Knowledge Management in German Industry

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FINAL REPORT

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Zusammenfassung

Hintergrund und Ziele

Die Anforderungen an das Management von Wissen in der Industrie haben sich in den letzten Jahren massiv erhöht. Wissen ist zu einem wichtigen Aktivposten in allen Industriezweigen geworden, es wird zunehmend strategisch definiert, geschützt und gehandelt. Es ist eine wichtige Säule in Bezug auf die Innovationsfähigkeit unter den Bedingungen verschärften Wettbewerbs, beschleunigter Innovationszyklen und erhöhter Fluktuation von Mitarbeitern.

Während Wissensmanagement in vielen Fällen auf die interne, durch IuK-Technologien gestützte Verarbeitung von Wissensbeständen und Wissensflüssen beschränkt wird, sind die Herausforderungen, die sich aus der zunehmenden Bedeutung von Wissen für Unternehmen ergeben, wesentlich breiter. Sie erstrecken sich auf das Erfassen, Archivieren, Schützen, Bereitstellen und Teilen von Wissen generell, auf die Fähigkeit, Wissen von außerhalb der Firmen aufzunehmen und es in den internen Wissensfluss und Wissensbestand zu integrieren, auf die dazu notwendige Veränderung von Einstellungen und Kenntnissen von Mitarbeitern. Im Idealfall begegnen Unternehmen diesen Herausforderungen strategisch, in dem sie die unterschiedlichen Ebenen und Herausforderungen systematisch verknüpfen und die Vielfalt der Maßnahmen im Hinblick auf ihre Kohärenz und spezifischen Markt- und Umfeldbedingungen der Unternehmen steuern.

Die vorliegende Studie trägt diesen breiten Anforderungen Rechnung. *Wissensmanagement (WM)* wird breit definiert und beinhaltet *jede Aktivität, die das Erlangen, das Nutzen und das Teilen von Wissen in Ihrem Unternehmen umfasst.* Diese Breite des Wissensmanagement wurde durch einen Katalog von 19 Praktiken erfasst, welche in die vier Kategorien *Kommunikation* (insbesondere IuK-Aktivitäten), Personalmanagement, Strategie und Policies zur Ausgestaltung von Wissensmanagement und schließlich die *Absorption* von Wissen von Quellen außerhalb der Unternehmen gruppiert werden können.

Das Ziel dieser Studie ist die Untersuchung von *Nutzung*, *Motivation*, *Effekten* und *Institutionalisierung* von Wissensmanagement in der deutschen Wirtschaft. Sie ist Teil einer breiten internationalen Initiative der OECD, welche zum langfristigen Ziel hat, das Wissensmanagement international vergleichbar zu erheben. Die deutsche Studie ist dabei mit wenigen anderen Ländern (insbesondere Canada, Irland) Vorreiter.

Während sich die für alle teilnehmenden Länder bindende OECD-Untersuchung den generellen Aspekten des Wissensmanagement widmet, setzt die deutsche Studie einen zusätzlichen *speziellen Schwerpunkt* beim Aspekt der *Aneignung von Wissen*

von Quellen außerhalb der Unternehmung, und zwar insbesondere in Bezug auf Wissen, das unmittelbar für die Innovationsaktivitäten der Unternehmen eingesetzt wird (technologisches Wissen). Dieser Schwerpunkt ist darin begründet, dass die *große Bedeutung* von *externen Innovationsquellen*, insbesondere auch der Wissenschaft, für deutsche Unternehmen empirisch belegt ist, dass aber die *Fähigkeit und Aktivitäten* der Unternehmen, dieses Wissen *produktiv aufzunehmen*, noch nicht breit erhoben und analysiert worden sind.

Die Untersuchungsfragen der Studie lauten wie folgt:

(a) Wie verbreitet ist die *Nutzung* der verschieden WM-Praktiken?
(b) Welche *Motive* liegen dem Wissensmanagement zu Grunde, welche Typen von WM gibt es?
(c) Welche *Effekte* werden der Nutzung von Wissensmanagement zugeschrieben, und wie wirken Praktiken, Motive und Effekte zusammen?
(d) *Institutionalisierung*: In welcher Form ist WM finanziell und oder organisatorisch verankert und welche Bedeutung hat diese Verankerung für die Performance des WM?
(e) Welche Bedeutung hat WM für die *Innovationsaktivitäten*? Insbesondere: welche Praktiken werden in welchem Ausmaß genutzt, um der zunehmenden Bedeutung von externem Wissen für die Innovationsaktivitäten Rechnung zu tragen und welche Effekte sind zu beobachten?

Ansatz und Sample der Untersuchung

Die Untersuchung basiert auf einer schriftlichen Befragung in sieben Wirtschaftssektoren, auf die 497 Unternehmen antworteten[1]. Aus der folgenden Übersicht ergibt sich die Verteilung der verschiedenen Sektoren und Größenklassen.

1 410 weitere Unternehmen beantworteten einen kurzen sogenannten Non-Response Fragebogen, welcher nach dem Verständnis des Wissensmanagement und den Gründen für die Nichtteilnahme fragte.

Übersicht 1: Das Untersuchungssample nach Sektoren

Sektor	***N***	***Sample***	***Anteil (%)***
Chemische Industrie (ohne Pharmazie und Biotechnologie)	409	**48**	9.66
Pharmazie	344	**31**	6.24
Biotechnologie	612	**76**	15.29
Maschinenbau	395	**51**	10.26
Fahrzeugbau	394	**36**	7.24
Elektrotechnik	614	**61**	12.27
Dienstleistungen (unternehmensbezogen)	727	**160**	32.19
Keine Sektorangabe		**34**	6.84
Gesamt	*3495*	***497***	*100*

Übersicht 2: Das Untersuchungssample nach Größe (Mitarbeiter)

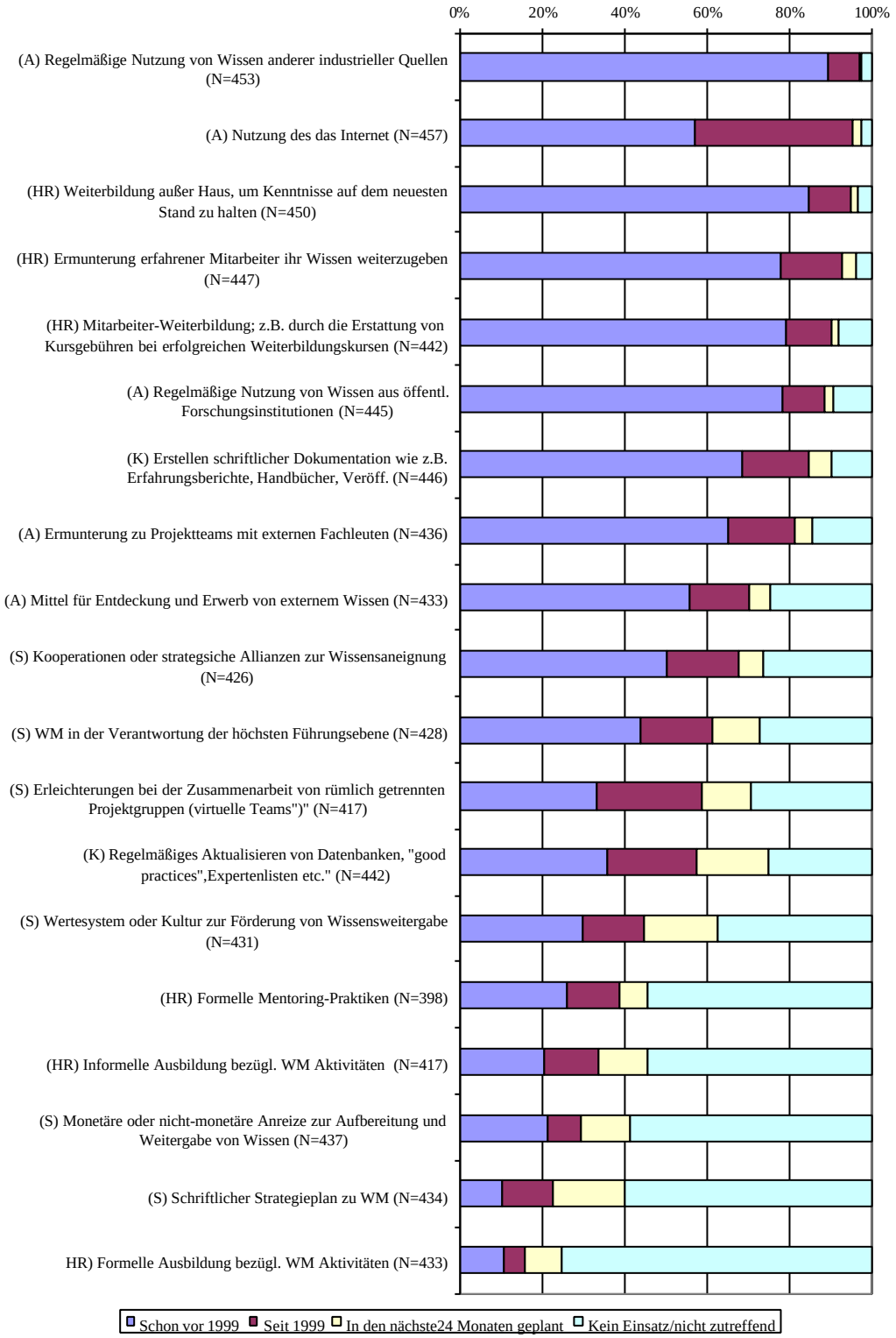
Größe	***1-49***	***50-249***	***250-1999***	***2000+***	***ohne Angabe***	***total***
Anzahl	121	150	139	64	23	*497*
Anteil	24,35	30,18	27,97	12,88	4,67	*100*

Wissensmanagement generell: Nutzung, Motivation und Effekte

WM ist eine horizontale Aufgabe, die sich in vielen unterschiedlichen Praktiken niederschlägt. Auch die Antworten derjenigen Unternehmen, die sich an der Befragung nicht beteiligen wollten, bestätigen, dass die Verengung des Wissensmanagements auf IuK-basierte Prozesse nicht zeitgemäß ist. Übersicht 3 auf der nächsten Seite zeigt die Nutzung der verschiedenen abgefragten Praktiken und gibt auch den Anteil der Unternehmen wider, die die jeweilige Praxis erst seit 1999 nutzen oder diese in der Zukunft einsetzen wollen. Für eine systematisch vergleichende Analyse wurden die unterschiedlichen Praktiken in vier Cluster eingeordnet, welche jeweils in Übersicht drei in Klammern angegeben werden: Absorption von Wissen (A), Kommunikation (K), Personalmaßnahmen (HR), Strategische Maßnahmen (S).

Im Durchschnitt nutzen die Unternehmen des Samples 11,6 der 19 WM-Praktiken. Dabei sind die Praktiken der Absorption von Wissen generell am weitestenverbreitet, gefolgt von Praktiken der Kommunikation (Datenbanken etc.) und des Personalmanagements. Am wenigsten verbreitet sind strategische WM-Maßnahmen wie die Aufstellung systematischer WM-Strategien oder das Setzen von WM-Anreizen. Das darin deutlich werdende Muster ist erstaunlich stabil über die verschiedenen Sektoren und Größenklassen. Für die Mehrzahl der Praktiken ist dabei festzustellen, dass sich der Gebrauch insbesondere in den letzten Jahren erhöht hat und nach Planungen der Unternehmen weiter erhöhen wird.

Übersicht 3: Verbreitung von Praktiken des Wissensmanagement (in %)



a: N bezeichnet die Anzahl der Unternehmen, die beim jeweiligen Item geantwortet haben. Index in Klammern bezeichnet die Zuweisung des Instruments zu vier Clustern von Praktiken: A = Absorption, HR = Human Resource, K = Kommunikation, S = Strategie.

Quelle: Fraunhofer ISI Umfrage 2002

Trotz einer dynamischen Zunahme bei der Verbreitung der meisten Praktiken zeigt es sich, dass eine stabile Minderheit, in einigen Fällen sogar eine Mehrheit der Unternehmen, auch in Zukunft auf viele der Praktiken verzichten wird. Insbesondere das Verständnis, dass WM eine strategische Führung brauchen könnte, hat sich noch nicht breit durchgesetzt.

