

THE TFV THEORY OF PRODUCTION: NEW DEVELOPMENTS

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ABSTRACT

This paper aims at reporting new developments in the understanding of the TFV (Transformation-Flow-Value generation) theory of production. This theory identifies three interdependent angles to production: transformation (achieved by resources workers, machines, etc.) oriented (T), materials oriented (F) and customer oriented (V). Fundamental ontological differences in the presuppositions of the three sub theories are pinpointed. In particular, the transformation theory subscribes to thing metaphysics, whilst the value generation theory is based on process metaphysics. It is suggested that for achieving an internal alignment among the sub theories, two different understandings should be distinguished: thing-metaphysics based (TFV)^t and process metaphysics based (TFV)^p. It is shown that the three different sub theories have often in practice been interpreted according to (TFV)^t. However, the fundamental problems associated to this understanding are also pinpointed, and the limited range of application of (TFV)^t is noted.

In the consideration of (TFV)^p, especially the transformation theory has to be reinterpreted as a processual conceptualization. It is suggested, following a hint from Shingo, that transformations equate to work. It is suggested that the traditional command and control (or management-as-planning) mode is in coherence with the (TFV)^t theory. Unfortunately, this mode of control amplifies the conceptual shortcomings of the (TFV)^t, and it has been found to be inefficient in practice. Instead, for (TFV)^p, more holistic modes of control are needed. An initial exploration of control coherent with the (TFV)^p conceptualization is made.

KEY WORDS

Transformation, flow, value generation, production, metaphysics.

INTRODUCTION

This paper aims at reporting new developments in the understanding of the TFV (Transformation-Flow-Value generation) theory of production, first presented in (Koskela 2000). The TFV theory has then been used as an explanatory framework in

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descriptive research (Tzortzopoulos & al. 2005, Elfving & al. 2003) and in prescriptive studies on production (Bertelsen & Koskela 2002).

One of the originally presented topics of further development was the integration of the three different theories of TFV (Koskela 2000). This paper endeavours to explore one possible avenue of integration, although no integrated theoretical construct will yet be presented.

THE TFV THEORY OF PRODUCTION

As a first step towards integration, it has been suggested (Koskela 2000) that we can conceptualize production simultaneously from three points of view: transformation, flow and value. Broadly viewed, there are three suggestions on how to proceed:

- balancing the prescriptions from all three viewpoints
- taking care of interactions between phenomena covered by the three viewpoints
- using the three viewpoints successively (Bertelsen & Koskela 2002).

However, the integration has to be carried out by the user of the TFV theory, rather than being taken care by the theory itself. As it is not readily obvious how the three different models could be unified, one angle of attack is to look for reasons why they are incompatible – perhaps the understanding of such reasons would provide new directions.

One place to start investigations is metaphysics. Are all the partial theories of TFV metaphysically coherent?

First, what is transformation, in metaphysical terms? Superficially, transformation is related to change and becoming, but let's take a closer look. Transformation, as defined in economics, is a relationship between input and output. Both input and output are usually understood as things or matter. The transformation itself is a black box, except that we can decompose it into further transformations (tasks). Thus, the transformation model overcomes the difficulty of representing change by jumping over it, from one instance of time, represented by a set of things, to another instance of time, represented by another set of things.

Thus, the traditional conception of production⁵ is – implicitly - based on, and practically equates to thing-based metaphysics.

The alternative view on production holds it as a non-decomposable, dynamic process, although we of course may pinpoint different parts in it (Deming 1982): “Every activity, every job is part of the process. A flow diagram of any process will divide the work into stages. The stages as a whole form the process. The stages are not individual entities...”

