse products accounting that the consumers will order only and exactly what they want, at a price they are willing to pay. As in case of mass-production, flexible production line and corresponding supply chain are to be properly designed, deployed and prepared for action.

- In mass-customisation based value chain the manufacturing is strongly controlled by the feedback in the form of the customer orders coming ahead of the manufacturing. Either direct link from the customer or the process of ‘Distribution marketing and ordering’ in the diagram (Fig. 2) (or both) are responsible for the specification of the products, which are to be produced and delivered to the customer.

The customer usually orders and pays for his/her personalized/customized product in advance, therefore, the refuses are assumed to be exceptional and the losses associated with product misaddressing and overproduction and not accounted for in the analysis.

2.3 Project cost structure and product cost elements

Taking into account that the businesses are driven by the profit, which facilitates their growth and development, a comparison of relative advantages and disadvantages of production paradigms should include analysis and assessment of corresponding elements of the product cost. Referring to process diagrams (Fig. 1 and 2) a project cost structure, can be presented as an integral of partial contributions from corresponding processes for mass-production:

$$C^m_s = C^m_a + C^m_c + C^m_p + C^m_d + C^m_r \quad (1),$$

and for mass-customisation based value chain:

$$C^c_s = C^m_a + C^c_c + C^c_p + C^c_d, \quad (2)$$

respectively. Upper indices (m, c) are used here to differentiate between mass-production (m), and mass-customisation (c) cost components, correspondingly. Equations having no upper indices are equally relevant for any of the two paradigms under consideration.

For the project with N_s product units sold, the cost per product unit (c_s) can be derived from the overall project cost (C_s) as follows:

$$c_s = C_s/N_s, \quad \text{or} \quad C_s = N_s * c_s \quad (3).$$

Similar relations can be written for partial contributions to the product cost from other processes in the value chain. However, for partial contribution form the oversupply management in mass-production we write:

$$C_r = (N_p - N_s) * c_p \quad (4),$$

assuming, for simplicity, that all oversupplied value is lost. Here, N_p stands for the total number of produced items. Obviously, $N_p = N_s + (N_p - N_s)$. At the same time, for mass customisation based value chain no oversupply is suggested, i.e. $N_p = N_s$, and therefore $C_r = 0$.

A project cost usually includes two parts, one of which is mostly independent from the number of manufactured product units, and is considered as an overhead. The other one typically reflects direct costs of materials, labour and components related to production/selling of each product unit, and should therefore be accounted times the number of the units. For example, the overall cost C_p of manufacturing of N_p product units, can be represented as $C_p = C_{p0} + N_p*c_{p0}$, were the overhead C_{p0} includes the cost of premises, supplies, technological equipment, training, management, and other expenses, which are necessary for the operation of a production line, but are not directly embraced in the cost of the unit of the end-product. Direct cost element c_{p0} includes the cost of off-shelf components, materials and labour, directly related to the manufacturing of each product item.

Similar equations could be drown for partial contributions from all processes in the value chain, i.e. for market analysis, construction, manufacturing, and distribution, as well as to the overall project cost itself, resulting with generic expression for the project budget:

$$C_s = C_{s0} + N_s*c_{s0} \quad (5).$$

Cost element C_{s0} here integrates overheads from all industrial processes constituting the value chain, while c_{s0} accounts for all direct costs associated with the product all through the chain.

To set up the scale, let us consider a no-nonsense example of a new-type DVD recorder project for a consumer electronic market. A table 1 below illustrates the structure of cost for the project. The figures are arbitrary and used only for illustration of relative importance of various aspects of real projects. The estimates are made assuming 0.5-1 year timeframe for the decision-making and product design, with extra one year contributed to the project lifecycle by production and marketing program.

Manufacturing and selling of totally N_p = 20 000 DVD recorders within one year of production activity is planned with a flat production-delivery rate of 2000 product items per month. Possible overproduction is not accounted for in the Table 1. However, detailed analysis (not presented here) shows that the oversupply of 10% of total number of produced DVD recorders, i.e. the failure in selling monthly output from the production line (N_p-N_s) = 2000, could result to the loss of 50% of expected $2 million profit.