Auch wenn das Muster der Verteilung für alle Größenklassen relativ ähnlich ist, so gilt im Grundsatz, dass *mit zunehmender Größe* auch *die Anzahl* der genutzten Praktiken *zunimmt*. Es sind vor allem die größeren Unternehmen, die in ihrer Mehrzahl WM auch schon strategisch begreifen. Die durchschnittliche Anzahl und die Reihenfolge der Praktiken ist bei den *verschiedenen Sektoren* ebenfalls *sehr ähnlich*. Zwei Sektoren heben sich etwas ab: die Dienstleistungsunternehmen nutzen WM-Praktiken etwas stärker, die Maschinenbauunternehmen etwas schwächer. Eine Annahme der Studie, wonach wissensintensivere Sektoren WM-Aktivitäten breiter nutzen, trifft nicht zu. Allerdings ist die Art und Schwerpunktsetzung bei diesen Unternehmen insbesondere hinsichtlich der Aneignung von Wissen eine etwas andere (s.u.).

Die relativ geringe Verbreitung von strategischem WM geht einher mit einer *gering ausgeprägten finanziellen und/oder organisatorischen Verankerung von WM* in den Unternehmen. Nur 25% der Unternehmen haben ein spezifisches WM-Budget bzw. eine für das WM hauptverantwortliche, zentrale Funktion oder Organisationseinheit. Es gilt wiederum, dass die großen Unternehmen WM stärker organisatorisch verankert haben als die kleinen. Die kleinen Unternehmen haben dagegen, auch aus strukturellen Gründen, die Verantwortung für WM direkt beim Top Management angesiedelt. Obwohl die sehr großen Unternehmen sehr viele Praktiken Nutzen, haben über die Hälfte von ihnen keine Top Managementfunktion für WM.

Zur Bestimmung der wichtigsten Gründe für das Wissensmanagement wurden die Unternehmen nach der Bedeutung von 19 Motiven gefragt. Übersicht 3 gibt die Rangfolge der Motive wider. Am *wichtigsten* ist offensichtlich *die interne Weitergabe und Integration von Wissen*. Danach folgt als zweit wichtigster Impuls ein eher defensiver, nämlich die Identifizierung und der Schutz von Wissen. Dies zeigt die zunehmende strategische Bedeutung von Wissen und die Probleme, die durch die Fluktuation von Wissensträgern entstehen. Ein drittes Bündel von Motiven des industriellen Wissensmanagements betrifft die Aus- und Weiterbildung der Mitarbeiter. Von geringerer Bedeutung ist dagegen die Notwendigkeit, Wissen mit externen Partnern zu teilen. Diese grundsätzliche Motivationsstruktur ist für die Größenklassen und (bis auf wenige Ausnahmen) die Sektoren erstaunlich gleichläufig.

Übersicht 4: Rangfolge der Motive zum WM, abnehmende Wichtigkeit

Motive	Top Two[a]	Mittel-wert
Weitergabe von Wissen an neue Mitarbeiter verbessern (N=449)	91	1.64
Wissen in Ihrem Unternehmen besser integrieren (N=450)	86	1.75
Unternehmen vor Wissensverlust durch Mitarbeiter-Weggang schützen (N=450)	82	1.77
Führungskräfte ermuntern, das Teilen von Wissen als Instrument zu nutzen (N=447)	80	1.91
Das strategische Wissen im Unternehmen identifizieren und/oder schützen (N=442)	77	2.00
Mitarbeiter ausbilden, ihre eigenen Fähigkeiten fortzuentwickeln (N=448)	76	1.95
Erleichterungen bei der Zusammenarbeit von Projektgruppen (N=359)	75	2.03
Das nicht dokumentierte Wissen der Mitarbeiter erfassen (N=437)	75	2.06
Mitarbeiter auf strategische Ziele ausrichten (N=447)	69	2.29
Wissen von außerhalb der Unternehmung besser erfassen und anwenden (N=440)	68	2.21
Unterstützung bei der Konzentration auf wesentliche Informationen (N=446)	67	2.28
Sicherstellen des Wissenstransfers aus/in alle Niederlassungen (N=299)	67	2.22
Mitarbeiter-Akzeptanz von Innovationen steigern (N=437)	65	2.30
Probleme des Informationsüberflusses im Unternehmen vermeiden (N=430)	59	2.45
Weitergabe bzw. Transfer an Kunden oder Auftraggebern fördern (N=418)	47	2.92
Integration nach Unternehmenskauf oder –zusammenschluss (N=279)	47	2.75
Weitergabe von Wissen an Partner in strategischen Allianzen verbessern (N=336)	37	3.05
Weitergabe bzw. Transfer mit Zulieferern fördern (N=383)	36	3.07
Auf dem Laufenden bei WM-Praktiken von Wettbewerbern sein (N=410)	31	3.23

Skala: 1: sehr wichtig, 6: völlig unwichtig
a: Prozentzahl der Unternehmen, welche mindestens einen Wert von 2 angegeben haben.
Quelle: Fraunhofer ISI, Umfrage 2002

Die Motivationsstruktur macht eine gewisse Spannung deutlich: Zum einen nutzen die Unternehmen aus Gründen der Effizienzgewinne viele Praktiken zur Absorption (s.o.). Zum anderen sind viele Unternehmen davon getrieben, ihr Wissen intern zu bündeln, intern zu halten und zu schützen und sind nur gering dadurch motiviert, Wissen mit externen Partnern zu teilen. Dieser zweite, eher defensive Modus scheint zu überwiegen. Ein intensiverer Austausch von Wissen, wie er in der Zukunft wichtiger zu werden verspricht, bedarf allerdings eine Kultur der Offenheit, insbesondere die Bereitschaft, eigene Wissensströme zu öffnen, um selbst Wissen anderer internalisieren zu können.

Die Effekte des Wissensmanagement wurden, mangels etablierter Messverfahren, durch eine Einschätzung der Unternehmen selbst ermittelt. Vier Gruppen von insgesamt neun Effekten wurden abgefragt. WM ist am erfolgreichsten in Bezug auf die Effekte am Markt und die Fähigkeiten der Mitarbeiter, während die direkt auf das WM selbst bezogenen Effekte (organisatorisches Gedächtnis, Absorption) schwächer ausfallen. Die schwachen Absorptionseffekte treffen insbesondere auf die Unternehmen der Chemie und des Maschinenbaus zu, während die Biotechnologie-

und Pharmaunternehmen hier effektiver sind. Angesichts der zahlreichen Praktiken zur Aneignung von Wissen sind diese geringen Effektivitätswerte erstaunlich und lassen Raum für Verbesserungsmöglichkeiten.

Übersicht 5: Effekte des Wissensmanagement

Art des Effekts	**Effekt**	**Top Two[a]**	**Mittel-wert**
Markt	Verbesserung der Anpassung unserer Produkte oder Dienstleistungen an Kundenwünsche (N=432)	73	2.07
Human Resource	Verbesserung von Kenntnissen und Wissen der Mitarbeiter (N=442)	73	2.08
Human Resource	Steigerung der Mitarbeiter-Effizienz oder Produktivität (N=436)	69	2.12
Markt	Besser neue Produkte oder Dienstleistungen hinzufügen (N=417)	61	2.34
Markt	Verbesserung der Beziehungen zu Kunden bzw. Zulieferern (N=417)	59	2.38
Org. Gedächtnis[b]	Verbesserung des "organisatorischen Gedächtnisses" unseres Unternehmens (N=413)	57	2.47
Org. Gedächtnis[b]	Vermeidung von doppelter Arbeit bei Forschung und Entwicklung (N=391)	53	2.55
Absorption	Verbesserung der Aneignung von Wissen aus anderen industriellen Quellen (N=434)	51	2.56
Absorption	Verbesserung der Aneignung von Wissen aus öffentlichen Forschungsinstitutionen (N=415)	38	2.87

Skala: 1: sehr effektiv, 6: völlig unwirksam.

a: Prozentzahl der Unternehmen, welche den Effekt mindestens mit 2 bewerteten.

b: Org. Gedächt. = Organisatorisches Gedächtnis

Quelle: Fraunhofer ISI Umfrage 2002

Die Anzahl der Praktiken, die die Unternehmen einsetzen, korreliert mit der Wirksamkeit, es zahlt sich also aus, breite Ansätze des Wissensmanagement einzusetzen. Die wichtigste Bedeutung für die Gesamteffektivität von WM haben die strategischen Maßnahmen, die Bedeutung von systematischen Ansätzen des WM kann nicht hoch genug eingeschätzt werden. Auch die Institutionalisierung des WM wirkt auf die Effekte mit einer Ausnahme positiv. Diese Ausnahme allerdings ist wichtig: eine zentrale WM-Einheit wirkt sich *negativ* auf die Fähigkeiten zur Absorption von Wissen aus, da sie die Austauschmöglichkeiten und –häufigkeiten tendenziell verringert, indem sie den Mitarbeitern diese Aufgabe abnimmt.

In Bezug auf die *Institutionalisierung* und organisatorische Ausgestaltung gibt es also *Verbesserungsmöglichkeiten*, die genutzt werden sollten. Dies umso mehr, da es einen klaren Zusammenhang zwischen WM-Aktivitäten einerseits und der Innovationsfähigkeit andererseits gibt. Produkt- und Prozessinnovatoren nutzen in der Regel wesentlich mehr WM-Aktivitäten als Nicht-Innovatoren. Insbesondere nutzen sie häufiger Praktiken zur Aufbereitung und Kommunikation von Wissen und sind wesentlich aktiver bei der Absorption von Wissen.

Aus den Ergebnissen der Studie zum *allgemeinen Wissensmanagement* lassen sich eine Reihe von Schlussfolgerungen ziehen:

- WM muss angesichts der starken Bedeutung von systematisch-strategischen Ansätzen stärker in den Fokus der Unternehmensführung rücken. Eine verantwortliche Führungsfunktion müsste insbesondere die unterschiedlichen Aktivitäten miteinander verknüpfen, eine offene Kultur des Austauschs von Wissen etablieren, Anreizsysteme schaffen und eine geeignete Abstimmung zwischen zentralen und dezentralen Aufgaben herstellen.
- Die eher defensiven Modelle des Wissensmanagement, die die interne Nutzung und den Schutz nach außen in den Vordergrund stellen, könnten in Zukunft bei der Integration externen Wissens Probleme bekommen. Strategische Optimierung von Patentportfolios und Schutzrechtsbestimmungen, die diese begünstigen, müssen auch vor dem Hintergrund der Folgen für den internen und externen Wissenstransfer überdacht werden.
- WM-spezifische Aus- und Fortbildungsmaßnahmen sind nur in einer Minderheit der Unternehmen zu finden. Das Personalmanagement muss einen weiteren Fokus in die Aus- und Weiterbildung aufnehmen, nämlich die Ausbildung von solchen Fähigkeiten, die zu einer aktiven Gestaltung von WM-Aufgaben benötigt werden.
- Angesichts breiter Anwendung von Absorptionspraktiken einerseits und geringer Effektivitätswerte andererseits müssen die zum Teil seit Jahrzehnten bestehenden Praktiken der Aufnahme von externem Wissen überdacht werden (siehe den nächsten Teil der Zusammenfassung).
- Insbesondere für kleinere Unternehmen und für Unternehmen der traditionellen Sektoren (Fahrzeuge, Maschinenbau) könnten politische Maßnahmen zur Unterstützung des Aufbaus von Bewusstsein und der Verbreitung von „good practice“ zum systematischen Aufbau von WM beitagen. Der Vorsprung, den die sehr großen Unternehmen dabei schon haben, könnte zu einem weiteren immanenten strukturellen Nachteil für KMU werden.
- Grundsätzlich muss strategische Unternehmensführung und unterstützende Politik dort, wo man einem engen, auf IuK-Technologien konzentrierten Verständnis des WM verhaftet ist, breitere Perspektiven einnehmen oder zumindest integrieren.

WM zur Absorption von externem, technologischen Wissen

Die Studie legt einen besonderen Schwerpunkt auf die Untersuchung der Absorption von *externem* Wissen, das als *technologisches Wissen (im Gegensatz zum Marktwissen)* in die Innovationsprozesse der Unternehmen einfließt. Grund hierfür ist, dass das Management dieser Prozesse bisher empirisch unterbelichtet scheint, obwohl es eine – zunehmende – Bedeutung im Innovationsprozess von Unternehmen spielt.

Die Analyse bestätigt zunächst die überragende und weiter zunehmende Bedeutung von externem Wissen. Dabei sind für das hier besonders interessierende *technologische* Wissen externe Quellen noch wichtiger als für das Wissen über den Markt. Diese Bedeutung ist für alle Größenklassen und Sektoren zutreffend, ist in den Sektoren Pharmazie und Elektrotechnik allerdings besonders ausgeprägt.

