DEFINING AND MEASURING INNOVATION GENERATION IN IMP DATABASES
## - A Work-in-Progress Paper for IMP-Denmark 2004-

By

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Following the Schumpeterian notion of "creative destruction" as the engine of capitalist growth, Tushman and Anderson (1986) maintain that there is a range of incremental innovations, which causes improvement in an "industry" standard. These improvements go on till a new standard is achieved through technological discontinuity. Anderson and Tushman characterize technological continuity as either competence enhancing or competence destroying. Competence enhancing discontinuities are those that build on the existing technological skills of the industry (e.g., turbofan jet engine in the context of airline industry). Existing skills do not become obsolete but can be easily upgraded. On the other hand competence-destroying discontinuities like the transistor over the vacuum tube technology implies that existing skills become redundant and completely new skills are needed. The discontinuity in technology leads directly or in steps to an industry standard or a "dominant design"(Abernathy and Utterback 1978) or "technological guidepost" (Sahal 1981). This design continues with incremental improvement till the next discontinuity comes about. Although the discontinuity can and frequently is created by newcomers to the industry it is almost always the veterans that create the industry standard from the radical innovation or technological discontinuity (Anderson and Tushman1991).

When innovations are conceptualized as a sequence of S-curves, each S-curve represents a distinct type (in some cases, a radically different type) of base technology with its own stream of incremental innovations (e.g., Chandy and Tellis 2000; Foster 1986). For ease of exposition, we denote incremental innovations as moving along the same S-curve (e.g., moving along S1, moving along S2, and so on) and radical innovations as moving from one S-curve to another (e.g., moving from S1 to S2, from S2 to S3, and so on). We will also develop the position that S1, S2, and S3 represent changes in the interacting individuals at the firm level and may be seen as "new" relationships at the process level.

Figure 1 "S" Curves and Innovation Theory

PERFORMANCE ↑ COST ↓

S1

S2

TIME →
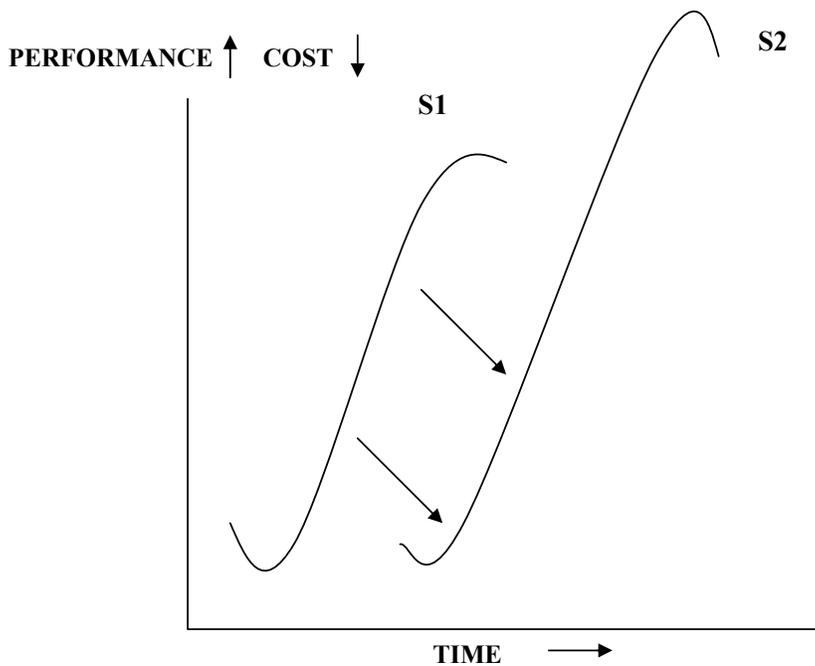
To us, radical business market innovation occurs when new relationships jump an "S" curve, from S1 to S2.   Incremental innovation occurs within existing relationships and involves movement up an "S" curve. Progressions from radio valves to transistors or from analog to digital recording are universally understood as radical innovations involving changes in "architecture" (Henderson and Clark 1990).By contrast, the computer industry may view a change in hard disk drive sizes as a radical innovation (Bower and Christensen 1995), but industry outsiders (or even some customers) may not view them as such.   The firm-level innovation literature (e.g. Chandy and Tellis 2000, von Hippel 1988) generally follows an industry poll method to identify historically "radical" innovations This paper takes the process perspective, and examines innovation within relationships. After "jumping" from S1 to S2, a great deal of incremental innovations must be achieved to enable the cost–benefit to surpass the previous S1. To provide context and perspective for the phenomena discussed in this article, consider the following examples:

•Refrigerator handles used to be made of coated steel (S1). They were improved radically to aluminum (S2) and once again radically to plastic (S3). Each radical innovation involved new relationships with new suppliers and an industry shift on the supplier side. Within each material, however, improvements were incremental within the same buyer-seller relationship (e.g., within S1) (following Gomory 1989).

•In the seventies, the leading mechanical technology (S1) watch manufacturer Seiko (following Chandy and Tellis 2000) foresaw the future promise of quartz technology (S2), despite the fact that the mechanical watch was improving. Working from the existing watch casings and dials of the mechanical watch, Seiko began development of a new innovation (S2) with fledgling quartz movement makers.

•Hard disk drive suppliers are constantly unseated as radically better-performing hard disk drives become available and computer manufacturers switch suppliers. In the disk drive industry, the leaders "stumbled" over each hard disk size reduction, from 14" (S1) to 8" (S2) to 5.25" (S3) to 3.25" (S4) (Bower and Christensen 1995, p. 45). During the dominance of each disk size, industry leaders were unable to transform the next discontinuous change into a different innovation. On each occasion in which the radical innovation was too beneficial to ignore for the sake of a relationship, the computer manufacturers switched suppliers.

Innovation theorists (Butler 1988,Christensen 1997) agree that within one "S" curve there is a long phase of sustained improvement involving steady improvements in cost/performance. Later in the article, we will present propositions as to how movements along one "S" curve can take place and when a jump from one to another apparently lower "S" curve is possible in buyer-seller relations.

Purely from the point of view of viability, unless a radical innovation exceeds the cost-benefit of the previous technology platform, it is difficult for firms to make sustaining profits. If we isolate the innovation function from other business functions, then we theorize that each buyer and seller across a supply chain would have their own set of "S" curves. Following Figure 1, there are long periods of time in which segmental/incremental innovation occurs in existing business market relationships. While managers would like to have stable input conditions, the emergence of a new S curve (e.g., S2) creates opportunities as well as challenges. Not only are S1 and S2 radically different in terms of innovation, but they also involve a different set of relationships in the supply chain. To make the particular S-curve as steep as possible, these new suppliers need to progress through the relationship stages so that the "segmental /incremental" stage of innovation and the "expansion/commitment" stage of the particular relationship coincide forcefully.

The focus of attention in this paper is on incremental types of innovation. Chandrashekaran et al. (1999) examined the introduction of new versions of shareware

Borttaget: As discussed previously, innovation generation in business-to-business markets, however, does not always focus on radical innovations but looks for improvements over previous situations. For example,

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software and defined high levels of innovation in terms of the number of versions of the software offered in a particular time period. We extend this notion of innovation generation to various products and processes in business markets where an adaptation or incremental improvement constitutes innovation generation. This notion of continuous improvement is consistent with marketing theories ofinnovation (Wind and Mahajan 1997).Continuous improvement and innovation generation call for adaptive learning (Tyre and von Hippel 1997) for those involved in both generating and using the innovation in the business market. Something is tried, its results observed, the approach is modified and something better is tried and, as a result, technological development takes placeand successive innovations are generated. As we will argue, the process of adaptive learning takes place through interactions and situated learning involving both the buyer and seller and other organizations.

This paper discusses innovation generation within an S curve and use the definition given by Christensen (1997) as the basic working definition i.e. "the processes by which an organization transforms labor, materials and information into products and services of greater value" p xiii. These processes are in turn a reflection of the know-how of the people involved within and between organizations. More importantly all processes take place in the context of an organization where value is added before the product or service moves to the next point in the supply chain within a business market. Technology thus, operates in a context and is examined next.