Table 1. Cost structure of DVD recorder project

Cost component	Cost Element Description	Per project	Per item	
		Abs. Value C_x ($)	Abs. Value c_x ($)	% of total (c_x/c_s)
Ca	Market analysis& decision making	500000	25	5%
Cc	Design cost	800000	40	8%
Cp	Labor cost	1000000	50	10%
	Special equipment, premises, supplies	3000000	150	30%
	Off shelf components and materials	2400000	120	24%
Cd	Delivery/distribution	100000	5	1%
	Marketing/selling/ order processing	2200000	110	22%
Cs	Project cost (planned budget)	**10000000**	500	100%
	Number of produced items Np (to be sold)	20000		
	Income (brutto)	**12000000**	600	120%
	Expected profit	**2000000**		

The overhead (C_{p0}) for the DVD recorder production process according to Table 1 comprises the cost of special equipment, premises and supplies ($3 million). Direct cost of single DVD recorder item c_{p0} includes the cost of the labour ($50) and that of the components ($120). The total cost for production of N_p = 20 000 DVD recorders calculated according to formula $C_p= C_{p0}+N_p*c_{p0}$, results with C_p = $6.4 millions. The overhead for the distribution and marketing is estimated as C_{d0} =$2.2 millions, while direct costs represented by the cost for delivery of N_s = 20 000 recorders comprise only $0.1 million ($N_s*c_{d0}$, with c_{d0} = 5$). This type cost structure is usual when the producer subcontracts another commercial company, e.g. a network of large supermarkets, for distribution and marketing of manufactured products. The total overheads $C_a+C_c+C_{p0}+C_{d0}$ comprise $6.5 millions or 65% of the overall costs, while direct expenses are expected to be at the level of only 35% of the project budget.

3. VALUE CHAIN ANALYSIS AND COMPARISON/SELECTION OF THE PARADIGMS

3.1 Evaluation of the value chain efficiency and setting up the threshold between mass-production and mass-customisation approaches

Correct assessment of advantages and disadvantages of the paradigms requires comparing corresponding value chain models at similar conditions, and making reasonable assumptions about cost elements associated with the processes involved. The projects can be compared, for example, based on their budgets C_s assuming production and selling of fixed numbers N_s of product units. This evaluation is important for investors, involved in optimisation of a business plan regarding the introduction of a new product in the market.

At the same time, vast majority of customers usually take decision about the purchase of the product (or service) comparing expected wealth with market price, which is based on the product cost. Therefore, the price is the most important factor of choice for competing products, and vital indicator of competitiveness of the value chain. Global sharing of information and online purchasing, facilitated by advancements of ICT, make this statement even stricter. Product personalization and/or customisation can change this situation either for comparatively small share of really rich people, which are ready to get desired product for any price, or when extra price for the customisation is negligible compared to the product price. Consequently, the threshold for selection of the products and the markets, which could benefit from the introduction of mass-customisation paradigm, can be presented in the form of equation defining the conditions, at which the cost of the unit of mass-produced product $c^m{}_s$ equals to that of mass-customized one $c^c{}_s$, i.e. threshold condition:

$$c^m{}_s = c^c{}_s \qquad (6).$$

No doubt, the analysis and evaluation of value chain efficiency assumes comparing product cost, i.e. $c^m{}_s$ and/or $c^c{}_s$, with the competitor product cost level c_c, which could be evaluated and derived as one of the project aspects from the market analysis. With the equations (3) and (5) the product cost can be presented in the form

$$c_s = C_{s0}/N_s + c_{s0} \qquad (7)$$

having separated overhead and direct cost components.

Multimillion figures, presented in the Table 1 illustrate a general rule stating that production of valuable products in modern, and especially in knowledge intensive economy, requires vast investments in value chain infrastructure. The equation (7) shows how these vast investments in industrial processes in the value chain turn with large production outputs into low end-user prices. With increasing number of produced items, N_s=>∝, the contribution to the product cost from the overheads in the value chain vanishes: C_s/Ns =>0, and only direct expenses (c_{s0}) remain intact.