Das wichtigste Motiv für die Aneignung externen technologischen Wissens ist die zunehmende Geschwindigkeit von Innovationszyklen, gefolgt von dem Mangel an eigenen Kapazitäten zur Generierung des notwendigen Wissens in-House. Etwas weniger wichtig sind die eigentlichen Kosten der internen Erstellung sowie die Tatsache, dass das benötigte Wissen zu spezifisch oder zu breit zur eigenen Erstellung ist. Letzt genannter Grund ist insbesondere für die KMU von Bedeutung, die häufig über ein sehr konzentriertes Wissens und Technologieportfolio verfügen.

Hinsichtlich der Aneignung externen technologischen Wissens sind die einzelnen Sektoren relativ unterschiedlich motiviert. Vom skizzierten allgemeinen Muster weichen der Elektroniksektor (Geschwindigkeit mit weitem Abstand am wichtigsten), der Fahrzeugsektor (Mangel an genügend eigenen Kapazitäten) und der Pharmaziesektor (Kosten eigener Erstellung) am deutlichsten ab.

Die Quelle zur Absorption sind vielfältig. Am häufigsten werden gedruckte und elektronische Quellen genutzt. Von den Organisationen, welche nicht mit dem eigenen Unternehmen verbunden sind, sind nach Einschätzungen der Unternehmen Forschungseinrichtungen, insbesondere Universitäten, am *wichtigsten*, wenngleich andere Firmen als Quelle häufiger genutzt werden. Dies passt auf existierende empirische Befunde, wonach zwar der Anteil der Unternehmen, die andere Unernehmen als Wissensquelle nutzen, am größten, die Bedeutung für den Innovationserfolg allerdings bei den Nutzern der Quelle „Wissenschaft“ am stärksten ist.

Innovationserfolg wird im Rahmen dieser Studie daran gemessen, wie groß in den letzen drei Jahren der Anteil des Umsatzes mit neuen oder merklich veränderten Produkten war. Ist dieser Anteil größer als 10 Prozent, wird ein Unternehmen als *Innovator* definiert. Die Ergebnisse der Studie zeigen, dass nicht so sehr die Häufigkeit, mit der Unternehmen externe Quellen nutzen, die Wirkung für Innovationen bestimmt, sondern die *Art der Nutzung*. Der Anteil der Innovatoren ist in den Gruppen von Untenehmen, welche sich ihr Wissen entweder durch *vollständige Internalisierung* (Aufkauf von Firmen, Einstellung von Experten) oder in *direkten Kooperationen* aneignen, wesentlich höher als bei den Unternehmen, welche dokumentiertes Wissen aufnehmen.

Die größten Hindernisse zur Aneignung externen Wissens liegen nach Angaben der Unternehmen *innerhalb* der Unternehmen und beruhen hauptsächlich auf der *Furcht des Verlusts eigenen Wissens* und auf *unzureichenden internen Prozessen*, insbesondere hinsichtlich der *Informationsgewinnung über das externe Angebot* an

relevantem Wissen. Die *Schwierigkeiten*, die die Unternehmen dagegen auf *der Seite der Anbieter des Wissens* am Markt (andere Unternehmen, öffentliche Forschungseinrichtungen) ausmachen, sind *geringer*. Bezogen auf die Sektoren sind es wiederum die Unternehmen des Fahrzeug- und Maschinenbausektors, welche die größten Hindernisse sehen, insbesondere hinsichtlich ihrer internen Prozesse, während die Unternehmen der Biotechnologie und der Pharmazie insgesamt weniger starke Hindernisse beim Erwerb externen Wissens ausmachen.

Gemäß der Selbsteinschätzung der Unternehmen ist das Wissen über das externe Angebot von technologischem Wissen in Deutschland bei etwa 60% aller Firmen ausreichend. Der Wissenstand steigt wiederum mit der Größe der Unternehmen an, und auch sektoral sind die Unterschiede zum Teil beträchtlich. Insbesondere Biotechnologieunternehmen und Unternehmen des Chemiesektors sind besser informiert, während Firmen des Fahrzeugsektors wesentlich weniger über externe Quellen informiert sind. Lediglich zwei Sektoren wissen mehr über externe industrielle Quellen als über öffentliche Forschungsinstitute, ein weiteres Indiz für die Bedeutung der öffentlichen Forschung für die Absorption von Wissen.

Eine Ausgangsvermutung der Studie, wonach es sich auszahlt, über das Angebot externe Wissensanbieter informiert zu sein, ist bestätigt worden. Der *Anteil der Innovatoren*, welche angeben, über das externe Angebot in öffentlichen Forschungseinrichtungen und bei privaten Firmen *ausreichend informiert zu sein*, ist *signifikant höher* als bei den Unternehmen, die kein ausreichende Informationen zum Wissen außerhalb ihrer Unternehmung haben.

All das bisher Gesagte hängt bei allen Unternehmen davon ab, welche spezifischen Praktiken sie zum Management des externen technologischen Wissens installiert haben und nutzen. Neben der allgemeinen Frage nach dem Vorhandensein von Innovationsstrategien wurden hierbei vier Praktiken abgefragt: Prozesse zur *Entdekkung externen Wissens*, Vorhandensein einer *spezifischen Managementeinheit*, sowie Prozesse zur Definition von *kurzfristigem* und *langfristigem* Bedarf an externem Wissen.

Im Gegensatz zu allgemeinen WM-Praktiken sind diese Praktiken wesentlich schwächer verbreitet. Lediglich die Bestimmung kurzfristigen, projektspezifischen Bedarfs wird von über der Hälfte der Unternehmen regelmäßig durchgeführt. Dagegen wird die systematische Definition von langfristigem Bedarf lediglich von einem Fünftel der Unternehmen betrieben. Auch hier gilt wieder, dass große Unternehmen stärker aktiv sind als kleinere, 70% der großen Unternehmen informieren sich systematisch über das relevante Angebot externen Wissens und 50% definieren langfristigen Wissensbedarf. Nicht nur bei den sehr kleinen, auch bei der Mehrzahl der Unternehmen mit bis zu 2000 Mitarbeitern hat die Bedeutung von externem technologischen Wissen noch nicht zu entsprechenden Maßnahmen geführt. In dieser

Dimension des Wissensmanagement sind die strukturellen Vorteile – oder das größere Bewusstsein – der ganz großen Unternehmen am augenfälligsten.

Angesicht der Tatsache, dass nahezu alle Unternehmen angeben, dass externes Wissen wichtiger werden wird, sind diese Zahlen kritisch. Dies wird deutlich, wenn man sich die Effekte der Nutzung dieser spezifischen Managementpraktiken vergegenwärtigt. Es gibt einen signifikanten Zusammenhang zwischen der Nutzung dieser Praktiken und der Performance der Unternehmen. Während die Häufigkeit der Nutzung externer Quellen sehr geringe Auswirkungen hat, sind die Unternehmen, die die spezifischen Praktiken zum Management externen Wissens anwenden, besser informiert über externe Quellen, sehen weniger starke Hindernisse zum Erwerb, weisen insgesamt auch in den anderen Dimensionen des Wissensmanagements eine höhere Effektivität auf und sind häufiger Innovatoren. Den wichtigen Zusammenhang zwischen spezifischen Instrumenten des Managements externen technologischen Wissens und der Innovationsaktivitäten von Unternehmen zeigt Übersicht 6.

Übersicht 6: Innovationseffekte von ausgewählten Maßnahmen des WM

Anteil der Innovatoren an...

...dem gesamten Sample	40.8%
den Gruppen des Samples, welche	
...eine explizite Innovationsstrategie haben ***	54.1%
...eine explizite Strategie des Wissensmanagement haben***	54.0%
...Praktiken zur Bestimmung des langfristigen Bedarfs an externem Wissen anwenden**	51.2%
...Praktiken zur Bestimmung des kurzfristigen Bedarfs an externem Wissen anwenden **	47.6%
...eine Einheit bzw. Managementfunktion bzgl. externem technol. Wissen haben***	47.2%
...sich systematisch über das relevante Angebot externen technol. Wissens informieren*	46.7%

* signifikant auf dem 10% Niveau, ** dem 5% Niveau, *** dem 1 % Niveau

Quelle: Fraunhofer ISI Umfrage 2002

Zusammengefasst heißt dies, es ist nicht die Häufigkeit, sonder die Art (Interaktion, Internalisierung) und Qualität (strategischer Fit durch spezifische strategische und operative Maßnahmen) der Aufnahme von externem Wissen, die die Effektivität der Absorption bestimmt.

Viele Unternehmen fangen an, diese Zusammenhänge besser zu verstehen und darauf zu reagieren. Der Anteil derjenigen, die erst seit wenigen Jahren adäquate Managementmethoden einsetzen bzw. planen, dies in der Zukunft zu tun, ist verglichen zu den Nutzern relativ hoch. Aber auch hier gilt, dass – mit Ausnahme der sehr großen Unternehmen – über die Hälfte der Unternehmen noch nicht in diesen Kategorien planen. Hier liegt ein wesentlicher Grund dafür, dass die Aktivitäten der Absorption zwar sehr stark verbreitet sind, ihre Effektivität aber als sehr niedrig bewertet wird (s.o.).

Die Schlussfolgerungen aus diesen spezifischen Betrachtungen zur Absorption von technologischem Wissen sind wie folgt:

- Da die intelligente Nutzung externer Wissensquellen den Innovationserfolg verbessert, müssen die Fähigkeiten zur Absorption stärker in den Mittelpunkt von unternehmerischen Strategien und auch unterstützenden Politikmaßnahmen rükken. Die Hindernisse sind mindestens so stark in den Unternehmen zu finden wie auf der Seite der Wissensanbieter.
- Die Unternehmen müssen sich noch stärker die Bedeutung der Form der Internalisierung externen Wissens bewusst machen. Da die effektivste Form, die volle Internalisierung von Wissen durch Aufkauf oder Einstellungen, nur in Ausnahmefällen möglich sein wird, ist die vielversprechendste Form die direkte Kooperation mit Wissensanbietern.
- Die Wissenskultur in Unternehmen muss sich in vielen Fällen stärker öffnen. Wissensaufnahme hat mit Wissensabgabe zu tun, die Furcht vor Verlust und die Konzentration auf den Schutz eigenen Wissens behindert eine effektive Aufnahme. Die Strategien zur Schutzmaximierung, die viele große Unternehmen in den neunziger Jahren aufgebaut haben, müssen vor diesem Hintergrund neu überdacht werden.
- Natürlich ist die Fähigkeit zur Aufnahme von Wissen ganz entscheidend auch von der Verfügbarkeit von ausreichend kenntnisreichen Mitarbeitern abhängig. Diese Stellschraube ist aber häufig nicht kurzfristig zu beeinflussen. Deshalb sollte – jenseits der Personalmaßnahmen – die aktuelle Tendenz, spezifische Maßnahmen zur Aufnahme externe Wissens stärker zu nutzen, über unterstützende politische Maßnahmen und Programme von Unternehmensverbänden auch in KMU getragen werden, und zwar in allen Sektoren. Dazu gehört insbesondere die Fähigkeit, den eigenen Bedarf langfristig abzuschätzen und das relevante Angebot richtig einschätzen zu können. Die Zentralisierung solcher Aktivitäten ist allerdings stärker auf die Unterstützung denn auf die Entmündigung der Mitarbeiter auszurichten, denn entscheidend ist der direkte Kontakt der Mitarbeiter.
- Politische Maßnahmen, die den Wissenstransfer von der Industrie in die Wissenschaft verbessern wollen, sollten auch weiterhin die Einstellung und die strukturellen Voraussetzungen auf der Seite der Wissensanbieter (Institute) verbessern und insbesondere direkte Kooperationen fördern. Allerdings sollte zu dieser Politik eine Wissensmanagementpolitik hinzutreten, die als horizontaler Ansatz die Bemühungen zur Verbesserung des Transfers von Seiten der Forschungsministerien mit Politikmaßnahmen – insbesondere aus Wirtschaftsministerien – ergänzt, welche an der Verbesserung der Absorptionsfähigkeiten, einschließlich Maßnahmen zu Management externen Wissens, ansetzen.

1. Introduction: Context and Scope

The notion of a knowledge-based economy points towards what has become the most important asset of OECD economies: knowledge. For some years now, international organisations such as the OECD and the EU have put knowledge and its management at the centre of many activities and analyses.[2] In order to systemise the knowledge on knowledge management (KM) within the OECD, the Centre for Educational Research and Innovation (CERI) of the OECD started an international study initiative in the year 2000.[3] The motivation for this initiative was based on the reflection that up till now too few internationally and intersectorally comparable data are available on how enterprises generate and productively implement knowledge and how they keep it permanently accessible. In addition, the studies which meanwhile exist use very diverging definitions and concepts concerning knowledge management and are for the main part based on case studies. The long-term goal of this OECD initiative will be to create for Knowledge Management (KM) – similarly as for „Innovation" (the Oslo Manual) and for „R&D" (the Frascati Manual) – a uniform, binding manual and thus to structure the international discussion on this subject.

