The interplay between coordination and interfirm innovation mediated by standardisation

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The aim of this paper is to explore the dual relation between coordination and innovation. It will be argued, that our ability to *coordinate* production activities is of crucial importance not only in order to keep coordination and short term production costs low but also, and in particular, to allow for *inter-firm innovation*. At the same time, the possibility of mastering this coordination process depends on a particular kind of innovation, innovation of *standards*. Standards allow even complex and urgent coordination tasks to be handled in a way that hinders shocks to propagate along the value chain; thereby creating an environment conducive to inter-firm innovation.

Furthermore it will be shown that the very nature for the objects of coordination - i.e. the *production activities* - significantly affects the task of coordination as well as the innovation of standards. Thus, the paper open up a new research agenda in the study of sectoral differences of innovative activity focussing on the very production activities and the coordination mechanisms employed in the pursuit of innovation.

In order to illustrate the framework suggested, this, this mainly conceptual paper ends up with addressing an empirical puzzle : how to explain the difference in innovation capabilities between two Danish low-tech sectors - the construction and furniture industries respectively – that in numerous ways are identical.

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Introduction – managing uncertainty

"Uncertainty is the enemy number one of business". It is tempting to use this quotation from Financial Times (18.9.00, Jacques Bougie of Alchan) as an entrance to this paper on how firms face uncertainty, how they cope with it and consequences hereof with respect to innovation and coordination.

Of cause the notion of uncertainty and its adverse impact on firms is not really new. An early recognition was made by Thompson (1967, p. 13):

> *"A newer tradition enables us to conceive of the organization as an open system, indeterminate and faced with uncertainty, but subject to criteria of rationality and hence needing certainty...we suggests that organizations cope with uncertainty by creating certain parts specifically to deal with it, specializing other parts in operation under conditions of certainty, or near certainty*"

If no environmental influences existed, technology could be analysed and used in a way dictated by the internal logic of the technology itself. In such a stable world a story of coordination and information would be of little interest: each party could adjust his behaviour gradually and sooner or later make exchange of information obsolete. Equilibrium (of materials, equipment, manpower or information) between two subsequent activities would, sooner or later, be perfect.

But the world of the firm *is not* stable and equilibriums *are* disturbed. The firm faces unforeseeable changes of a qualitative and quantitative nature concerning inputs and outputs. And it is exactly because the economy is disrupted by shocks that communication and coordination is required on a continuous basis (Casson 1997, p. 46).[1]

At the other hand, the level of uncertainty the firm face can, to a certain degree, be managed. And since a reduction of uncertainty enhance the likelihood of obtaining a desired result, we expect firms "subject to criteria of rationality" exactly to do so.

This paper explores the different ways a firm can reduce uncertainty. As it will be argued, understanding how uncertainty, and ways to reduce it, differ for different production activities is a key to understand why we across sectors observe diverse (a) coordination mechanisms, (b) levels of standardisation, (c) kinds and levels of innovation.

In essence the idea is that for some production activities it is possible to establish systems that prevents shocks to propagate from one part of the production chain to another. Here, production activities are in general not very dependent on each other, knowledge transfer is indebted in standards working with low costs allowing for high degrees of innovation and specialisation promoting and promoted by a market based coordination. In other areas it is harder to separate production activities. Here, more information intense coordination mechanisms like *teaming* are needed, innovation is troubled by problems of externalities and free riding and in turn the level of innovation and the division of labour is less developed.

The paper is mainly conceptual in nature. In particular, it departs from the ideas of Thompson (1967), Casson (1997) and Grandori (2000). However, in order to illustrate some of the main ideas put forward, the paper ends up with an empirical example: how to explain the difference in innovation capabilities between the construction and furniture industries respectively – two sectors that in many ways are alike.

Coordination and Interdependencies

According to Thompson (1967, p.p. 54-55), organisational parts can relate in three distinct ways:

- pooled interdependence,
- sequential interdependence, and
- reciprocal interdependence.

Pooled interdependence refers to a situation where organisational parts are elements in the same system, and yet not interdependent in any direct way. It can be describes as a situation where "each part renders a discrete contribution to the whole an each is supported by the whole." (Ibid. p. 54).

Sequential interdependence on the other hand describes a direct not symmetrical relation between activities; for instance, activity 1 has to be carried out before activity 2 can proceed.

And finally, *reciprocal interdependence* characterises a direct and ongoing symmetrical relation between two parts: part 1 depends on part 2 and visa versa.