Mass-production benefits from technological efficiency of costly machinery and technological processes. Sophisticated high-yield manufacturing processes decrease direct expenses and continuously generate huge numbers of products, lowering down the cost per unit of produced, delivered and sold product. This is a fundamental principle of industrial economy used by mass-production to 'conquer the world'. Taking into account, that introduction of mass-customisation does not bring in revolutionary-new low-cost technologies drastically improving the efficiency of processes of the product design, manufacturing and distribution, the principle 'produce in mass', is equally valid for this paradigm.

Proposed formulas and cost models can be directly applied to the analysis and optimisation of a structure of industrial value chain, facilitating the selection of the most suitable paradigm, either mass-production or mass customisation, for specific product and market niche, as follows.

Project aspects should be identified, as it is mentioned in section 2.1, and value chain models similar to those presented in Fig. (1) and (2) designed.

Partial contributions to the product cost from all involved processes should be evaluated for each value chain model (as presented in equations 1, 2, 3, 4 and 5), and integrated into project budgets for both paradigms. Expected product unit costs should be calculated using equations (3) and (7). The results could be presented in tabular form, similar to Table 1 in section 2.3 above, for further project evaluation.

Variants of the project business plan, i.e. drafts based on various assumptions including those regarding the choice of production paradigm, should be evaluated and compared accounting for relative importance of various project aspects, i.e. product unit price, competing products, project budget, timeframe, etc.

The latter is important, since regardless of the fact that the threshold condition (6) and the mechanism of lowering end-user prices, presented in (7), are powerful tools for analysis and selection of production paradigm, 'local conditions' may set higher priorities to different aspects of evaluated projects. For example, shorter product lead-time required or budget limitations may give preference to the project plan resulting with higher product unit price, and so on.

Obviously, this simple at a first glance plan, strongly depends on the specifics of the product and the market situation concerned, and assumes processing of vast amounts of statistical, and usually vague information regarding market expectations and product costs/prices. For example, the evaluation of expected losses from overproduction according to formula (4) is based on estimated market capacity, namely, on the amount of items to be sold N_s. Real amounts of sold products can be calculated only after the project is implemented and product sold. The forecasts usually have a dispersion of probability to appear higher or lower the mean estimated value of sold products $N^m{}_s$. This, i.e. the dispersion of N_s, should be evaluated, and the momentum of lost value calculated, giving the expected figure. It should also be noted that companies often undertake various active measures targeted to reuse overproduced products and reduce looses of oversupplied wealth. More details on project budget evaluation and comparison of paradigms could be found elsewhere (see Shevchenko A. Shevchenko O., 2003).

The following sections provide some generic and robust considerations useful for rough evaluation of advantages, disadvantages and perspectives of introduction of mass-customisation or flexible mass-production approaches, and present our vision of prospective structure of a industrial production in forthcoming knowledge based economy.

3.2 Industrial processes and value chain paradigms

1. Mass-customisation is inevitable. Progress of ICT facilitates changes in principles of interaction between industry and customers (see Pitt L. F., Berthon P. R., et al., 2002). With advancements of ICT more and more customers will enjoy using services, which allow selection and purchase of products with desired and/or individually ordered combination of properties. This will require corresponding changes in corporate image and advancements in customer services from all players in the market, affecting industrial processes deep in the supply chain.

2. Mass-customisation is not associated with new industrial revolution. Introduction of mass-customisation into integrated product value chain does not revolutionize production techniques, which utilize shared with mass-production knowledge and technology. Therefore, the costs associated with corresponding processes in a value chain should be roughly the same for both abovementioned paradigms, except for the cases, when process organization requires distinctly visible extra efforts. Applying these considerations to the evaluation of value chain models presented by the diagrams (Fig. 1 and 2), and characterized by the project cost structures described in equations (1) and (2) correspondingly, one could come to conclusion that most of the costs related to the processes in mass-production have their equivalents in mass-customisation. The differences between the paradigms could be associated mostly with individual ordering and processing of the products in mass-customisation value chain.