This study is the German contribution to this international OECD undertaking, based on a survey in seven industrial sectors, including services. Therefore, its concept is to a large part the result of a moderation within the international study group of the OECD. The questionnaire used for the survey contains a core that was binding for all country studies. As the study is exploratory, the understanding of KM is broad and covers the usage of 19 rather diverse KM practices, as well as the motives for and effects and institutionalisation of KM.

In addition to this uniform core study, the study on hand goes beyond the OECD core and has integrated a series of questions that relate to a specific dimension of KM, i.e. the management of interfaces to capture knowledge from outside the company. To be sure, there are many aspects of KM that would deserve a deeper analysis. The motivation for the selection of this special focus stems from the fact that while the importance of external knowledge for the performance of industry as regards innovativeness and market success is well known meanwhile, not much systematic knowledge exists on how this sourcing across interfaces is managed. But if external knowledge, especially scientific and technological knowledge, has an impact on the performance, and if we share the premise that it becomes even more

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2 Most recently, the OECD organised a Global Forum on the Knowledge Economy (OECD 2002).

3 These empirical studies on knowledge management in enterprises are incorporated in wider activities of the OECD on the subject of knowledge management. They comprise among others high-level seminars, regular scientific activities of a „high level study group on knowledge management" and a systematic review of national education systems from the perspective of knowledge management.

important in the future, the management of it is a core pillar of knowledge management as well as of innovation management.

The following introducing chapters explain the meaning and concept of KM (1.1), present the objectives of the study (1.2) and point towards the related knowledge gaps on KM in German industry (1.3).

1.1. The growing meaning of knowledge and the new needs for knowledge management

To claim that the meaning of knowledge and its management has grown meanwhile is a commonplace. But in order to understand the importance of managing knowledge and to tailor appropriate analytical concepts, it is important to understand the major drivers for this enhanced meaning of knowledge. These drivers are of course numerous, and the relative weight of each of these drivers differs with the context of companies as well as with the concepts of knowledge and KM in mind. Without any implicit ranking, the major drivers for the enhanced meaning both of knowledge and its management that can be found in the literature are as follows:[4]

- We observe a growing stock and flow of knowledge that needs to be taken into account by decision-makers. Knowledge has become a commodity that is traded and transferred in numerous new ways. This not only necessitates the management of knowledge flows, but leads to the creation of new knowledge through re-combination (e.g. Cowan et al. 2000).
- There is not only greater demand to trade knowledge as a commodity, but this can be done with decreasing costs. Information and Communication Technologies (ICT) lower costs of knowledge storing, seeking, employing and transferring.
- The acceleration of the production of knowledge and shortening of product life cycles and related innovation cycles increases the pressure on the processing of knowledge.
- Due to increasing fluctuation in industry and the increasing mobility of knowledge workers, there is a growing danger of costly loss of knowledge and build-up of new knowledge in companies. It is therefore becoming more important to document knowledge and to make it available to newcomers.

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4 The literature on the meaning of knowledge has become abundant. The major drivers enumerated here are, among others, based on Cowan et al. 2000; OECD 1999, 2000, 2002, Worldbank 2002.

- The borders of organisations are changing more rapidly, mainly due to increased merger and acquisition activities. This leads to ever new demands to integrate existing knowledge stocks and to create new, integrated knowledge flows.
- The two preceding tendencies especially put pressure on the Human Resource Management (HRM) of companies, as the workforce must be enabled to manage, update and store the knowledge flow relevant to their work. Above all, individual knowledge needs to be transferred into organisational competencies in a sustainable way, i.e. not only the workers, but the organisation must take up and process the knowledge available.

The changing role of knowledge has, above all, severe implications for *innovation* and innovation management:

- Almost ten years ago, analysts observed a changing mode in the production of (technological) knowledge („mode 2"[5], Gibbons et al. 1994), characterised by heterogeneous interaction and hybrid interaction forms. This demands – among other things – openness of organisational knowledge production systems to the environment. Above all, appropriate organisational interfaces are called for that enable the members of an organisation to interact internally, as well as with outsiders. These interactions include especially the interaction between companies and research sources such as public research institutes.
- Generic technologies, most obviously ICT or nanotechnology, have led to a fusion of technological disciplines and knowledge areas, thus triggering new demands to integrate knowledge across a wide variety of knowledge areas and disciplines that used to be separate.
- Innovation must increasingly be understood as a re-combination of existing knowledge or as a consequence to utilise and exploit existing knowledge sources effectively (among others Foray/Gault 2002; Foray 2002). The transfer of knowledge as a commodity and the re-combination of knowledge leads to creation of new knowledge to foster innovation. This constructive process demands a management of the acquisition of knowledge, both from outside and from within companies. In addition, the economies of speed do *not allow* companies to generate in-house what already exists elsewhere. Moreover, as the complexity of technologies and the underlying scientific knowledge has grown, companies are *less and less capable* of generating all knowledge needed for the innovation process in-house, e.g. within their R&D departments and laboratories (Barabaschi 1993).

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5 Mode 1 production of knowledge refers to the traditional, more linear model of university-based, pure knowledge creation that diffuses through the system downstream and is, at the latest stage, applied to the market. In mode 2, by contrast, knowledge is produced largely as a result of demands expressed from the application side, it is transdisciplinary, entrepreneurial and embedded in networks (Gibbons et al. 194, see also OECD 1999, p. 61).

- It pays off to internalise external knowledge, and it is especially beneficial to use scientific knowledge. The consequence of the increased interlinkages between the innovative activities of companies and external knowledge providers have already been analysed on an aggregate level. Janz. et al. (2000) have analysed the meaning of four different sources for the innovation process in depth. They have impressively shown that the usage of external sources makes a difference as for the innovation and thus for the economic performance of companies. In the manufacturing sector, users of scientific knowledge have the highest market share with innovative products and – even more striking – expect employment and sales to grow by far the most compared to users of other sources. At the same time, the share of companies using science as a source is lowest as compared to other sources. Similar results are shown for the service sector, albeit to a lesser extent (Blind et. al. 2000, especially p. 49). Given these obvious effects of using external knowledge, the management of the processes to monitor and internalise external knowledge are crucial. The interface between companies and especially between companies and the science system need to be a major focus both of analysts and corporate strategists. A major objective must be the increase and optimisation of the usage of external knowledge for the innovation process.

What are the consequences of all this? In light of all these challenges – and opportunities – at different levels, a *comprehensive* knowledge management is necessary which must exceed the classical instruments like the maintenance of in-company databases, a well-functioning internal reporting system, and periodical further education/training measures. The aim must be to establish a self-renewing knowledge cycle that enables organisational learning and the exchange with the environment. It is increasingly necessary thereby to process the knowledge distributed throughout the whole enterprise and make it accessible to all employees, to minimise the loss of company knowledge through the increased fluctuation of personnel. Furthermore, the knowledge cycles in enterprises must constantly be fed by knowledge and ideas from outside the firm, just because of this broadening of the knowledge base for innovations. The generation of the total relevant technological knowledge can increasingly no longer be performed in a single enterprise on its own. The practices to absorb external knowledge – which have already been in existence for years, through Public Private Partnerships, cooperations, contract research, publications etc. – must be extended, systematised and made more effective, against this background (interface management).[6] This applies particularly to SMEs, which are confronted with similar technological challenges as the large enterprises but which can only enlarge their knowledge base to a certain extent autonomously, due to more limited capacity.

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6 For an early recognition see for example Barabaschi (1993): Managing the Growth of Technological Information; in: Rosenberg et al. (Ed.), Wealth of Nations; Stanford: Stanford University Press; pp. 407-434.

The obvious micro-economic necessity of an effective inter-face and knowledge management is accompanied by diverse macro-economic benefits. Potentials for cost savings lie for example in avoiding duplicated research, or in the multiple utilization of once financed knowledge gain, the cross-pollination of public research and industry, or in the minimisation of so-called „sunk costs“ through knowledge loss as a result of the flexibilisation of jobs. Even although numerous enterprises already have impressive knowledge management systems in place[7], it appears that the necessary awareness for comprehensively understood knowledge management can still be improved across the industrial spectrum as a whole (see among others Schmoch et al. 2000, Brockhoff 1999).

To sum up, „the capacity of firms, industries and countries to develop and manage knowledge assets is a major determinant of competitiveness and economic growth" (OECD 2002, p. 2). The consensus on that analysis both within the academic world and with policy-makers is overwhelming.[8] The empirical analysis of the meaning of knowledge and its management requires a definition of knowledge management that is able to capture its width and complexity, including the management of knowledge interfaces. Therefore, this study uses the broad definition of KM developed within the OECD core group according to which

knowledge management (KM) involves any activity related to the capture, use and sharing of knowledge by the organisation.

Above all, this broad definition means that KM for a variety of reasons not only relates to the management of codified information with the help of IT processes. ICT and ICT-related communication is important, but should not be misunderstood as the major or even sole dimension of KM. In addition, the importance of human resources as the carrier and transmitter of knowledge is growing, both as related to KM practices (training for KM), as well as other functional knowledge that needs to be shared with others. Finally, there are indications that, in order to cope with the growing dynamics and complexity of knowledge development, companies increasingly have to rely on knowledge that cannot – for reasons explained above – be produced within the company itself. In fact, in some cases the acquisition of external knowledge has been defined as crucial for the persistence of an efficient evolution and innovative capacity of companies.[9] It is crucial to learn if the companies

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7 Cf. e.g. the case studies in Mertens et al. (2001), Knowledge Management. Best Practices in Europe; Heidelberg: Springer-Verlag or Bach et al. (2000): Business Knowledge Management in der Praxis; Heidelberg: Springer.

8 To mention only a couple of key studies and analyses: OECD (1999), Leonard-Barton (1995), Prusak (1997), Davenport/Laurence (1998), de la Motte, J./Foray, D. (2001) Willke (1998), Den Hertog/Huizenga (2000), Calvo/Sancho Munoz 2002).

9 An early recognition of this was made by Barabaschi (1993), a former manager of a large Italian company in the electronics sector.

are systematically dedicated to KM, i.e. if they have formulated KM strategies, if they have an appropriate value system etc.[10]

Consequently, the approach of this study encompassed an ensemble of practices ranging from IT solutions for internal storage and communication of data to training and mentoring, from KM strategy plans to practices of knowledge acquisition, and had a special focus on external knowledge interfaces.

1.2 Knowledge gaps in industrial knowledge management in Germany

For German industry – as for the industry of many other countries – a survey applying a broad concept of KM and covering a wide range of sectors was overdue for several reasons. First of all, almost all empirical work done on KM practices in Germany is based on case studies (e.g. Willke 1998).[11] As many of these case studies are limited to one key aspect of KM, i.e. ICT-based approaches (Bach et al. 1999, Bach et al. 2000), even the aggregate of case studies cannot provide a general picture of KM in Germany.

A *second* open question regarding our understanding of KM in German industry is, does KM mean different things in different sectors and for different company sizes? There is only one survey that besides a couple of European firms, mainly includes German companies (Heisig/Vorbeck 2001). This very valuable work is limited to some 140 German companies and therefore does not differentiate the answers according to different sectors and sizes. Only from the response rate did the authors find indications that – in very general terms – KM is apparently used more broadly in certain industries - such as chemistry and pharmaceuticals, consulting, automobiles, ICT and mechanical engineering (Heisig/Vorbeck 2000, p. 121). In addition, although it has been shown that the usage of KM practices correlates with size, i.e. KM is used more widely in larger companies,[12] a broad empirical analysis for Germany is still lacking.

Thirdly, the existing studies – and this is true not only for German companies – are focused mainly on the *internal* KM processes and somehow neglect the interface between internal and external knowledge sources and knowledge processing. However, one central premise of this study is that due to a number of reasons – growing complexity, interdisciplinarity, economies of speed, inter-organisational co-

10 In this section, the German study expanded the OECD core questionnaire and added the questions on top management responsibility, respectively incentives (see table 2).

11 Some German cases can also be found in Mertens et al. 2001.

12 See for example Prusack 2001.

operation etc. – internal knowledge generation is under pressure and must increasingly integrate external knowledge quickly and smoothly.

Fourth, the added value of this study on Germany, and especially the dimension of KM and innovation, results from the fact that for the first time, the practices to absorb knowledge for innovation purposes are not only analysed in more detail, but also put into the context of knowledge management in companies in general. In their analysis of innovation sources Janz et. al. 2000 (Manufacturing) and Blind et al. 2000 (Services) not only conclude that external sourcing – especially but not exclusively from science – has a high positive leverage as for innovative capacities. They, moreover, conclude in demanding better absorptive capacities within companies in order to exploit the valuable source „science". To analyse the state of the art as for the management of this important absorption will be a central focus of this study.