Innovation generation in business markets involves adaptations and improvements along an "S" curve of technology, within existing buyer seller relationships. These include changes in the product itself and other associated processes like delivery, information exchange. The construct captures the changes made in terms from previous situations, the greater the change, greater the innovation generation. The domain of innovation generation in business markets excludes new technology, product ideas that the supplier or buyer may provide to each other. The items used here are perceived changes made by the customer to adapt the suppliers' product and the changes supplier makes to adapt to customer requirements. These include changes in product, production process, production schedules, technical information, quality control procedures and changes unique to each other. The technical advise by supplier items in the IMP questionnaire appear together with the changes and adaptations made by supplier. However, upon factor analysis, these

two factors appear distinctly different and are accordingly classified.

Table 1 Innovation Generation: Pool of items chosen for refining

Section and No.	IMP Sup13 Database Code	Question	Scale

I.2-20
 	
20.1
20.2
20.3
20.7
 	
20.9
	
	CHCFINP
	CHCPPROC
	CHCPSCHE
	CHCTEXCH
	
	CHCQUALC
		Changes your <u>customer</u> has made in order to adapt to yourselves or to your product regarding:
		
		- his final product?
		-his production processes (techniques)?
		-his production schedules?
		
		-the technical information exchange(documentation, training, staff assignment etc.)?
		-his quality- control procedures?
			1 = none
			2 = small, e.g.
			   only minor
			   investments in
			   the relationship
			   are made
			3 = neither small
			   nor large, e.g.
			   some investments
			   are made
			4 = large, e.g.
			5 = very large,

I.2-22	CHANGE_C (Reverse Coded)	To what extent are the changes the customer has made unique to you or similar to those he has made with regard to other suppliers?	1 = unique 2 = rather uncommon 3 = neither nor 4 = rather common 5 = standard procedure

I.2-23
 	
23.1
23.2
 	
23.3
23.4
23,5
23.6
23.7
23.8
23.9
23.13
	
	CHS_PMOD
	CHS_PDEV
	
	CHS_PCAP
	CHSPPROC
	CHSSTOCK
	CHS_DEL
	CHS_TADV
	CHS_MAINT
	CHS_TECI
	CHSQUALC
		Changes your <u>company</u> (or by the intermediary on your behalf) to adapt to the customer or its products or procedures,
		regarding :
		
		-product modification?
		-new product development for this customers sake?
		-your production capacity?
		-your production processes?
		-location of your own stocks?
		-your own delivery procedures?
		-your technical advisory service?
		-your maintenance service?
		-your technical information?
		-your quality control procedures?
			1 = none
			2 = small, e.g. only
			   minor investments
			   in the relationship
			   are made
			3 = neither small nor
			   large, e.g. some
			   investments are
			   made
			4 = large, e
			5 = very large, e.g.
			   the relationship
			   can only be
			   discontinued at
			   large costs

I.2-25	CHANGE_S (Reverse coded)	To what extent are the changes the customer has made unique to you or similar to those you have made with regard to other suppliers?	1 = unique 2 = rather uncommon 3 = neither nor 4 = rather common 5 = standard procedure

Table 2 Innovation Generation: Missing Values, Skewness and Communalities

Item Description	Missing	Commun-alities	Factor Loading-Varimax Rotation
Technical Advisory Services by Supplier (IGCHSTEC)			
-technical advisory service (CHS_TADV)	3	.863	81
-maintenance service (CHS_MAINT)	39	.794	76
-technical information(CHS_TECI)	12	.872	91
% of variance explained			15.09
Cronbach Alpha (Europe) 0.83 Cronbach Alpha (China) 0.96			
Changes Made by Supplier to adapt to customer product, procedures:	IGCHSDEV		
-product modification (CHS_PMOD)	3	.677	79
-new product development (CHS_PDEV)	2	.718	80
-production capacity (CHS_PCAP)	3	.652	52
-production process (CHSPPROC)	3	.634	59
-quality control procedures (CHSQUALC)	42	.527	53
**-location of stocks (CHSSTOCK)	6	.280	
**-delivery procedures(CHS_DEL)	2	.391	
% of variance explained			14.28
Cronbach Alpha (Europe) 0.84 Cronbach Alpha (China) 0.89			
Changes Made by Customer To Adapt to suppliers ' product:	IGCHCUST		
- the final product (CHC_FINP)	14	.511	51
-production process (CHCPPROC)	16	.613	70
-production schedules (CHCPSCHE)	23	.440	58
-technical information exchange including documentation ,staff training(CHCTEXCH)	17	.497	40
-quality control (CHCQUALC)	59	.492	
% of variance explained			10.23
Cronbach Alpha (Europe) 0.75 Cronbach Alpha (China) 0.91			
Total Variance Explained by the four factors (%)			50.18
Goodness of Fit Measures for factor analysis: Chi Square: 118.56; Degrees of Freedom: 74; Significance: 0.001			
Unique Changes			
**Unique changes made by the customer compared to changes made for other supplier	78	.350	deleted
**Unique changes made by the supplier compared to changes made for other customer	72	.414	deleted