For example, market analysis, decision-making and product construction in mass-production usually cope with comparatively small number of product specimen or/and prototypes, and therefore direct costs associated with prototyping are negligible. Mass-customisation, however, may assume extra efforts associated with individual servicing, e.g. individual ordering and/or constructing products on individual basis. If this is the case, extra direct cost elements (c^c_{a1} and c^c_{c1}) should be added to the process cost balance for mass-customisation. Individually purchased products should be delivered to the customers. Mass-production uses low-cost mass-delivery processes. Mass-customisation affecting customer-producer interaction, may assume new options in product delivery schemas. Extra expenses for introduction of individual delivery of purchased items could be accounted for with extra cost element c^c_{d1}. From another hand, mass-production suffers from the overproduction losses, which can be described with equation (4).

Taking into account the abovementioned considerations, the threshold condition for mass production/customisation described by the equation (6) can be presented after simplification and omitting all equivalent values from both sides, as:

$$(N_p - N_s) * c_{p0} = (c^c_{a1} + c^c_{c1} + c^c_{d1}) * N_s \qquad (8).$$

This simplified equation has a very clear meaning. In order to be competitive mass-customisation should keep the contribution from extended services, e.g. individual ordering, design and delivery (c^c_{a1}, c^c_{c1} and c^c_{d1} respectively) to the product cost c_s below the level of evaluated potential losses from overproduction in mass-production paradigm.

At the same time, the equation (8) states that mass-production has no disadvantages, compared to mass-customisation, in the markets where no overproduction is foreseeable (N_p=N_s, and produced wealth is not lost). This is true, for example, in case of introduction of a (new) product(s) in unsaturated markets, production of limited volumes of products 'expected' by the customers, and in some other specific cases allowing accurate prognosis of the market capacity. The equation (8) allows balancing between the risk of overproduction and extra expenses, associated with flexible manufacturing and extended customer services. It should be noted however, that (8) assumes comparing projects at equal conditions, in particular, at similar numbers of produced items.

3. Mass-customisation paradigm could expand market capacity for company's product. As it is mentioned above, mass-production is an efficient paradigm for 'pioneers of industry' taking advantage of new and unsaturated markets. In this case initial investments and direct production costs usually are reimbursed without problems as most of produced goods meet their customers. The risk of overproduction is negligible, and could only slightly reduce the profit at various stages of the value chain. With properly designed mass-production business plan vast investments in the value chain infrastructure are returned in a short time, and additional production generates significant profits. However, the business plan should insure having Return of Investments (ROI) succeeded prior to the saturation of the market with company's own and/or competing products, as the situation changes drastically with the market maturity.

Competing products from numerous producers struggle for customers in order to extend the company's share in the mature market. Forecasts of market capacity (represented by the values of N_s and c_c in our terminology) become less consistent, resulting with increased risk of overproduction, and decreased reliable estimated values of market capacity (N_s). As it can be seen from the equation (7) lower values of N_s used for production planning result with increased product unit costs. At the same time, lower competitor prices limit extra price, which could be assigned to the product. ROI rate speeds down, and production becomes less attractive for the investors. The antagonism among independent producers of competing products complicates control of the market drastically worsening the situation. The complete system becomes unstable and faces the risk of overproduction collapse, which often takes place when manufacturing exceeds payable consumption while proper feedback is lacking.

Advanced and extended customer services associated with mass-customisation could extend company's share of mature market in this situation, as these services along with product qualities affect customers' preferences. Moreover, the effect of services may even dominate, as the customers in our dynamic world do not always have sufficient competence and capacity for proper evaluate and compare product properties (the 'brand name' effect).

At the same time, continuous feedback from the customer assumed by mass-customisation, facilitates more flexible and predictable operation of processes in the value chain. This 'manageability' promises reduction of losses associated with oversupplies and other 'unexpected' deviations from the plans. Having value chain infrastructure built and amortized in the previous years of mass-production, the acceptation of mass-customisation approach, assuming comparatively small investments in the design of customized products and restructuring of product distribution network, is an attractive alternative to closing business and cutting the jobs.