By doing so, the study will – *fifth* – counterbalance existing analysis of this transfer especially from the research system to the companies. Existing studies and especially programmatic papers have reviewed the transfer of knowledge and technology between the different spheres of the German innovation system by almost exclusively analysing the activities of public research institutions. In contrast to the German private companies, public research institutions as a major source of external knowledge for companies, have been analysed again and again in order to improve their ability to transfer knowledge (recently see Schmoch et al. (2000); Edler, Schmoch (2001)). More relevance and more openness is demanded (e.g. Nicolay/Wimmers 2000; Wissenschaftsrat 2000). Especially business federation put the burden of more effective transfer of knowledge on the research organisations (e.g. ZVEI 1999, BDI/DIHT 2001). However, Reinhard (2000) has done exploratory work on the basis of case studies in the German industry. He has found a massiv lack of consciousness and process competence when it comes to absorptive capacities of companies. This case study work will be complemented by this broad survey.

1.3 Objectives of this study

In line both with the broad concept of KM and the special focus on the meaning of KM for the innovation process, the objectives of this study are twofold:

(1) It seeks to *explore the practices of KM* in German industry according to our broad definition. To do so, research questions on the following four key dimensions are posed[13]:

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13 For the detailed questions, see the annex for the questionnaire used for the survey.

(a) *Usage*: How widely are the various KM practices used and how dynamic is the diffusion of these instruments? Does KM have the meaning one would expect given the rhetoric about knowledge management?
(b) *Motives*: What are the driving forces to employ KM practices, and can we find certain key drivers that define different types of KM?
(c) *Effects*: What are the effects attributed to the usage of the ensemble of KM practices? The effects analysed range from dimensions on which KM directly impinges upon, i.e. human resource capabilities, organisational memory and capture and integration of knowledge to functional effects related to the market success of companies.
(d) *Institutionalisation*: What share of companies has KM institutionalised within the companies organisationally (e.g. by special units or key management responsibility) and/or financially (i.e. KM budgets) and what effects does institutionalisation have?

(2) In addition, in light of what has been said above on the meaning of interfaces, external knowledge and its relation to innovation, the study has a deeper look at one specific key dimension of KM, i.e. the usage of KM practices in the innovation process.[14]

(a) *Link of KM and innovation*: What is the relationship between KM in general and innovation management? Is KM a central element of innovation management; if yes, in which sense?
(b) *Capture of external knowledge*: The main focus here is to analyse the capture of knowledge from outside the company, more specifically, the *capture of technological knowledge* that is directly *linked to the innovation process* of the company. As stated above, the underlying hypotheses here are that innovation is increasingly managed by using KM, respectively integrating it into the KM of companies, and that especially absorbing and integrating external knowledge is increasingly important. The study seeks to test this hypothesis, for if it were true, it would have severe implications for KM, since it would have to cope systematically with the complex knowledge environment and link its fruits to the internal knowledge circulation. Since the science system as source is most effective in terms of innovation and economic performance (Janz et. al. 2000), this part of the study will put a focus on the science system as source, without, however, neglecting other companies as knowledge providers.

The analysis will always differentiate the company sample as for *size* and *sector*. This follows the central hypothesis that the requirements and capabilities of compa-

14 The French study in the context of the OECD study initiative (Kremp/Mairesse 2002) also connected the innovation dimensions and KM practices. While the German study inserted selected innovation questions into the broad KM survey, Kremp/Mairesse inserted selected KM questions into a broad industry and innovation study (CIS 3).

nies of different size or from different sectors impinge upon the usage and management of KM instruments.

Our broad scope means, above all, that the study must be understood as an exploratory endeavour. Thus the empirical findings on the diffusion of practices, the importance of motives, the attribution of effects, the institutionalisation of KM and the connection of KM to innovation activities may very well contribute to further conceptualisations of KM in the future, and generate new hypotheses rather than answering all questions asked.

After a short introduction of the methodology, especially the sampling, the structure of this study is guided by the above mentioned five thematic building blocks, providing necessary interlinkages and concluding with a summary and overarching lessons.

2. The Sample

Due to the lack of systematic knowledge on the sectoral and size influence as regards KM, it is extremely important for the understanding of the following analysis to characterise the sample. 497 firms answered the questionnaire adequately, which is 14.22% of the total sample of 3.495 companies that were randomly chosen.[15] This response rate is very satisfactory, compared to other non-mandatory business surveys in Germany. In addition to the questionnaire, a non-response analysis was conducted, to which 410 companies answered, which makes a total of 907 companies answering (see below). The main survey was prepared by a preceding pilot study with a smaller sample that served the purpose of optimising the questionnaire and to get a feeling for response behaviour of companies.

The company sample consists of companies from seven sectors (see table 1) covering a broad range of traditional industries, as well as knowledge-intensive sectors. Knowledge intensity can be defined as weight of R&D in a sector or as the relation of basic science with applied oriented science, indicated by publication citations in patents (Grupp/Schmoch 1992). According to this definition, chemical, pharmaceutical and the biotechnology sector can be defined as knowledge intensive, and thus one would expect more intensive usage of instruments. Out of these sectors only the pharmaceutical companies are more intensively engaged in KM in general. The reason to cover both traditional and knowledge intensive sectors is to test the assumption that the management of knowledge is – among other things – dependent from the intensity of knowledge in a given sector.

A similar consideration has led to the inclusion of a large group of service companies, enabling an analyse of service companies vis-à-vis companies from manufacturing industries. The assumption here is that service companies rely even more than manufacturing companies on the knowledge of their employees as well as their organisation, and use KM more intensively and differently. In selecting service companies we have focused on four service sub-sectors which are supposed to be rather knowledge-intensive: Market/opinion research (Nace 74.13), strategic and PR company consulting (74.14), architecture and engineering services (74.20), technical, physical and chemical expertise, consultation (74.30).

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15 The most distinguished German company database Hoppenstedt, which classifies on NACE basis, was used for all sectors except for Biotechnology, since Biotechnology is not yet clearly defined as a NACE code. NACE is an official industrial classification (Nomenclature générale des Activités économiques dans les Communautés Européennes). The list of biotechnology companies was constructed at Fraunhofer ISI three years ago. The survey itself was conducted in spring and summer 2002, all companies received two reminders.

Table 1: Company sample and response rate – sectoral distribution

NACE[16]	*Sector*	*N*	*sample*	*rate (%)*
24 (except 24.4)	Chemical (except pharmaceutical and biotech.)	409	**48**	11.7
24.4	Pharmaceuticals	344	**31**	9.01
Internal Database	Biotech	612	**76**	12.42
27-29	Mechanical engineering	395	**51**	12.88
34-35	Vehicles (including transport equipment)	394	**36**	9.14
30-32	Electrical engineering/Electronics (ICT)	614	**61**	9.95
74 (selection)[17]	Business-related services	727	**160**	22.01
	No sector/company name given		**34**	
	Total	3495	**497**	14.22

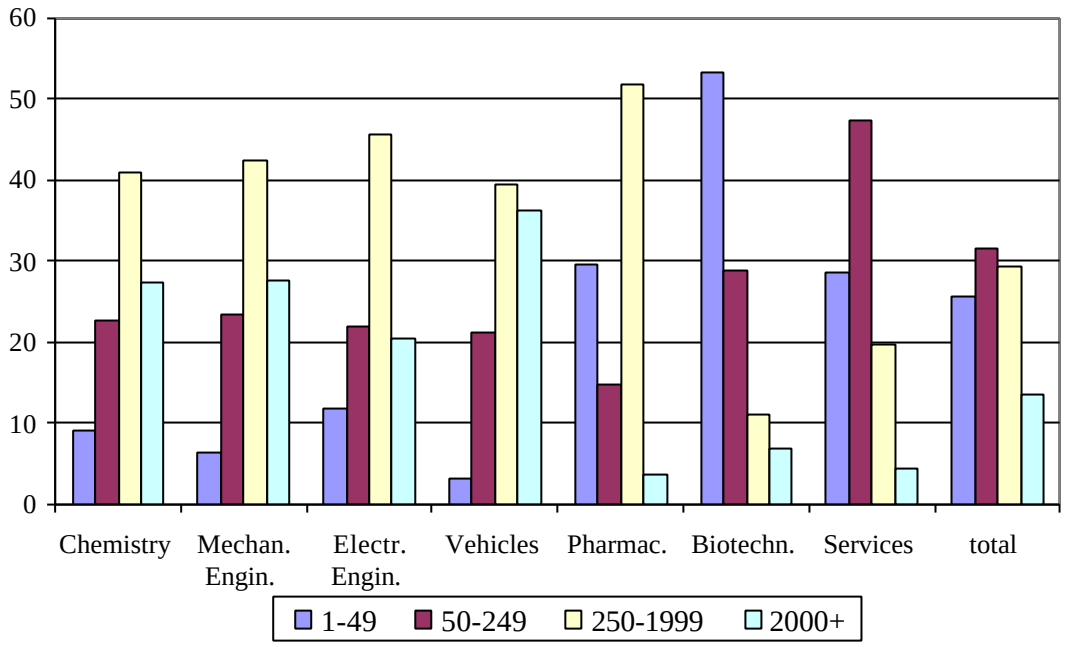
The size of the various randomly selected sector samples has been defined following the experiences of the pilot survey. Somewhat surprising was the low response rate by the pharmaceutical companies and the very high response rate of the service companies. However, this might be interpreted as a first indication of the (low) importance of KM for these companies. In any case, the resulting sample is large enough for *sectoral* differentiation.

The same is true for the *size* distribution of the responding sample. Figure 1 shows that for the whole sample three of the four groups are represented very similarly, and even the group of larger and largest companies (over 2.000 employees) is big enough for an in-depth analysis. The size distribution shows significant differences between sectors, which is important for the analysis. The service and especially the biotechnology sector are dominated by smaller companies, while the pharmaceutical sector is dominated by companies with more than 250, but less than 2.000 employees and the remaining four sectors are dominated by companies with more than 250 employees, including very large enterprises.

16 For "NACE" see preceding footnote.

17 See text for details on service sub-sectors.

Figure 1: Size distribution of the sample (%): total and sectors



3. Relevance of a Broad KM Concept: A Non-response Analysis

The non-response analysis served the purpose of testing the relevance of the overall topic, and to ask if companies had a totally different understanding of KM. 410 companies sent back the non-response form. Table 2 below gives the possible answers that were formulated (multiple responses possible) and the absolute numbers as well as percentage of responses and cases.

It can be seen that the broad understanding of KM was no major problem for the companies surveyed, only very few indicated that they followed a narrow, ICT-focused KM approach. Furthermore, there are only few companies that do not have KM at all, but plan to introduce it. That means that KM is already started, or is not considered at all. The most important reasons for not participating in the survey – next to the practical ones of time and principle objections to surveys – is that in many companies there is KM in place, but it is distributed, loosely connected and not systematically managed. Only 86 companies, out of more than 900 companies who answered the survey, indicated that KM plays no role whatsoever and is not on the agenda either. While it is clear that most of the non-users of KM might have not answered in the first place, the percentage below 10% indicates that KM – one way or the other – is an important topic in German industry.

Table 2: Non-response analysis

	Count	Percentage of	
		responses	cases
Reasons related to KM			
KM is a horizontal task within the responsibility of every manager, therefore systematic statements for KM as such are hard to make.	99	17.4	24.1
KM plays no major role and there are no plans to build up systematic KM.	86	15.1	21
KM is a major task of our ICT management (databases, information systems) and not as broad as in the definition given in the questionnaire	37	6.5	9
KM plays no major role, but a build up of systematic KM is planned	14	2.5	3.4
General reasons, not KM related			
Answering takes too much time	124	21.8	30.2
No participation for principle reasons	93	16.3	22.7
Other reasons (company dissolved etc.)	116	20.4	28.3

N = 410, Multiple answers possible
Source: Fraunhofer ISI Survey 2002

4. The Employment of KM Practices in German Industry

4.1 Overall pattern

How diffused are individual practices, which practices are diffused widely in German industry, and which are still not very common? Following the broad definition of KM given above, the companies were asked about their usage of 19 different practices. On average, the companies of the sample use 11.6 of the 19 practices. Table 3 presents the usage of single practices, which have been grouped according to one of the following types of practice: (1) communication (mainly ICT-based practices), (2) training and mentoring, (3) policies and strategies and finally (4) knowledge capture and acquisition.. The first column indicates the ranking of the instruments, i.e. ranking „1" indicates that the practices are used by the highest percentage of companies.[18]

First of all, of the individual practices most widely used (i.e. by more than 75 % of the companies), four are related to knowledge capture, three to training, only one to communication and none to KM policies and strategies. The two most popular practices, measured by the percentage of companies using them, are the use of knowledge obtained from other industrial sources and the use of the Internet (capture), followed by off-site training, inter-personal knowledge transfer and work-related formation (training), using knowledge from public research (capture), written documentation (communication) and encouraging collaboration with external experts (capture). At the low end, out of the six practices used by less than half of the companies, three are related to policies and strategies (appropriate value system, incentives and written KM strategy)[19], three stem from the training category. It is obvious that in contrast to *general* training practices – which are rated highly – human resources practices geared towards the build-up of *KM capabilities* are not broadly established. In fact, only 16% of the companies have a formal KM training - which is the lowest rate of use.