Three different modes of coordination suit the respective interdependencies: with pooled interdependence, *coordination by standardisation* is appropriate, with sequential interdependence, *coordination by plan* is suitable, and finally *coordination by mutual adjustment* matches reciprocal interdependence.

Standardisation involves "the establishment of routines or rules which constrain action of each unit or position into paths consistent with those taken by the others in the interdependent relationship"; coordination by plans work by schedules and the like; and coordination by mutual adjustment involves "new transmission of information during the process of action" and is for the same reason called *coordination by feed back* (ibid. p. 56).

Even though the three different mechanisms for coordination solve the problems of coping with the different interdependencies, they do so at different costs, since the later forms of coordination requires more resources devoted for communication and decisions. However, the later forms are also increasingly able to handle more variable and

unpredictable situations and hence may be necessary to apply in spite of their higher costs.

The characteristics of interdependencies and coordination modes as proposed by Thompson is summarised in *Table 1*

Table 1: Coordination and interdepencencies according to Thompson 1967

Type of interdependence	Mode of coordination	Information and decisions costs / difficulties of coordination	Suitable environment
Pooled	Standardisation	Low	Stable
Sequential	Plans (+ standardisation)	Medium	Less stable
Reciprocal	Mutual adjustment (+ plans) (+ standardisation)	High	Very unstable

Decomposing "interdependence"

Summing up, we know from Thompson that modes of coordination are associated with different types of interdependencies between organisational parts. And that these interdependencies can be classified as either pooled, sequential or reciprocal. But what in turn causes a relation to be any of these three possibilities?

Once again, Thompson (1967, p.p. 20-23) offers an interesting conceptualisation in the distinction between *buffering*, *smoothing*, *adaptation*, and *rationing* as ways in which shocks in one part of the system can be isolated.

Buffering absorb environmental fluctuations by surrounding the technical core with input and output components. A way of doing this is by stockpiling supplies or outputs. Buffering brings considerable advantages to the technical core, but at the same time induce storage costs.

A second option is *smoothing* fluctuations by affecting the environment. For instance, lowering prices in low-peak periods can reduce variability in use of electricity. Similarly, fines can be introduced if services or products are not delivered on time.

Adaptation is a third option. In case changes in environment can be foreseen they can be incorporated in plans or schedules and the technical core is only mildly affected. Unanticipated fluctuations interfere more seriously with the operation of the technology and thereby reduce its performance.

In case none of these shock-absorbers work, *rationing* is the only option left for securing an organisational part some degree of stability. But it is "an unhappy solution, for its use signifies that the technology is not operating at its maximum" (Thompson 1967, p. 23). Either the production facilities are idle in low-peak periods or/and there is waiting time in high peak periods.

Even though Thompson is less explicit on this matter, the four shock-reducing methods presented here obviously relate to the three different coordination mechanisms and the associated types of interdependencies previously described.

Adaptation works by plans and schedules and is clearly associated to the coordination mechanism of *planning*. Coordination by *standardisation* requires rather stable and repetitive situations, which seems to be best honoured by *buffering*. *Smoothing* is an ongoing interaction with the environment (for instance by informing about price-levels in low- and high-peak periods) and in that sense it resembles coordination by *mutual adjustment*. However, Thompson has a rather extensive interaction in mind when he discuss this coordination mode (for instance, he describes it as something that is done in crews or teams, ibid. p.58) and hence the congruity between smoothing and mutual adjustment is only partial. Perhaps for the same reason Grandori and Soda (2000) suggest that *communication ties* or *teaming* are ways to ensure mutual adjustment in order to solve reciprocal interdependencies. Finally, *rationing* is the outcome if none of the three coordination modes works. Perhaps this situation could be perceived as *coordination by non-coordination*.

Clearly, some shock-reducing methods seem nicer than others. Buffering allows for a very high degree of shock absorption with low communication costs and few disadvantages transferred to other levels (as in *smoothing*), little planning costs (as in *adaptation*) and appears obviously to be preferable to the "unhappy solution" of *rationing.* In short, buffering keeps coordination and production costs low.

Why then, do we find all four methods in work? Or put differently: which conditions need to be meet in order for each of the methods to function?

Here, I would like to suggest three important characteristics of the production activity that affects the possibility (or to coin it in economic terms, *the cost*) of applying the different shock-absorbing methods:

The *urgency* in which a production activity has to be carried out. Some products are perishable or changeable (for instance mortar) and other products – i.e. service products – are consumed at the same time as they are produced.