4. Expansion of mass-customised production could be constrained with logistics. Taking into account that wide variety of similar products having diverse properties are already produced over the world, the area for mass-customisation activity could be, in principle, limited to fulfilment of customer desires with the products, which already exist somewhere in the global market. However, purchased products must be delivered to the customer. This takes time and efforts and could be costly. Mass-production has developed low-cost mass-delivery schemas assuming the transportation and distribution of the products ahead of demand. Provided the time is not a very critical parameter, high costs of product transportation could be converted into low (or at least acceptable) extra prices, when divided by large numbers of delivered items. How can industry producing customized products on customer orders survive in this world? A Table 2 and the explanations below illustrate the problem.

Table 2. Cost of delivery of small packets for TPG post, the Netherlands.

Delivery costs						
Weight (kg)	1	3	5	12	17	30
Cost (€)	7,9	10,5	11,0	12,9	14,5	17,9

Heavier packages may require from €2 to €10 extra per package depending on the size. Delivery usually takes 2-4 days, with about two days spent for package acceptation and 'last-mile' delivery. Transportation for longer distances, for example by air from any point in Canada to any point in US, might cost about $60-70 for the packages below 8 kg. The package will spend few hours in the air, but the delivery may take a couple of days in total.

As it can be seen from presented figures the issues of delivery of purchased products to individual customers set several limitations on introduction of mass-customisation paradigm in production:

- Unlimited individual delivery can be accepted only for expensive products having the price, which significantly exceeds any possible costs for delivery;
- Pure, i.e. independent from the methods of mass-production, mass-customisation paradigm could be efficient only 'locally, i.e. on limited territory adjacent to the factory.

For the products consisting from several components delivery costs may grow multi-fold if all components are to be delivered timely and 'on the order'. Three options exist in this case:

- The product cost must be extremely high to cover all delivery expenses;
- All components could be produced locally (unrealistic in modern economy); or
- Most (if not all) components should be produced and delivered 'in mass' and 'ahead of demand'.

Taking into account that the products most suitable for customisation are usually complex, i.e. multi-component in nature, one can easily conclude that successful operation of mass-customisation value chain requires well-developed underlying mass-production industry.

5. Mass-production make use of more efficient engineering technology and process organization. As it was mentioned above in this chapter, using shared technological basis mass-customisation is unable to gain comparative economical advantages over mass-production from technical evolution. Therefore, it is interesting to compare these paradigms from the point of view of process organization.

Any process, and especially complex engineering processes in a value chain, has a lifecycle, which includes introduction, full-operation and dissolution stages. Usually, industrial processes are most efficient when fully and continuously operating. The efficiency decreases with scaling down the process in time, yield, or in the total number of produced items. If due to continuous adaptations and changing load associated with product customisation the process yield and efficiency suffer, the production cost increases. As a result, even when based on Computer Integrated Manufacturing (CIM) and Flexible Manufacturing Systems (FMS) technologies (Ranky P.G., 2000) the manufacturing of customized products cannot surpass mass-production and mass-delivery processes in cost and efficiency. In equal conditions the overheads and direct expenses in mass-customisation based value chain are always higher, and can be roughly equal to these in mass-production only in the case of steady and predictable flow of customer orders, allowing stable and manageable processing of the products. This statement has several consequences:

For efficient operation of industrial value chain, a customer oriented 'front-end' process of 'Distribution marketing and ordering', which is responsible for ordering products in our model, should be designed to generate smooth and predictable flow of orders irrespective of the production paradigm;

'Predictable and steady processing conditions' is exactly what mass-production needs for efficient operation. Hence, flexible mass-production could serve 'massive' flows of orders, generated by 'front-end' processes in mass-customisation based value chain. Actually, existing processes in mass-production are often discontinuous having daily, weekly, monthly and so on periodical structure. This feature simplifies introducing flexible control of processes and adjusting production line output to serve 'mass' of customers with requested customized products.

As a result, the mass-customisation is expected not replace the mass-production, but rather to change customer oriented 'front-end' of basically mass-production based value chain.