* High missing values hence deleted

** Low communalities hence deleted.

The Communalities for the original pool of items for Maximum Likelihood Factor Analysis were computed and since no items showed low communality none were deleted. As indicated with an asterisk in the table four items were **deleted** because of large numbers of missing values. Next Communalities were assessed and items marked ** were deleted for low communality #Factor Loading in two decimal places. As can be seen from the above table the Cronbach alphas are all acceptable for purposes of theory testing with the Chinese measures having higher Cronbach alphas than the European data.

Three summated scales are created Technical advice provided by supplier (IGCHSTEC), Technical and product development undertaken by supplier (IGCHSDEV) and Technical development undertaken by customer (IGCHCUST) by computing the mean of the items representing each factor. The correlations are examined below to establish the discriminant validity of the measures in the European Database.

Table 3 IG Discriminant Validity in European Database

	IGCHSTEC	IGCHSDEV	IGCHCUST
IGCHSTEC	1.000		
IGCHSDEV	.511	1.000	
IGCHCUST	.178	.258	1.000

Since the correlations are not high (below 0.6), we may infer that these constructs are conceptually distinct and different from each other.

Table 4 Correlation Matrix: Innovation Generation

S.No	Scale Item	1*	2**	3	4	5	6	7	8	13	14	15	16	17		Item to scale Correlation with:	Skew-ness
Technical Advisory Services by Supplier (IGCHSTEC)																IGCHSTEC	
1	-technical advisory service	2.55	1.29													0.87	0.27
2	-maintenance service	0.62	2.13	1.37												0.85	0.81
3	-technical information	0.79	0.78	2.50	1.29											0.88	0.37
Changes Made by Supplier to adapt to customer product, procedures (IGCHSDEV)																IGCHSDEV	
4	-product modification	0.33	0.19	0.31	2.66	1.39										0.80	0.68
5	-new product development	0.22	0.20	0.29	0.70	2.39	1.45									0.83	0.72
6	-production capacity	0.34	0.45	0.47	0.38	0.42	1.78	1.11								0.76	0.65
7	-production process	0.39	0.25	0.29	0.42	0.42	0.58	1.57	.94							0.77	0.63
8	-quality control procedures	0.46	0.37	0.47	0.46	0.40	0.40	0.43	2.12							0.74	0.53
Changes Made by Customer To Adapt to suppliers ' product (IGCHCUST)																IGCHCUST	
13	- the final product	-0.06	0.26	0.19	0.04	0.03	0.13	0.04	0.11	1.60	1.00					0.68	0.51
14	-production process	-0.03	0.23	0.19	0.07	0.13	0.01	-0.14	0.08	0.29	1.76	1.14				0.76	0.61
15	-production schedules	0.03	0.11	0.20	0.08	0.10	0.27	0.10	0.09	0.34	0.48	1.79	1.13			0.76	0.44
16	-technical info-exchange	0.27	0.44	0.41	0.13	0.05	0.20	0.12	0.26	0.33	0.33	0.27	2.37	1.17		0.69	0.50
17	-quality control	-0.11	0.05	0.10	0.09	0.12	0.04	-0.05	0.38	0.24	0.36	0.24	0.23	1.90	1.12	0.69	0.49

*The diagonal from the vertical column no. 1 represents the mean value for each item in horizontal rows

** The diagonal from the vertical column no. 2 represents the standard deviation for each item in horizontal rows

Further development and implications of the research

Building on Roy, Sivakumar and Wilkinson (2004) this paper would attempt to try Structural Equation Modeling to test the structure of the Innovation Generation construct and examine the extent to which this construct is currently measured in the IMP questionnaire. Organizations would benefit from know the types of variables they may want to monitor when evaluation supplier performance so as to enhance innovation generation in buyer-seller relationships.

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