The *complexity* of the production activity. Some activities are easy to carry out, either because they are simple or because the information needed is inherent in the object transferred. Other activities require knowledge on how the product is handled in previous or subsequent parts of the value chain. This creates a demand for more intense knowledge transfer along with the transfer of the actual product.

The *specificity* of the output (or input) of the production activity. This relates to the potential numbers of buyers or sellers of a product as well as the overall frequency of trading the product.

As recalled by Thompson (1967, p 20) *buffering* is dependent on low urgency in the sense that it is difficult to stockpile perishables. But it is also dependent on low degrees of specificity since it is very costly to store products that are only sold occasionally.[2] In principle, buffering can work with high and low degrees of complexity, but since complexity often is (negatively) correlated with specificity, there is, most likely, a tendency to that buffering work best with low levels of complexity.[3]

By definition, low degrees of specificity equal many potential buyers and sellers. This is general make *planning* and *mutual adjustment* in teams less favourable since they, as opposed to standardisation, are most efficient in small units (Thompson 1967, p. 57).

At the other hand, mutual adjustment by teams or dense communication ties do not face problems when complex production activities impose substantial information to be transferred back and forth the value chain. Though, this process is very time consuming which makes teaming inappropriate with high levels of urgency. Adaptation is just the opposite: due to the prescribed actions in plans or schedules it is a swift method but also a method that face difficulties in handling high degrees of complexity.

Smoothening works by someone (directly or indirectly) postponing their needs. For this reason, urgency, or specificity, has to be low.

Summing up – drivers of coordination modes

The way coordination modes are linked back to the characteristics of the production activities are summarised in Figure 1.

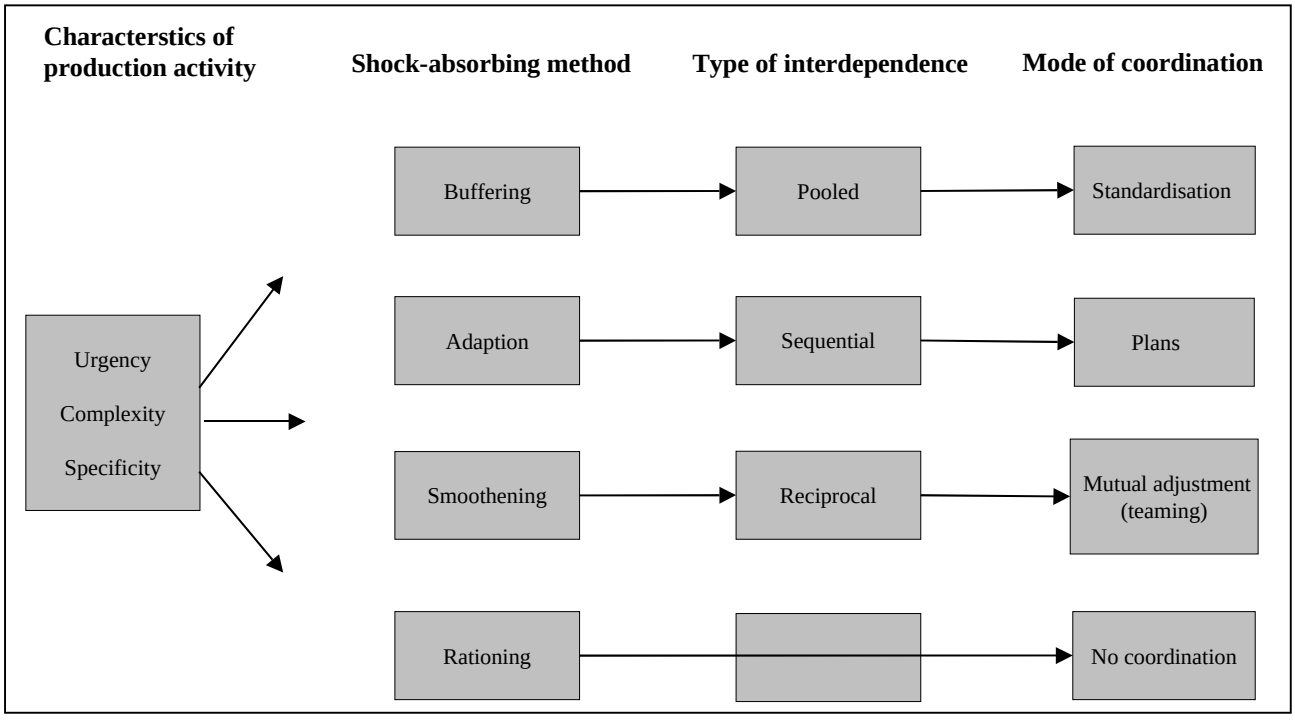

Figure 1: Drivers of coordination modes

The impact of coordination with and without standards on innovation

But the importance of the manageability of the coordination process is not fully captured by its effect on coordination and production costs. In the long run, the impact of coordination forms on innovation is likely to be superior.