6. Mass-customisation will change the customer oriented 'front end' of the industry. As it is well known from the literature (Davis S., 1996, Pine J., 1993, Pit L. F., Berthon P. R., et al., 2002) and confirmed by the follow-ups from our analysis presented in this paper, mature markets set specific requirements to the operation of industrial value chain. With global sharing of information taking advantages of 'pioneering' in the market will become more and more difficult. The industries have to adopt themselves to the rules of mature markets, become more flexible and responsive to the consumer, better know the consumer needs and fulfil the desires. This will require redesigning the principles of operation and organization of, first of all, those structures in the value chain, which directly communicate with the customer, i.e. of the processes of distribution, marketing ordering, purchase and delivery in our model. New principles of interaction with the customer, including those specific for mass-customisation, should be further developed proven in practice and widely implemented. With advancements of ICT, the society becomes capable to address each individual, accounting for his/her needs and desires. It is here a new technological revolution is expected to occur, and it already emerges in our days. Mass-customisation along with Computer Integrated Manufacturing (CIM), Flexible Manufacturing Systems (FMS), and other approaches, are expected to contribute heavily to the development of future economy with their concepts and new practices.

At the same time, the bulk of production value chain, and more generally, of modern economy, will remain on our opinion mass-production oriented. With advancements of ICT these 'mass-production clusters' will become more manageable, responsive to market requirements and flexible, however, focused on production of predefined quantities of specified product(s) with maximum possible efficiency.

Besides economic reasons, introduction of mass-customisation in production is postponed on our opinion by lacking of clear vision on the role and place of mass-customisation in modern industry. Insufficient acceptance from top managers, traditions of thinking in terms of mass-production paradigm, deficit of experience in flexible process and value chain design and risk of losses in new businesses, all play their roles. Clear identification of the 'niche of efficiency' for mass-customisation could on our opinion stimulate further introduction of theoretical constructions into practice.

4. PROSPECTIVE STRUCTURE OF INTEGRATED VALUE CHAIN

The progress of the ICT drives the evolution of engineering methods of industrial production in contemporary economy. At the same time, the advancements of ICT, and improvement of web-based services in particular, lay background for deep processes of organizational restructuring in modern, mostly mass-production based economy, e.g. outsourcing, formation of smart manufacturing networks and development of B2B partnering, globalisation of integrated supply and production, and strengthening of the competition among the economies of scale (see Cravens D., Shipp S. H., 1994, Lascelles D. 2002, Mathias D., Kapur V., et al., 2002 and Leisk C., 2002). As it was mentioned above in the Chapter 3, production of customised goods tends to be localised on limited territories nearby the manufacturing sites due to logistic constrains. In the light of abovementioned considerations, the postulation that prospective organization of industrial production will assume development of global networks of comparatively small industrial units serving local customers with both mass-produced and customised products and advanced services seems to be fairly reasonable.

Focused on fulfilment of local customer needs, these factories will hardly be able to produce their products in mass for competition on global arena. They could be expected mostly to assemble customized products from external supplies of off shelf components and provide finishing operations, while manufacturing only unavailable parts (if any), when required and is reasonable. Efficiency of such factories could be based on the use of comparatively low cost, simple and easily adjustable engineering processes, which are not targeted for high yield and therefore do not contribute significantly to the end product cost. Given that activity in these regional units is driven by the requirements of local market, the delivery of their products to remote markets will compete with the option of opening one more similar factory close to the customer.

Distributed production of end products from off shelf components heavily depend on reliable and well-developed supply chain, and could be efficient mostly in mature markets. Along with product related know-how, product development lead-time, delivery costs and communication delays are critical parameters for this type businesses. Small factories, or in general terminology Small and Medium sized Enterprises (SMEs) are hardly capable to cope with this type problems by their own, and will tend to be aggregated into networked communities around supply centres similar to web-based warehouses or supermarkets. Following Steven Kaplan and Mohan Sawhney (Kaplan S., Sawhney M., 2000) we call these centres e-Hubs.

Another alternative for the development of efficient distributed customer oriented value chains is associated with the aggregation of existing SMEs, e.g. traders, end product manufacturers and service providers, into distributed Engineering Clusters (ECs) around web-based Engineering Service Broker (ESB) e-Hubs. Details about ECs and ESB e-Hubs framework can be found elsewhere (see Shevchenko A., Horvath I., Vergeest J.S.M., 2004 or visit www.e-hubs.org/wp1/). It is our assumption that the framework of ESB e-Hubs, which was developed for forming ECs and setting up inter-organisational engineering collaboration in engineering clusters of SMEs, could be used for the aggregation of independent SMEs in the clusters around specific type engineering project, i.e. the projects targeted to the satisfaction of customer needs with selected family(s) of customized end-products based on a set of components available off the shelf.