The two other theories of production, namely the flow model (production is a flow - in time and space - of material towards the output) and the value generation model (production is conversion of a - particular - customer's requirements into products

⁵ The traditional approach to production, characterized as static optimization, and the dynamic approach have been interestingly compared by Jaikumar and Bohn (1992). They argue, in essence, that static approach to production can be effectively used only in special cases; the production situation is dynamic and requires a dynamic approach.

which fulfil them) take this dynamic view on these issues, but do not necessarily exhaust it (Koskela & Kagioglou 2005).

Thus, we have to acknowledge that there are fundamental ontological differences in the presuppositions of the three sub theories of TFV. In particular, the transformation theory subscribes to thing metaphysics, whilst the flow theory and value generation theory are based on process metaphysics.

REINTERPRETATION OF THE TFV THEORY

It is suggested that for achieving an internal alignment among the sub theories, two different understandings should be distinguished: thing metaphysics based (TFV)^t and process metaphysics based (TFV)^p.

Thing Based Understanding of TFV

Actually, one understanding of TFV that is based on thing metaphysics can be found in business process re-engineering. According to Davenport (1993), a (business) process is

a structured, measured set of activities designed to produce a specific output for a particular customer or market. It implies a strong emphasis on how work is done within an organization, in contrast to a product focus's emphasis on what. A process is thus a specific ordering of work activities across time and space, with a beginning and an end, and clearly defined inputs and outputs: a structure for action. [...] Taking a process approach implies adopting the customer's point of view. Processes are the structure by which an organization does what is necessary to produce value for its customers.

Indeed, here, the three production models are integrated into one - a process simultaneously is

- a set of activities, with input and output, as suggested by the transformation model
- temporal, that is, activities across time, as suggested by the flow model
- adding value to customers, as suggested by the value generation model.

Thus, integration has been achieved by superimposing features deriving from the flow and value generation model onto the transformation model. However, this is problematic due to differing assumptions in these models. Among the features associated with the transformation conceptualisation of production, attributable directly to the underlying metaphysical assumptions, are the following: (1) tasks are considered as black boxes, (2) tasks are considered similar by nature; (3) tasks are considered (nearly) independent (Koskela & Kagioglou 2005). Together, the last two assumptions imply that the transformation model is linear, i.e. additive.

The similarity of processes and their decomposed parts is explicitly assumed to apply for business processes for example by Armistead & al. (1996), who present a "business process breakdown structure" of four levels:

Characteristic of the four levels of hierarchy are that they share the process characteristics that were identified earlier. They are all transformations, but differ only in scale...

Unfortunately, the flow phenomena are arguably non-linear. In turn, the value generation phenomena are emergent. Thus, if you want to predict features related to

the flow model or the value generation model, a thing metaphysics based conceptualization will not provide right results. Thus, the prospects of integrating the three different viewpoints of production based on thing metaphysics seem discouraging.⁶

Process Based Understanding of TFV

In the consideration of (TFV)^p, especially the transformation theory has to be reinterpreted as a processual conceptualization. It is suggested, following a hint from Shingo (1988), substituting transformations with the concept of work (Parkan 2004). After all, transformations are realized through work of men and machines.

Thus, the process oriented interpretation of the three angles to production identifies the following aspects:

- Work oriented angle looking at the interaction of resources (men and machines) with the materials: we are interested in what the resources are doing and achieving⁷
- Flow oriented angle looking at the spatial and temporal movements of materials (or information)⁸ – of course this has been traditionally called logistics⁹.
- Value generation oriented angle looking at the process of designing and making products to fulfil the customer's requirements

This understanding acknowledges that there are three essential entities in production: workers (and generally resources), materials, and customers, as well as processes related to each of them, which have to be covered, for achieving, or at least approaching, a complete conceptualization of production.

CONTROL IN THE THING AND PROCESS BASED UNDERSTANDINGS OF TFV

After defining (TFV)^t and (TFV)^p, the appropriateness of different kinds of control in these two cases is analyzed. Here, the term control is used in its widest sense, to denote a pursuit of influencing the state of affairs (broadly in the same sense as management).