In order to illustrate this, let us examine how innovations are likely to take place in two different set-ups; one with standards and one without standards.

To recapitulate, the importance of standards is that they reduce uncertainty and thereby allow production facilities to be used efficiently. More specifically, standards reduce uncertainty of a *quantitative* (unforeseeable changes in demand and/or supply) as well as of a *qualitative* (unforeseeable and costly to control variations in the inputs used for processing) nature. Quantitative uncertainty is reduced by standards since standards increase the extent of the market (due to lower transaction costs) and thus allow for buffering (e.g. stockpiling) or "the law of big numbers"[4]. And qualitative uncertainty is reduced simply because standards contain information exactly about the quality of the product.

Uncertainty affects innovation. In order to see this consider the impact of standardisation on the follwoing three different levels of innovation:

I. Firm innovations: (process) innovations that only concern the internal business of the firm.
II. Inter-firm innovations: innovations that involve specific inter-firm relations.
III. Sector innovations: innovations that encompass all firms within a sector (or perhaps even several sectors).

From a firm perspective, the benefits of pursuing innovations belonging to any of the three levels are very different with and without standards.

Without standards, the output is more tailor-made than if standards are prevailing. This in turn make *firm innovations* harder to obtain since the need for customised products have a tendency to "creep up on" the very production process. This is less of problem with standards where a firm can be reassured that as long as the standards are meet, the next link in the value chain will not mind any change in the production process. Thus, even though firm innovations are not impossible without standards, they are less likely to arise.

Inter-firm innovations are presumably even more unlikely without standards. This has to do with the quantitative as well as the qualitative uncertainty. Quantitative uncertainty force companies to be flexible – i.e. enter new relations and new segments on the market - in order to compensate for unanticipated and undesired down- or upswings. The benefits of firm-specific relations are significantly reduced in this - due to (at least partly) missing standards[5] - turbulent environment where the counterpart most likely will be a new one in the next transaction. Secondly because one of the benefits of inter-firm innovations is to allow for fine-tuned and specialised production units. However, if the qualitative uncertainty is high, it is more beneficial to stick to simple multi-purpose production units instead of specialised ones (Casson 1997, p. 53).

It seems that the only way a firm could benefit from inter-firm innovations in the turbulent environment caused by no initial standards is if the innovation were applied to the whole sector at once. However, from a firm perspective it will not be a very prosperous strategy to engage in such sector innovations since the firm will bear the costs but all firms share the benefits. Consequently, innovations in this environment are more likely to be launched by a third party representing overall objectives, for instance governmental institutions. In a set-up with standards third party driven innovations are less needed due to the dynamics of firms- and inter-firm innovations. However, sector innovations can take place here by a process where successfull inter-firm innovations outperform less successful ones and thereby become dominating.

The essence of this discussion on innovations with and without standards are shown in *Table 2*

Table 2 : The impact of standards on innovation

	No standards	Standards
Firm innovations	Few	Many
Inter-firm innovations	Few	Many
Sector innovations	Some ("third party" driven)	Some (firm-driven)

The impact of innovation of standards on coordination

Up to now, the paper has pointed out how coordination modes can be traced back to shock-reducing methods that again can be explained by some fundamental properties of the production activities subject to coordination. And how this in turn is likely to affect the level and extent of innovations.

This part of the paper reverses the logic and examines how innovations effect coordination. In particular, the emergence of standards are examined since it is believed that these are main drivers in reducing the task of coordination.

The importance of standards

As noticed by Thompson (see for instance *Table 1*), standardisation is an attractive way to coordinate activities since it allows each production activity to be performed in an efficient manner and at the same time

involve few direct coordination costs. As a classification of products agreed on by two or more parties – on matters such as size, content, the way the product has been produced, performance and perhaps also terms of delivery – standards are a way to ease knowledge transfer. They involve set-up costs (the cost of establishing the standard) but ensure low variable costs. Hence, standards are a way to institutionalise knowledge transfer made profitable by ongoing interactions: "When change is continuous then institutions will emerge to channel information routinely in an appropriate way. The process of change becomes embedded in institutionalized procedures" (Casson 1997, p. 10).