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18 Figure A 1 in the annex provides the instruments in the order of their importance rather than in the order determined by the clusters.

19 This is true although 60% of the companies indicate that KM lies within the responsibility of top management (as was asked additionally in the German questionnaire). Apparently this high institutionalisation has not yet led to formalised KM policies.

Table 3: Percentage of companies using selected KM practices – total sample[20]

Rank[a]	Practice	In use			plan	not in use
		total[b]	*before 99*[c]	*since 99*		
	Communication					
13	Regularly updating databases of good work practices, lessons learned or listings of experts	57	*36*	*21*	18	25
7	Preparing written documentation such as lessons learned, training manuals, good work practice etc. (organisat. memory…)	85	*69*	*16*	6	10
12	Facilitating collaborative work by projects teams that are physically separated („virtual teams")	59	*33*	*26*	12	29
	Training and Mentoring					
19	Providing formal training related to KM practices	16	*11*	*5*	9	75
16	Providing informal training related to KM	34	*21*	*13*	12	54
15	Using formal mentoring practices, including apprenticeships	39	*26*	*13*	7	55
4	Encouraging experienced workers to transfer their knowledge to new or less experienced workers	93	*78*	*15*	3	4
5	Encouraging workers to continue their education by reimbursing tuition fees for successfully completed work-related courses	90	*79*	*11*	2	8
2	Offering off-site training to workers to keep skills current	95	*84*	*11*	2	4
	Policies and Strategies					
18	Having a written KM policy or strategy	23	*10*	*13*	18	60
14	Having a values system or culture promoting knowledge sharing	45	*30*	*15*	18	37
10	Using partnerships or strategic alliances to acquire knowledge	68	*50*	*18*	6	26
11	KM within responsibility of top management	61	*44*	*17*	11	27
17	Monetary or non-monetary incentives	30	*21*	*9*	12	59
	Knowledge Capture and Acquisition					
1	Using knowledge obtained from other industry sources	97	*89*	*8*	0	3
6	Using knowledge obtained from public research institutions	88	*78*	*10*	2	9
9	Dedicating resources to obtaining external knowledge	70	*56*	*14*	5	25
2	Using the Internet to obtain external knowledge	95	*57*	*38*	2	3
8	Encouraging workers to participate in project teams with external experts	81	*65*	*16*	4	14

a: instruments ranked according to the percentage of companies using them (decreasing order), i.e. the practice with the rank „1" is the one most widely used in the sample.
b: total percentage of companies using the practice, no matter when they introduced it.
c: percentage of companies having introduced the practice before 1999.
Source: Fraunhofer ISI Survey 2002

One of the most striking results of the analysis at the level of single practices is that the pattern of diffusion is very similar for the sectors and size groups, the similarities of patterns at the level of categories is mirrored at the level of instruments. Es-

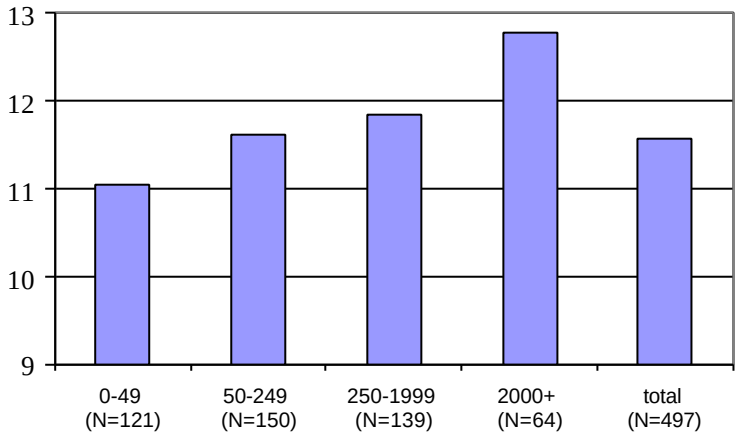
20 See Footnote 18.

pecially at the low end of practices, there are almost no differences, the distribution of policies and strategies is low for all sectors and size groups. The sectors deviating most from this general pattern are mechanical engineering with a special focus on human resource practices in use, and electrical engineering, a sector that is allegedly prepared to undertake comprehensive, strategic KM in the near future. Finally, as to size, the stronger usage of KM by large companies in general is also characterized by a different pattern, as very large companies lay much more emphasis on the acquisition of knowledge from outside the company (especially from research institutes (95%)), with 88% of them dedicating resources to do so.

4.2 Comparative analysis of the diffusion of KM practices

The employment of the practices differs according to the size and the sector of companies. As for the size, the larger the company – i.e. the greater the need and capabilities for broad KM - the higher the average number of KM instruments used (figure 2).[21] This finding is in line with other empirical work, both for Canada (Earl 2002) and France (Kremp/Mairesse 2002).

Figure 2: Average number of KM practices used - size



Source: Fraunhofer ISI Survey 2002

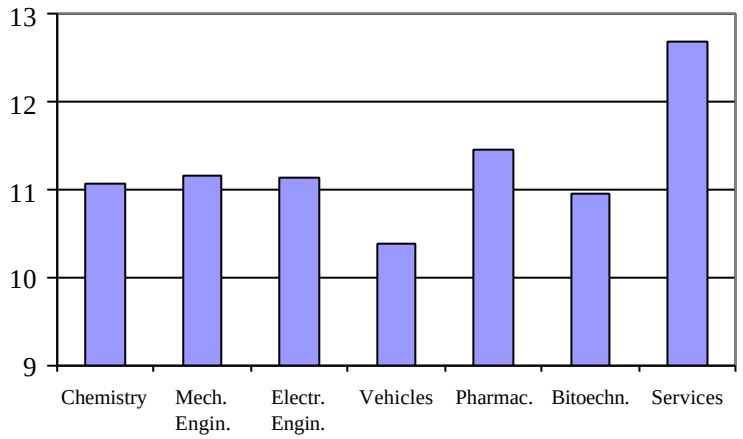
The pattern for the sectors is less clear cut (figure 3). Only two sectors stand out, while the rest show a very similar average number of KM practices. Apparently our hypothesis that KM is more important for service sectors is confirmed, at least for the service sub-sectors we have selected, which are business-related and knowl-

21 The relationship between number of employees and number of practices used was tested with a correlation test, it is statistically significant at the level of 1 percent, however, the Spearman coefficient is rather low (0.14). For the explanation of statistical significance see the methodological annex.

edge-intensive (see above). These service companies on average employ almost 13 out of the 19 instruments we asked about – although the sector sample consists mainly of SMEs. Exactly the opposite pattern is true for the vehicle sector, here the sample is characterised by large companies, still the average number of KM practices is lowest.

The results do not confirm the assumption that more knowledge intensive sectors employ more practices. As concerns the biotechnology companies, the quite low usage is rather a size effect, as biotechnology companies in the sample are predominantly small ones. However, when it comes to the sourcing of knowledge from various sources supplying more basic oriented, technological knowledge (see below, chapter 8), the picture changes, since these sectors are more active in capturing relevant knowledge form selected sources. Using primary data as for R&D intensity, it was, the relationship of R&D intensity and usage of KM measures in general was confirmed for the French industry (Kremp/Mairesse 2002).[22]

Figure 3: Average number of KM practices used[23] – sectors



Source: Fraunhofer ISI Survey 2002

To be able to systematically compare the patterns of different sectors and size groups, the level of 19 single instruments is too complex. To structure this complexity of motives and to conduct the comparative analysis, as well as more elaborated statistical analysis later on, the 19 practices have been clustered into the four groups already presented above (see table 3). To compare the usage of these four basic clusters of instruments, an index from 0 to 1 was calculated for each of the

22 In the Fench case the questions on the usage of KM could be related to R&D intensity directly as KM questions were inserted in the regular industry survey. Therefore, not traditional sector groups, but company groups clustered for R&D intensity were correlated with KM usage.

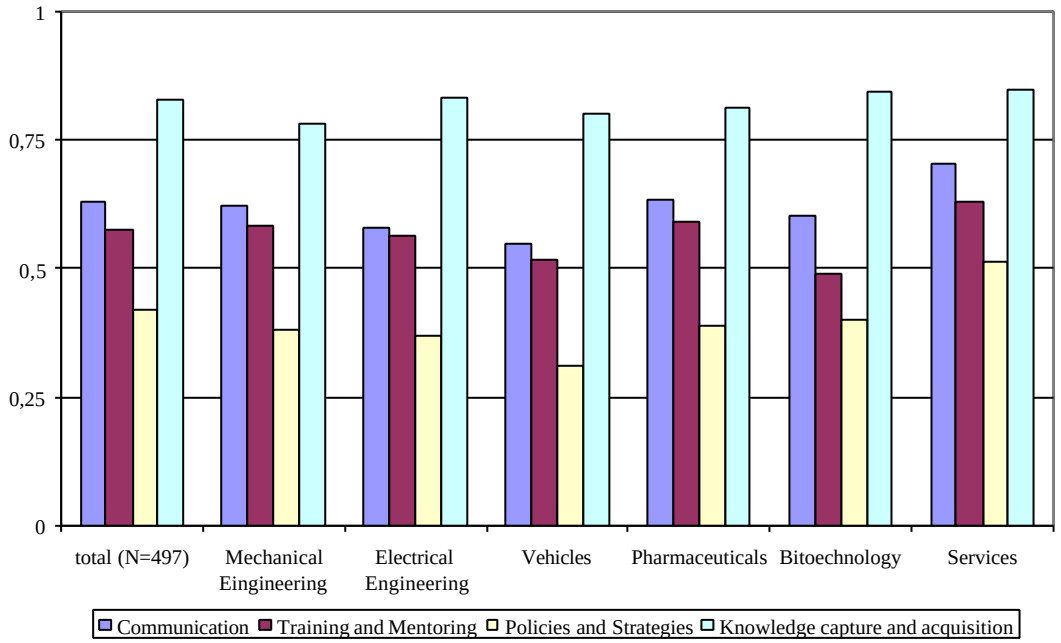
23 The maximum number of practices asked for is 19.

four clusters. A value of „0" would mean that no company of the sample (respectively size group or sector) uses any of the instrument in the category, a value of „1" would mean that all companies use all practices in the cluster.

Figure 4 shows impressively that the practices to capture and acquire knowledge are most widely used, confirming the hypothesis that external knowledge acquisition is becoming an increasingly important task and a major pillar of the competitiveness of companies. The second most widely used cluster comprises the mainly ICT-based communication practices, followed by the human resource instruments. Interestingly, for the German companies KM is a practical reality that is not yet guided by related corporate strategy, policies, cultures and commitments.

Most interestingly, at the aggregated level of the four clusters, *this pattern* of high emphasis on capture and acquisition on the one hand and the low emphasis on policy and strategy is *true for all size groups* and *all sectors* (figure 4). The differences at the level of clusters of practices are almost negligible. The persistence of this pattern is even more striking, considering the differences in the average number of KM practices used between the sectors, and especially the size clusters demonstrated above.

Figure 4: Usage of KM measures – mean value for KM categories (indices)[a] – sector



a: 0 = no instruments at all in category, 1 = all instruments in category

Source: Fraunhofer ISI Survey 2002

As the comparison of the four size groups and seven sectors at the level of 19 motives would be overly complex, and given the high resemblance of patterns at the

level of clusters, the percentage of usage (table A1) as well as the patterns for size groups and sectors are given in the annex and not discussed in depth here. For comparative purposes he figures in the annex show the deviations of each size group and sector, ranked in decreasing order of distribution for the overall sample (figures A 2 to A 12). Some hints at the few strong deviations at the level of single instruments may suffice here. As for size, the only tow groups that show some interesting deviations are the very small and the very large companies. The very small companies employ less instruments across the board and they are especially less inclined to encourage their workers to co-operate with external experts and to build up human capabilities with the help of mentoring or other training mechanism. However, KM is – due to structural reasons – very often in the responsibility of the top-management. The very large companies are more active with all but two instruments, they have established dedicated budgets for KM, are intensively engaged in co-operation across the border of the company and are especially more active when it comes to human resource measures related to KM.