Thing Oriented Understanding of TFV

It is suggested that the traditional way of managing, consisting of the cycle of planning, execution and control, is in coherence with the (TFV)^t theory. The planning stage is usually in a dominant position (hence the term management-as-planning). Due to its roots in the transformation model, a plan typically indicates what should be achieved at selected time points. This is because even if transformation is related to change and becoming, it is just a relationship between input and output and nothing between them. Both input and output are usually understood as things or matter. The

⁶ Of course, this analysis does not definitively rule out the possibility that there would be some other way of thing-based integration; however, it pinpoints the intrinsic difficulties of such an endeavour.

⁷ Shingo calls this subject flow.

⁸ Also the flow theory has to be somewhat adjusted, for allowing phenomena, such as making-do, that transcend the thing ontology.

⁹ Shingo calls this object flow.

transformation itself is a black box, except that we can decompose it into further transformations. Thus, the transformation model overcomes the difficulty of representing change by jumping over it, from one instance of time, represented by a set of things, to another instance of time, represented by another set of things (Koskela & Kagioglou 2005).

There are several strands in the critique against the management-as-planning model (Johnston & Brennan 1996). Firstly, it has been held that it is not generally possible to maintain a complete and up-to-date representation of the world and intended action (i.e. plan) in it. Secondly, this model assumes that the organization consists of a management part and an effectors part. This leads to a centralized mode of management. Thirdly, the plans push tasks to execution without taking the status of the production system into account. Fourthly, the model does not acknowledge that processes of production do not necessarily require an external representation in the form of a plan for being realized.

Closely related to management-as-planning is the understanding of execution as commanding, and of control¹⁰ as correction. Both have argued to be problematic (Koskela & Howell 2002).

Thus, unfortunately, this mode of control amplifies the conceptual shortcomings of the (TFV)^t, and it has been found to be inefficient in practice (Koskela & Howell 2002). Interestingly, even in military thinking there is a movement¹¹ away from command and control¹², which has been one starting point for the traditional way of management (Smith 2003).

Process Oriented Understanding of TFV

Theoretical considerations

Obviously, in (TFV)^p there are still three different processes to control, and their synchronization and alignment has to be targeted. However, we can relax on the many constraining assumptions that are related to thing based understanding of production and its management. Such a new understanding of control (or management) has earlier been analyzed, regarding the framework of management, in (Koskela & Kagioglou 2006a) and contents of management in (Koskela & Howell 2002). These earlier considerations are not repeated here, but only summarized in Table 1. Rather, here, a number of new aspects deriving from metaphysical assumptions related to the production conceptualization are added.

As mentioned above, there are three assumptions associated with the transformation view. First, we have the assumption that transformations can be handled as black boxes, which only can be decomposed into further black boxes. There are two consequences from this that have turned out to be especially

¹⁰ Here we are using the term control in the narrow sense of the stage occurring after the productive act.

¹¹ The new alternative to command and control is network centric, effects based operations (Smith 2003). The term “network centric” can be interpreted to refer to distributed cognition. In turn, the term “effects based” refers to the need of justifying military action through its multiple effects (ends), rather than through physical outcomes (means). In the previous doctrine, means and ends were so tightly coupled that often they were not distinguished.

¹² Note that in the term “command and control”, the word “control” is used in a narrower sense than otherwise in this presentation.

counterproductive. First, to view something (at the macro level) as a black box is profoundly atheoretical: at the outset, we decline to address any theories that could be found in the box, if opened. Second, this assumption tends to push the technological contents of a certain task and the competence to carry it out outside of the remit of production management. Namely, at the end of the chain of decomposition, we have to assign a black box to somebody for execution, and we tacitly assume that he is capable of doing it.

The second assumption is about the similarity of tasks across decomposition levels and at each level. The convenient consequence is that the same managerial principles can be used across situations. However, in so doing, we fail to see the differences between situations.