In order to illustrate the importance of standards let us once again consider a set-up with no standards compared with a set up where interactions along the production chain is dominated by standards. Identical interdependencies will be handled by very different shock absorbers in the two set-ups[6].

Table 3 : Methods for handling interdependencies with and without standards

Type of interdependence	Methods for handling interdependencies	
	Set up 1: No standards	*Set up 2: Standards*
Pooled	Stocks and queues	"Law of big numbers" = Prices
Sequential	Planning	"Law of big numbers" = Prices
Reciprocal	Communication ties	Standards
Intensive reciprocal[7]	Teaming	(this situation does not exists)

The innovation of standards

Taking the benefits of set up 2 into account, we should expect firms to engage in a particular form of innovation, the invention of standards. In other words, firms efforts to reduce the cost of interaction – not only to reduce transaction cost but also to enhance specialisation - is potentially an important source to the emergence and development of standards. The firm with the highest benefit will engage in such market promoting activities (Loasby 1994).

However, innovations of standards are troubled by the same problems as innovations in general (discussed previously). Thus it is very likely that it is not profitable for firms to engage in standards promoting activities. Especially not if it is the first shock-absorbing mechanism introduced.

As explained, standards ease transactions along the value chain and hence are mainly an innovation at the inter-firm or sector level. If at the sector level, the problems of free riding make firm-driven innovations of standards unlikely. Consequently, standards have to be, at least in the outset, inter-firm specific in order to launched and promoted by firms. But inter-firm innovations require low uncertainty. And uncertainty is indeed *not* likely to be low in a situation without standards.

The situation appears to be insoluble: in order to introduce standards we need some pre-existing standards, but where should these come from?

Of course a way out of the dilemma is to recall that other shock-absorbing methods exists. In the initial situation – before any standards have been invented – shock-reducing mechanisms has to be non-relational and yet not possible to copy in order to be firm driven. Stockpiling is an example of such a method.

What I am suggesting is that firm-driven standards hardly will emerge in a situation with no other shock-absorbing methods in force. Only if other methods decrease the need for flexibility, it is profitable to innovate at the inter-firm level. On the other hand, if such methods can be applied, a circle with innovations of standards allowing for an easier process of coordination, then again allowing for more innovation, among other of standards etc. can be established. Increased specialisation will be a important outcome of this positive circle.

To sum up, innovation of standards is a powerful way to reduce the cost of coordination even for production activities that in the outset is sequential or reciprocal related. However, in order to initiate such a process it is beneficial (and for sectors with high demand volatility *crucial*) to identify shock-reducing methods that at the same time are non-relational and yet not possible to copy. Buffering is an example of this. But whether buffering is possible to use or not depends once again on the nature of the production activities (for instance, are the outcome perishable).

In essence, even though the more dynamic explanation of the interplay between coordination and innovation is more complex than the one presented in the first part of the paper, the character of the

production activities still remains a crucial, perhaps ultimate, unit to consider.

An empirical illustration – the case of the construction and furniture industry

From an innovation point of view the Danish furniture and construction sector respectively are very interesting to compare because they show different innovation capabilities in spite of many shared features.

Both sectors are (a) mature industries in which (b) Denmark has usually performed well internationally (c) partly due to unique design skills; (d) they both produce physical objects, thus transportation and distance matters (irrespectively of new information technologies); (e) skilled craftsmen constitute a significant part of the people employed and consequently, the educational background is to a high degree the same; (f) to some degree they work with the same materials and tools, in fact quite a few companies shift between production of furniture and construction components; (g) the regional setting of production is partly overlapping (since construction on at least site-level takes place all over the country); and (h) they are, in general, both subject to the same external conditions constituted by legislation and government policies.

Yet, there are indications of that firms within the two sectors perform different with respect to innovation. A benchmarking of productivity growth and innovation in various Danish sectors found that in spite of less financial resources and people devoted to Research and Development, the furniture industry performed far better than the construction industry with respect to patents in the period 1989-1995 (Oxford Research, 2000). And an large survey (the DISKO survey)[8] covering in total 1900 Danish firms, only 27% of the 52 furniture companies included in the survey identified themselves as non-innovative in the period 1993-95. The identical figure for the 249 construction firms were 78%.