Proposed model assumes, that the components and sub-blocks necessary for manufacturing of customised end-products are produced in mass by efficient high yield processes and delivered by mass-delivery procedures to regional redistribution and supply centres, i.e. eHubs. At the same time, the integration of random orders from local customer in e-Hubs will result with comparatively steady and predictable flow of orders for components, which will allow component manufacturers to take advantage from mass-production and delivery approach. This way the constrains associated with efficiency and cost of processes of long-distance delivery could be resolved. Furthermore, huge diversity of components required to fulfil the orders for dissimilarly customized products hardly could be obtained from a single source. On our opinion the mass-production of components is assumed to have a networked structure with many self-governed participants proposing their products and manufacturing capabilities, and competing for orders from the e-Hubs.

Proposed networked organization of industrial production allows combining best features of emerging mass-customisation with existing mass-production practices in prospective industrial value chain of forthcoming knowledge based economy. The structure of this value chain somewhat resembles that of global product distribution networks, which can be observed in existing multinational corporations and corporate alliances. It differs from these however, in that the variety of customized end products is produced not in few central mass-production nodes, but at the periphery of distributed networked structure and many component-producing sources are involved. It is our assumption, that introducing mass-customisation approach large corporations could be able to build up and manage this type integrated production/distribution corporate value chains.

Detailed consideration of various aspects of building customer-oriented global value chain(s) described above is hardly possible within the limits of the scope of this paper. It should be noted, however, that the elements of this type business organisation are already observable in modern economy, in particular, in e-commerce related to the personal computer (PC) manufacturing. Let us consider for example the situation in online market of desktop PCs and related components in the Netherlands having in mind to illustrate state of the art and perspectives of the development of distributed customer oriented production system.

A desktop PC is a unique high-tech product, which benefits from the advantages of open architecture. Open standards for module interconnection have resulted with development of mature market with numbers of module and peripheral device providers. The market is self-organized with most of PC modules and peripherals produced in high-yield mass-production facilities and typically delivered from countries with low labour cost. Thus, a personal computer considered as the end-user product, is on top of well-developed value chain incorporating the layers of mass-production of modules and peripherals, manufacturing of Integrated Circuits (ICs), production of special materials, instruments and so on. Mass-production based industry has already successfully solved most of the problems associated with the operation of this global value chain and is producing wide variety of assembled PCs and compatible PC modules for continuously decreasing prices. The efforts and cost for assembling PC from components at local sites are low compared to those associated with manufacturing of the modules. Architectural compatibility of sub-blocks with similar functions but different properties allows easy assembling PCs with wide variety of desired features on local customer orders. Several companies, including large corporations and SMEs, OEMs and small sellers propose online PC configuration services (visit, for example, www.dell.nl, or www.norrod.nl, www.crazypc.nl, and almost any from hundreds of PC sellers, which can be found on www.tweakers.net hobbyist community web site). A customer, especially buying online, has hundreds of options to choose from.

The overall picture is similar, in principle, to our vision on organisation of prospective integrated value chain(s) of the future economy. Therefore, on our opinion existing global value chain of production/distribution of desktop PCs could be considered, in general, as an example of 'best practices' for the organization of efficient customer oriented industry for other branches of the world's business. It should be noted however, that theoretical analysis and modelling allow finding out the deviations between proposed concepts and existing practices and drafting the recommendations for business improvement.