The third assumption is about the independence of decomposed tasks. Again, the most convenient consequence is that each decomposed task can be managed separately, without taking the rest of the world into any account. Unfortunately, in so doing, we fail to see the connections between tasks.

Thus, when relaxing these assumptions, we are suggested to

1. address theories of (macro)processes and the technological contents and skill at the task level
2. address the differences between tasks and the managerial implications of the these differences
3. address the interdependencies of tasks.

From these, it is easy to see where the last two points lead. The recognition of waste is an example of the acknowledgement of differences between tasks. In turn, the very models of flow and value generation address the interdependency of tasks. Instead, the first point needs clarification, to be provided below.

Next, the three processes of (TFV)^P are analyzed, in an exploratory way, in view of the theoretical characterization of Table 1.

Table 1. Summary of two understandings of control (partially based on Koskela & Kagioglou 2006a)

<i>Domain of assumptions</i>	<i>Control based on thing metaphysics</i>	<i>Control based on process metaphysics</i>
Basic metaphysical assumptions related to the production conceptualization	The total task and the decomposed tasks are black boxes	Externalizing of competence to carry out tasks Control based on substantial theories of the setting
	Tasks are similar	Differentiating control according to the nature of task
	Tasks are independent	Holistic approach, where tasks are considered in their context
Features of the setting of management	Centralized cognition, i.e. designated individual as subject of management	Distributed cognition
	Acts of management are discontinuous	Acts of management are continuous
	Things and their abstractions as objects of management	Processes, change and emergence as objects of management
	Fixed objectives: getting the task done	Maintaining a fit between different aspects and parts of the situation
Contents of management	Management-as-planning	Management-as-organizing
	Execution as commanding	Execution as conversation
	Control as correcting	Control as learning

Work¹³ processes

Which are there alternatives to traditional centralized control (or command and control)? How can we manage work in a way that is coherent with a processual understanding of it? In the following, a number of such control strategies are pinpointed. The exploratory nature of the examination is emphasized.

BASIC METAPHYSICAL ASSUMPTIONS RELATED TO THE PRODUCTION CONCEPTUALIZATION

Theory based management of work

As one recent example on theorizing on work, we may consider the concept of *flow*¹⁴, as presented by Csikszentmihalyi (1990). He claims this concept to be central to understanding people in a work setting. In this context, *flow* refers to “a state of concentration so focused that it amounts to complete absorption in an activity and results in the achievement of a perfect state of happiness”. His studies revealed the facilitating and hindering factors to flow. This phenomenon could possibly be used in practice by preventing all obstacles for such a *flow* experience. Here the river bank analogy presented by Winch (2002) can be adopted (and slightly adapted) as a metaphor: if you take care of the river bank, the river will by itself smoothly flow. Another metaphor is that of fire (Bertelsen & al. 2007): A fire will proceed by itself as long as there are appropriate amounts of oxygen and combustible as well as sufficient temperature.

Externalization of the competence

Visual management can be viewed as an attempt to externalize, not only the plan of work, but also the required competence (Rooke & al. 2007). Galsworth (1997) has defined a visual workplace, resulting from visual management, as follows:

A visual workplace is a work environment that is self-explaining, self-ordering, self-regulating, and self-improving - where what is supposed to happen does happen, on time,
every time, day and night.

Only when externalized, competence and its continuous development may become objects of management.

FRAMEWORK OF MANAGEMENT

Examples on processual management regarding its framework have been presented in (Koskela & Kagioglou 2006a). As an additional example, relational contracting (Koskela, Howell & Lichtig 2006) can be forwarded.

CONTENTS OF MANAGEMENT

As it is known, practices have evolved, especially in construction and software development, which are based on the alternative theories of management, management-as-organizing, language-action perspective and scientific

¹³ We have defined work in terms of its resultant transformation, which is the usual way of understanding this term. In practice, work can also focus on realizing flow processes or value generation processes.