At the sector level the patterns are more diverse. Again only some highlights are reported here (see annex, figure A6 to A12). Compared to the overall sample, the chemical companies are less often engaged in strategic alliances to acquire knowledge, less often collaborating in virtual teams, less active in building up human capabilities for KM and have KM responsibility less often within the top management. The latter is especially true for biotechnology companies also. The electronic companies show a similar deviation as the chemical companies, while the mechanical engineering companies dedicate significantly less resources for KM. As was to be expected from the clustered analysis, the vehicles company are deviating from the overall picture by far most. They use almost all instruments less often than the sample, and are especially little engaged in IT based knowledge storage (databases) and strategic activities such as a KM strategy or dedicated budget. The companies of the pharmaceutical sector indicate – strikingly – to use knowledge from public research organisations rather rarely, while they are stronger in the application of human resource measures. The service companies show almost no deviation from the overall pattern as for the upper half of the most widely used practices of the sample, but are much more actively using all those instruments that are less frequently used by the overall sample, i.e. mainly human resource and strategic instruments. Therefore, service companies are not only more active, they also cover the whole range of instruments and organise their KM strategically.

4.3 The recent and future dynamics of KM practices

What about the dynamics of the diffusion of KM practices *in recent years* in view of the increased importance KM has received in business management literature and conference circles? The companies were asked to indicate if they had introduced a practice they use *before* 1999 or if they use it *since* 1999 (see table 4). Across the

board, KM practices gain importance. Not surprisingly, the usage of the Internet has diffused most in German industry lately (38 % out of the 95 % using it now have introduced this since 1999). Secondly, there is a growing need to integrate knowledge across organisational borders and distances, be it from inside or outside the company, as indicated by the increased importance of – first – attempts to ease collaboration of teams that are physically separated and – second – inter-firm partnerships to capture knowledge. Thirdly, there has been a diffusion of ICT-based KM solutions, as the updating of databases has greatly gained importance. And finally, KM has increasingly become a responsibility of top management, since 40 % of the companies who indicate that they have placed KM within the responsibility of top management have done so only within the last three years.

And where will the German companies go from here? The companies were also asked which practices they *plan* to introduce in the coming 24 months (table 4, above). The signals are mixed. On the one hand, there is a large share of companies that plan to organise their KM more comprehensively, as 18 % of the companies indicate plans to foster an appropriate value system or culture and another 18 % plan to formulate a written KM strategy. At the same time, the tendency to employ ICT-based databases and to ease collaboration across distances remains. Finally, in the future the practices to capture knowledge from outside the company will be standard within German industry, although one fifth of the company will do so without specifically dedicated budgets.[24]

On the other hand, however, this development should not be overrated, there are limits to the diffusion of KM as a management task in German industry. Especially for policies and strategies and KM-related human resources instruments, there seems to be a stable and large portion of German companies that will continue to do without. Almost half of the companies will remain without a KM related incentive system, 42 % of all companies indicate they will not introduce a KM strategy or KM incentives in the future, almost 20 percent of the companies do not even intend to establish a KM culture or value system that promotes the sharing of knowledge.[25] Apparently, the upgrading of KM as a management responsibility – as indicated above – has in the recent past only weakly been accompanied by related KM training, as only 5 % of all companies have introduced formal KM training within the last three years. Moreover, KM capabilities will not become a major topic in human resources and training. The rather low share of companies that have a formal or in informal KM training will only grow by 9 % and 12 %. 66 % of all companies

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24 The only exception will remain „collaboration with external experts", which will not be introduced by 10 % of the companies.

25 The percentage of companies which do not use and will not use an instrument is derived from table 3 above, by subtracting the percentage of companies which plan to introduce from the percentage which do not currently use the practice.

will remain without formal KM training and almost half of the companies will not use formal mentoring practices or provide informal KM training.

5. The Driving Forces of KM: Motivation Patterns in German Industry

5.1 Overall pattern

What are the most important reasons for German companies to use KM? Can we see a pattern of motivation? In line with the broad understanding of KM, the motivations to use KM practices are manifold. The companies were asked to rate the importance of 19 different motives on a scale from 1 (extremely important) to 6 (not important at all). Table 4 indicates the motives in the order of decreasing importance for the whole sample.

The motives can be grouped into three clusters. The group of the most important ones are those eight motives for which at least 75% of the companies indicate an importance of 1 or 2 (top two boxes) as being most, [26] for the least important group of 5 motives less than half of the companies indicated an importance of 1 or 2. The top rated group is characterised by three main drivers. The two most important motives to employ KM practices are the transfer to new workers and the integration of knowledge within the company. Thus, the *internal integration of knowledge* – which also includes the improvement of collaboration of physically separated teams (rank 7) – is the most important driver of KM. This internal integration is followed by a rather defensive instrument, i.e. the protection of loss of knowledge due to the departure of workers (rank 3). This reflects attempts to *react to the increasing fluctuation of the workforce* as well as the growing importance of knowledge as a strategic asset, especially if one adds to this the motive to identify and/or protect strategic knowledge present in the company (rank 6) and the capture or workers' undocumented knowledge (rank 8). Finally, the companies use the opportunity provided by KM tools to upgrade their workforce internally, as KM is a major tool for *human resource development* (motives ranked 4 and 5). However, this human resource motivation is confined to training aspects in general, and does not include KM training.

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[26] Top two category reflect the percentage of companies which indicated a value lower than 3 on the scale from 1 (extremely important) to 6 (not important at all).

Table 4: Motivations to use KM - whole sample[27]

Rank	Motive	Top Two[a]	Mean[b]
1	To accelerate and improve the transfer of knowledge to new workers	91	1.64
2	To help integrate knowledge within your firm or organisation	86	1.75
3	To protect your firm or organisation from loss of knowledge due to workers' departure	82	1.77
4	To encourage managers to share knowledge as a tool for professional promotion of their subordinates	80	1.91
5	To train workers to develop their human resources	77	2.00
6	To identify and/or protect strategic knowledge present in your firm or organisation	76	1.95
7	To ease collaborative work of projects or teams that are physically separated	75	2.03
8	To capture workers' undocumented knowledge (know-how)	75	2.06
9	To ensure that knowledge resident in all international work sites is accessible to the entire firm or organisation	69	2.29
10	To train workers to meet strategic objectives of your firm or organisation	68	2.21
11	To help managers to focus their attention to key information	67	2.28
12	To improve the capture and use of knowledge from sources outside your firm or organisation	67	2.22
13	To increase worker acceptance of innovations	65	2.30
14	To avoid information overload problems within your organisation	59	2.45
15	Following merger or acquisition to help integrate knowledge within your new firm or organ.	47	2.92
16	To promote sharing and transfer of knowledge with suppliers	47	2.75
17	To improve sharing or transferring of knowledge with partners in strategic alliances, joint ventures or consortia	37	3.05
18	To promote sharing and transfer of knowledge with customers	36	3.07
19	To update your firm or organisation on KM tools or practices used by competitors	31	3.23

a: Top two indicates the percentage of companies who have rated one or two on the scale from 1 (extremely important) to 6 (not important at all).

b: Scale ranging from one (extremely important) to 6 (not important at all).

Source: Fraunhofer ISI Survey 2002

Analysing the low end of the motives, most obviously knowledge management in German industry is still not integrating knowledge flows from outside the company. Three out of the five least important motives are about the sharing of knowledge with customers, suppliers and co-operation partners. This marks an important characteristic of the relations with the outside world when it comes to KM. While the practices used to obtain knowledge from outside are diffused broadly within industry (see table 3 above), and while using the environment as a knowledge source gets at least a medium mean value and is an important motive for two thirds of companies (motive 12), the inclination to actually *integrate* the internal circulation of knowledge with the relevant environment is weak. One preliminary explanation is conceivable: As we will see below, sharing knowledge with the environment is still

27 Within a scale ranging from 1 (extremely important) to 6 (not at all important). „Top two" indicates the percentage of companies that rated the motive 1 or 2. The motives are ranked according to the „top two" values

accompanied and hampered by the fear of giving away critical knowledge (chapter 6).

The ranking of motives earmarks an important tension within KM: For reasons of efficiency and effectiveness it is about the sharing and integration of knowledge as broadly as possible. At the same time the company also employ KM in reaction to their constant fear of losing critical knowledge (fluctuation, leakage) or rate those motives that relate to the sharing and transfer of knowledge with the environment rather low. Up to now, the more defensive use seems to be the dominant model.

5.2 Comparative analysis of KM motivation

A more systematic comparison can be done by defining a clear set of basic motivations to utilise KM practices. To do so, we conducted a factor analysis[28]. This is a statistical method that groups those items (here: motives) that are related on the basis of their common variance and thus results into a reduced set of components or factors. This resulting reduced set of factors is both easier to interpret and enables an aggregated comparison between sectors and size groups.

Table 5 (following page) indicates the five groups of related motives (five factors).[29]**.** Factor 1 encompasses variables that all describe the overall operative function of KM practices regarding *human resources*. Factor 2 describes the *capture and protection of knowledge,* it is strategic in a more defensive sense. The factors 3 to 5 are all concerned with the sharing and integration of knowledge. Factor 3 encompasses *the vertical knowledge transfer in the market*. Factor 4 can be labelled *as knowledge integration across interfaces within (!) the company*, while finally, factor 5 earmarks the *integration of knowledge in very general terms.*

28 More specifically: a principal component analysis with varimax rotation.

29 The ranking of the five factors follows their contribution to the explanation of the overall variance, see annex for details. Together, the five components underlying these factors explain around 60% of the total variance of the answers given (see annex for a table on the factor loadings and the contribution to the explanation of variance, table A 6).

Table 5: Definition of factors: motivation for KM (varimax rotated factor loadings)

Factor	Description	Imp.[a]	Major Variable	Factor loading
1	Operational and instrumental motivation geared towards **human resources**	11	To help managers focus their attention on key information	0.535
		10	To train workers to meet strategic objectives of your firm or organisation	0.694
		5	To train workers to develop their human resources	0.572
		4	To encourage managers to share knowledge as a tool for professional promotion of their subordinates	0.722
		13	To increase worker acceptance of innovations	0.633
		19	To update your firm or organisation on KM tools or practices used by competitors	0.661
2	**Knowledge capture** (including external) **and control**	12	To improve the capture and use of knowledge from sources outside your firm or organisation	0.471
		3	To protect your firm or organisation from loss of knowledge due to workers' departure	0.737
		6	To identify and/or protect strategic knowledge present in your firm or organisation	0.645
		8	To capture workers' undocumented knowledge (know-how)	0.771
		14	To avoid information overload problems within your organisation	0.503
3	**Vertical knowledge transfer in the market**	16	To promote sharing and transfer of knowledge with suppliers	0.785
		18	To promote sharing and transfer of knowledge with customers	0.786
4	**Transfer and sharing of knowledge across interfaces within the company** respectively. with **close partners**.	15	Following merger or acquisition to help integrate knowledge within your new firm or organisation	0.754
		9	To ensure that knowledge resident in all international work sites is accessible to the entire firm or organisation	0.839
		7	To ease collaborative work of projects or teams that are physically separated (i.e. different work sites)	0.775
		17	To improve sharing or transferring of knowledge with partners in strategic alliances, joint ventures or consortia	0.564
5	**Internal integration of knowledge**	2	To help integrate knowledge within your firm or organisation	0.781
		1	*To accelerate and improve the transfer of knowledge to new workers*	*0.793*

Principal Component analysis- varimax rotation with Kaiser-normalisation, Kaiser-Value 0.86, Barlett's test of sphericity 2953.348. p=0.000

a: Ranking of importance for the single variable (see table 4 and text)