Our experience in ordering customized PC from world's leader in practical introduction of mass-customisation in the world of PC manufacturing Dell (we have visited www.dell.nl web site) has resulted with conclusion that the prices for low-end PCs are comparatively large. Dell Dimension 2400 (Value 0901) with Intel® Celeron 2.20GHz processor, integrated video, 256MB memory, Dell 17" E171 flat panel CRT monitor, 40GB Hard Drive (5400 rpm) and 48x CD-ROM is proposed for 737.8 € including Value Added Tax (VAT) (data valid on 22.09.2003). A delivery cost of 89.25€, not included in the total price in our case due to promotion action, also seems to be somewhat too high for the Netherlands in a view of the figures presented in the Table 2 above. The customisation, e.g. the replacement of proposed outdated 48xCD-ROM with CD-RW drive was possible, but for extra cost exceeding the price for similar CD-RW at a nearby shop. A desire to have 15" LCD monitor instead of proposed 17" CRT was feasible for only 34€ less then the cost of ordering and buying online extra Philips 150S4F 15" LCD for 269€. Alas, one cannot buy Dell's computer with inexpensive Philips's CD-RW drive and LCD monitor from Dell.

Visiting web sites of smaller online PC sellers, which can be found for example on www.tweakers.net, was also somewhat inadequate (we have visited www.dynabite.nl, www.crazypc.nl and few others). For instance, one can buy inexpensive Philips 150S4F 15" LCD for 269€ and CD-RW for 43€ from Dynabite B.V., but the lowest price for the PC similar to the Dell's one mentioned above is 899€, and no customisation options are proposed. Other companies propose customised PCs for the prices starting from about 399€ for a system block (without monitor), the 17" CRT monitors starting from 130€ and 15" LCD monitors starting from 330€. A PC specialist can chose a set of components combining best technical characteristics with optimal price from this diversity of online market proposals, but buying from several independent suppliers means facing inconveniences and increased delivery expenses. Visiting tenth of online shops in desperate search for cost efficient PC, which can be customized online to have desired features, takes time and efforts. It is not so easy, if possible, to find optimal solution from a single vendor.

On our opinion, despite significant progress in web services, which was observed within last years, the organization of online PC marketplaces, at least in the Netherlands, has yet potential for improvements. Large corporations are too closed for collaboration with their likely partners/competitors and sluggish in developing really customer oriented value chains. Smaller companies operate independently and propose only limited services. This creates a favourable situation for the introduction of web-based facilitators of engineering collaboration like abovementioned ESB e-Hubs, which could flexibly aggregate SMEs into competitive economies of scale, introduce advanced technologies of process organization and form efficient regional and global value chains focused on servicing customers.

Processes of reorganization of large corporations into distributed networks of collaborating businesses are currently underway in modern economy. About 60-80% of product value, according to Colin Leisk (Leisk C., 2002) from IBM, lies currently outside of the direct control of any single player in the product supply chain. Existing e-Hubs advertise and sell online mass-produced commodities in growing scale (Kaplan S., Sawhney M., 2000, Harbour P., 2001). The operation of an e-Hub usually assumes online ordering and payment for the products, which are available somewhere in the supply chain, but not necessarily stored in stock at the nearest to the customer shop or distribution centre. The e-Hubs can easily accommodate extra software and online services necessary for customisation of wide variety of ordered products. What is left out is an entrepreneurial initiative targeted to the selection of proper products and markets, and organization of the clusters of engineering service provider SMEs capable to collaboratively accomplish engineering projects and fulfil the end-user orders with customised products. Further guidelines for setting up engineering collaboration in SME clusters can be found, for example, in publications related to the framework of ECs and ESB e-Hubs (see Shevchenko A., Horvath I., Vergeest J.S.M., 2004 and Shevchenko A, Horvath I., Vergeest J.S.M., 2003, or visit the site www.e-hubs.org/wp1/).

5. CONCLUSIONS

The methodology of using cost evaluation and modelling of integrated production value chain for revealing competitive aspects of various approaches to fulfilment of social needs with industrial methods is presented. Engineering method of selection of appropriate production paradigm for specified product and market niche, and vice versa, is proposed.

The advantages and disadvantages of mass-customisation and mass-production paradigms of industrial production are evaluated and compared regarding the efficiency of value chain operation. The analysis has led to the conclusion that the introduction of mass-customisation could not replace mass-production, but it will drastically change the footprint of existing mass-production based economy making it more customer oriented.

Results of analysis are used for making conclusions regarding expected impact of mass-customisation on the organization of processes in modern industry. A structure of prospective integrated value chain, targeted to improve the fulfilment of customer needs with combined mass-production and mass-customisation approaches, is proposed.

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