¹⁴ To denote the particular sense, in which Csikszentmihalyi (1990) is using the term *flow*, italics is used.

experimentation (Koskela & Howell 2002a). From these partial theories, especially the language-action perspective (Howell & al. 2004) and the scientific experimentation model (as meant but not mentioned by Spear and Bowen, 1999) have been under intensive academic or industrial development. Regarding the managing-as-organizing model, a synthesis remains to be done. A mode of control recommended by complexity theorists are simple rules, which would take care of coordination (Lissack & Roos 2000). The four rules of Toyota, as identified by Spear and Bowen (1999), might be interpreted as such simple rules. Perhaps also management based on line-of-balance (Kenley 2005), if it leads to the formation of stable patterns of working, can at least partially be understood as falling into managing-as-organizing.

Flow processes

Regarding flow (and value generation) processes, the examination of control strategies is even more selective and sketchy, reflecting our scarce present understanding.

THEORY BASED MANAGEMENT OF FLOWS

As suggested by Hopp and Spearman (1996), the flow processes can advantageously be modelled through the application of queuing theory. It reveals the central significance of variability for the performance of flow processes, as well as the role of the process duration as a metrics.

FRAMEWORK AND CONTENTS OF MANAGEMENT

How flow processes should otherwise be managed, regarding framework and contents of management, is still poorly understood, even if of course much experimentation and good practice exists. Clearly, this provides a fertile ground for research.

It suffices here to give a few examples of holistic control. Queuing theory, as mentioned above, also pinpoints to one important possibility of holistic control, namely pull control. The difference between push and pull systems in production control, has been characterized by Hopp and Spearman (1996) as follows: "Push systems schedule the release of work, while pull systems authorize the release of work on the basis of system status." Push systems operate on the basis of the plan, while pull systems take the situation into account. Thus, push systems resonate with management-as-planning, whereas pull systems with management-as-organizing.

Another example is provided by the prescription of total supply chain visibility (Lee & Whang 2000), which resonates with the idea of distributed cognition.

Value generation processes

THEORY BASED MANAGEMENT OF VALUE GENERATION

The value generation process consists of the designing and making stages. There have not been precisely formulated theories connecting these two stages. However, the research on the proto-theory of design (Koskela & Kagioglou 2006b) has advanced the claim that the ancient method of analysis and synthesis also provides ingredients for a theory of value generation. The assessment of this claim remains to be done in the future.

FRAMEWORK AND CONTENTS OF MANAGEMENT

In outline, similar control strategies to the case of work, as presented above, have been used. Thus, the visibility or transparency of the flowdown of requirements is being pursued, with Quality Function Deployment and requirements management as technical means. Also, solutions based on distributed cognition are being used, like in agile project management. However, similarly to the case of flow processes, it can be stated that we still poorly understand how value generation processes should be controlled, regarding framework and contents of management. Again, a fertile ground for research exists.

CONCLUSIONS

The considerations presented lead us to suggest five main conclusions. First, the common conceptualization of business process serves as an example where the flow processes and the value generation processes are considered as thing based processes, in essence just as additional characteristics of transformation processes. Unfortunately, this thing based approach misses the intrinsic features of the flow and value generation processes, and cannot be recommended for generic use.

Second, if transformation is substituted by work in the TFV framework, we move towards a metaphysically coherent, process based understanding of production.

Third, new kinds of control are needed – and indeed evolving - to tackle the processual understanding of production.

Fourthly, we realize that the concept of work does not exhaust the phenomenon of production, as usually assumed in organizational science (for example Barley & Kunda 2001). If we are interested in how organizations are formed by the evolution of production, it is not enough to consider work solely – there is more to production.

Fifthly, the findings made provide added evidence in support of the proposition (Koskela & Kagioglou 2005, Koskela & Kagioglou 2006a) that a changeover from thing based metaphysics to process based metaphysics is the current determining primus motor in the evolution of management.

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