How to account for the vast difference in innovation suggested by these figures? The framework proposed in this paper could be a potential explanation (but of course, no proof is offered here).

Despite similarities, the process of producing a, say, house compared with producing, say, a chair is not identical with respect to urgency, complexity and specificity.

Concerning urgency, often the same materials are used in the two sectors, which set aside the importance of how perishable products are. However, due to the size, construction often takes place in open air, which calls for a quick coordination of some of the vital building parts. And perhaps more importantly, due to the very cost involved in building there is a high pressure on fast completion whereby interest costs can be reduced.

The length of the value chain is in general longer in construction compared with furniture production. In this process the product becomes more and more complicated whereby the information that needs to follow the transfer of the actual product is likely to be increased. The fact that different materials and different professions are included in the various steps is also a potential source for increased complexity.

And finally, the specificity is often higher in construction. Partly this has to do with the long long, and in turn complex, production chain whereby the output to some degree is specially designed for a specific house. Partly with the in-build nature of construction that makes the number of potential buyers of say, a brick-wall, very low after the brick-wall has been build.

In other words, construction is likely to more troubled by high degrees of urgency, specificity and complexity, which makes it difficult to reduce shocks by buffering, and to some degree also by adaptation and smoothening. Besides explaining why we are likely to observe high coordination costs and phenomena like idle production facilities and delayed projects (the two latter caused by rationing, the only shock-absorber left if none of the three former works) within construction, the difficulties in reducing uncertainty by coordination could also account for lower levels of innovation.

This in turn could explain why firm-driven innovations of standards are less likely to be found in construction compared with the furniture industry. This even more so due to the high volatility within construction - caused by, among others, the long lifetime of building products – that in it self increase the quantitative uncertainty and thereby decrease the amount of inter-firm innovations. An outcome of this is lower degrees of specialisation (changes do only come about if they take place simultaneously within the whole, or a majority, of the sector) which in turn creates weak selection mechanisms.

Even though highly speculative, this example illustrates that the natures of the very production activities are crucial to consider in order to understand coordination, innovation, and standardisation and how they interact. And as indicated, the nature of production activities may also account, at least partly, for a wider range of organisational phenomena such as levels of specialisation, firm-size, the nature of inter-firm collaboration etc.

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Notes

[1] Casson distinguishes between three kinds of volatilises causing different kinds of shocks (Ibid., p.p. 10-11). The first is the long-run structural change of the kind described by Schumpeter. The second is associated with fluctuations in demand and supply within an established market. And the final kind of volatility relates to the breakdowns and disrupts in a sequence of production activities. Structural changes are typically of large amplitude and low frequency, market fluctuations are more frequent but with lower amplitude and disrupts in production often the most frequent and less dramatic.

[2] In accordance with this, Thompson (1967, p. 56) finds that the coordination mode associated with buffering, *standardisation*, is dependent on stable and repetitive – that is non specific – situations.

[3] This argument is further strengthened by the fact, that buffering allows for coordination not only by standards but also by *prices*. Prices as a mode of coordination rely on the ability to structure, transfer and understand information in an easy and unambiguous way which is hard to do when the information complexity is high (Grandori 2000).

[4] "The law of bug numbers" refers to that due to the many actors involved, fluctuations in demand (or supply) statistically are likely to cancel each other.

[5] Other reasons for fluctuations in demands can be given. For instance sector characteristics such as the lifetime of the products (products with long lifetime increase the volatility since a marginal, say, reduction in the total stock equals a substantial reduction in production activities for quite a while).

[6] In brief, the line of reasoning is as follows. Standards lower the cost of transaction and thus increase the extent of the market. If there are many buyers and sellers, stocks and queues are not needed since fluctuations in demand (or supply) will cancel each other. Furthermore, many buyers and sellers can make a market clear even for changeable products without planning. This is exactly what we see in auction markets for highly perishable products like, say, fish and vegetables. Thirdly, if standards exists communication ties are not necessary even though the way the input has been produced has bearings to how it should be processed in the subsequent stages (that is to say, that if a input is well specified, it is known how to process it).

[7] Grandori and Soda (2000) have suggested this type of interdependence. It characterises a situation where the object transferred change on an ongoing basis during the process which make the reciprocal relation very intensive.

[8] I would like to thank Aalborg University for giving access to this database.