Source: Fraunhofer ISI Survey 2002

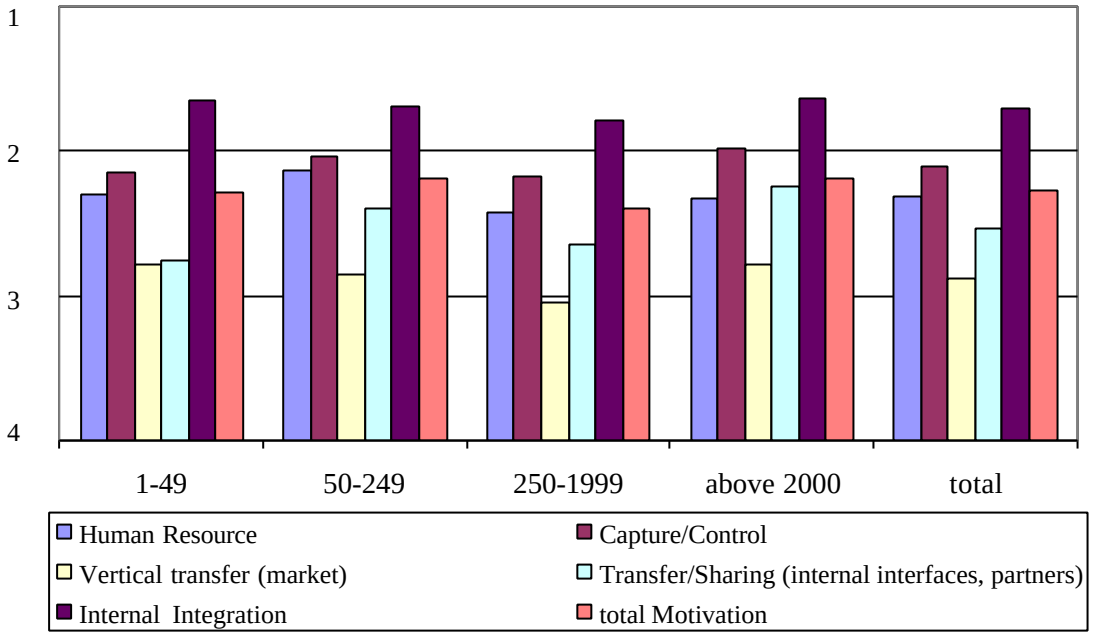
What do these groups of motives tell us? Above all, this result of the factor analysis stresses the fact that the companies have clearly distinguishable types of motivations to use KM which – moreover – confirm the intuition as to possible „families" of motives.[30] Furthermore, for future analysis of KM motivations these reduced factor set may lead us to think about KM in terms of clear-cut categories rather than analyse the whole ensemble of possible motivations – but still stick to our broad understanding of KM.

On the basis of this factor analysis, we grouped the original motivation variables according to „their factor" as shown in table 5 and calculated the mean values for these factors as too their overall *importance,* as indicated by the companies. The most important set of motives is the one grouped under the heading *internal knowledge integration (factor 5),* followed by the motives to *capture and control* knowledge *(factor 2),* the motives within the *human resource* dimension (factor 1) and the motives related to the *transfer and sharing of knowledge across organisational interfaces within the company (multiple sites) and/or with close partners* (factor 3). Of least importance are those motives geared towards the *vertical external knowledge transfer in the market* (factor 4) (see figure 5).

Strikingly again, the *order* of motivation clusters is the same, no matter the size (figure 5), but similar to the usage of instruments, the ratings for the motivation also increases with size, meaning that in larger companies the values for the most items are higher than in smaller ones: Activity corresponds with motivation. The only exception to this pattern is the transfer across internal borders and with close partners which – due to more fragmented structures – is more important for larger companies.

30 The result of the factor analysis almost exactly confirms the intellectual clustering of motivation variables that was grouped hypothetically ex ante by the OECD study group on KM. *Ex ante*, these motivations were grouped into the following five categories: knowledge sharing and integration (S/I), knowledge capture and control (CC), information management (IM), human resource management (HR) and external (ext.) This latter category simply asked for the motivation to update the company on KM of the competitors. These ex ante classifications differ from the factors resulting form our factor analysis only in two respects, *first,* the two variables from the information management category (IM) are no part of the operational motivation (help managers focus their attention on key information) respectively – and somewhat counter-systematic – the capture and control motivation (avoid overload problems). Second, the broad ex ante category of integration and sharing of knowledge has been differentiated into the three factors 3 to 5. The fit of the result of the factor analysis with the intellectual clustering of motives stresses the fact that the groups of motives derived from the factor analysis have a high explanatory value.

Figure 5: Importance of Cluster of KM Motives - size

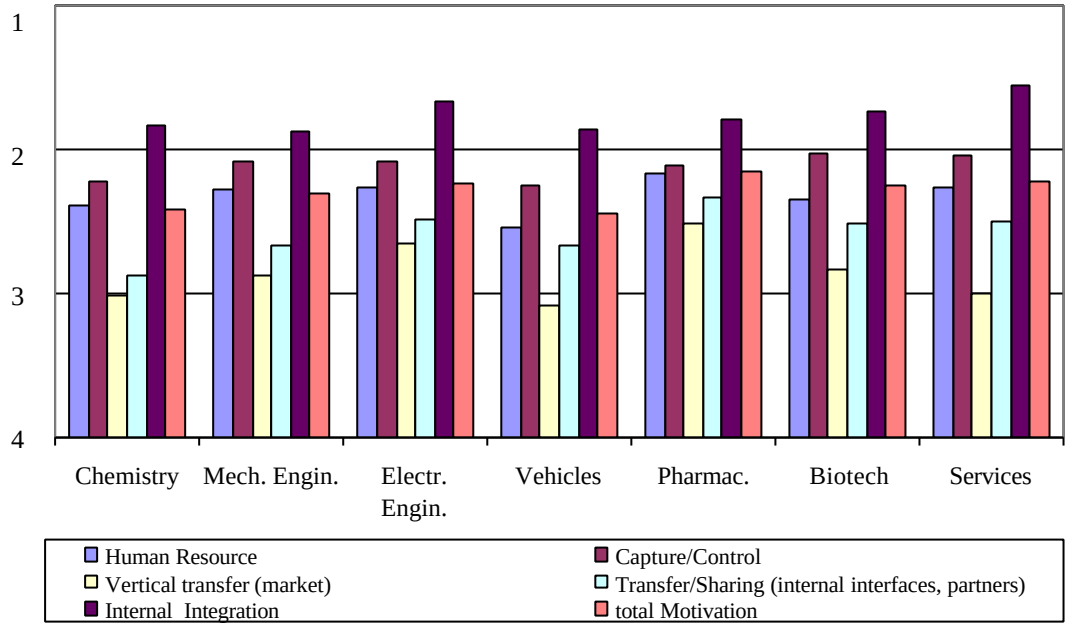


1 = extremely important, 6 = not important at all

Source: Fraunhofer ISI Survey 2002

The rather uniform pattern of motivation is also true for the sectors (figure 6), as they all show the same order of motivation types. Still, there are some important sectoral differences in two dimensions: external vertical sharing of knowledge (market) and knowledge transfer across borders within the company respectively with close partners. Apparently, the *service* companies are – in relation to other sectors – driven rather weakly by the need to share knowledge with customers and suppliers. This is somewhat counter-intuitive, as service companies, especially the knowledge-intensive ones that we included in the service sector, are dependent upon the exchange of knowledge. This might indicate that service companies are not driven by the need to *exchange* knowledge with their environment that much, but rather capture the necessary information needed to deliver their specific service. The little relevance of sharing knowledge with the environment is also true for the *chemical* companies, which – in addition – indicate least importance of transfer of knowledge across intra-company interfaces or with close partners. According to our survey data, the chemical companies seem to be least open to letting their knowledge circulation come into contact with outside actors. The opposite is true for the *pharmaceutical* and, to a lesser extent, for *electronic* companies, for which the sharing of knowledge with external partners, especially vertically (market) is significantly more important.

Figure 6: Importance of cluster of KM Motives - sectors



1 = extremely important, 6 = not important all

Source: Fraunhofer ISI Survey 2002

A systematic differentiation of all these 19 motives according to sectors and size groups would again be overly complex. Again, those readers interested in a specific sector may consult the annex, where a table (table A3) with mean values for each sector and size group as well as a deviation figure for each sector and size group are provided (figures A 13 to 24).

Finally, the clustering of motivations allows an analysis of the correlation of motives with the (clustered) practices used, which would be overly complex on the level of single practices and motives. Across the board of all clusters, the relation is significant, the higher companies are motivated, the more they use KM practices.[31] The correlation analysis shows that the need to transfer and integrate knowledge within the company, e.g. after merger or acquisition or to bridge geographical distances, most significantly correlates with the usage of practices.[32] This is of course also a size effect, as big companies have this need much more often than small ones, but it makes clear that if a company is forced to integrate knowledge dispersed geographically, it is necessary to invest in KM practices intensively.

31 The correlation of all clusters of motives with all clusters of practices is statistically significant, however, the coefficients are mostly below 0.20.

32 The motivation to transfer and integrate knowledge across internal company interfaces is the only cluster of motives showing correlation coefficients above 0.20.

6. Effects of KM

6.1 Overall effects

How effective are the companies in employing KM? As yet, indicators for KM are still to be defined. A recent project funded by the European Commission has only started to work on guidelines for the reporting of intangibles in companies, which should, as a working programme, include indicators for KM practices (Calvo/Sánchez Munoz 2002). However, the empirical findings on the actual practices of companies to measure and even report on their intangibles and the related management practices are extremely poor, the majority of companies do not have measuring practices and reporting systems, although they often report on their activities as „part of the knowledge economy", and those who do are rather reluctant to disclose them. Secondly, the knowledge of the relative impact of KM on certain business indicators we might have is still rather poor.[33] Therefore, up to now effects of KM cannot– beyond the level of case studies – be measured systematically. The simple solution chosen in the study was to ask those responsible what they think about the effectiveness of the ensemble of their KM – not single instruments. The German survey asked for nine possible effects on a range between 1 (extremely effective) and 6 (not effective at all). The effects are presented in table 6 in decreasing order of attributed magnitude.

First of all, there is a strong association between the number of practices used and the effects reported. The more practices are employed, the higher the score for effects.[34] *Secondly*, KM is most effective when it comes to the improvement of human resources and the direct market effects. Table 6 indicates that two of the three top rated effects are human resource effects (skills, productivity). This is interesting, since the improvement of human resources is not the most important driving factor for KM (see above). *Thirdly*, the single biggest effect (adaptation in the market), as well as number 4 and 5 (table 6), are directly linked to the market success of companies. Again, we have seen that the companies at the same time rate the motivation for external transfer or sharing of knowledge with clients very low. In other words, the companies either see no necessity to share and transfer knowledge with their clients in order to meet their needs properly, or they are reluctant to

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33 One recent example of measuring effectiveness of KM is given by Kremp/Mairesse (2003) in a study on French industry. They show that there is a statistically significant correlation between usage of KM and labour productivity. Their basis is the linkage of questions on KM practices and data stemming from the regular French industry survey panel.

34 We conducted a Chi-Square test (explained in the methodological annex), for which an *index of overall usage* was constructed and the sample was grouped into those companies that employ not more than 50% of the instruments (N=128) and those who employ more than half the instruments. The *total effect* was calculated, building the overall mean value on the scale from 1 (extremely effective) to 6 (not effective at all). Three groups reporting high (mean below 1.5), medium (mean between 1.5 and 3) and low effectiveness (mean above 3) were formed. The resulting crosstable was tested, the association showed high significance on the 1% level (on „statistical significance" see the methodological annex).

do so.[35] The fact that they still rate the market effect as high might rather point to the general effects obtained through the efficiency gains of internal mechanisms of KM. *Fourthly*, the direct KM effects (capture of knowledge and the improvement of the organisational memory), are rated rather low. It would be interesting to find out, through more qualitative research, why these direct KM effects are rated lower than the functional effects (human resources, market). One explanation – as indicated above – might be that the companies simply have no measurement tools, maybe not even a feeling for their KM abilities, and thus are not able to assess the effects in the first place. Furthermore, the limitations of the direct KM effects (capture, memory) might point towards the slow reaction of the companies to a KM culture that needs to be institutionalised in order to be effective. The functional KM effects (human resource, market), on the other hand, are traditional dimensions that might very well have improved through KM, however, KM on that level is only one explanatory variable among many other managerial tasks, and its effects are hard to attribute.

Table 6: Effects of KM – whole sample

Type of effect[a]	Effect	top two[b]	mean[c]
Market	Increased our adaptation of products or services to client requirements	73	2.07
Human Res.	Improved skills and knowledge of workers	73	2.08
Human Res.	Improved worker efficiency and productivity	69	2.12
Market	Helped us add new products and services	61	2.34
Market	Improved the relation to customers and/or clients	59	2.38
Organ. Mem.	Improved the memory of our organisation	57	2.47
Organ. Mem.	Helped avoid duplicating R&D activities	53	2.55
Capture	Increased our ability to capture knowledge from other businesses	51	2.56
Capture	Increased our ability to capture knowledge from public research instit.	38	2.87

a: ex ante, intellectual clustering of effects; Organ. Mem. = Organisational Memory
b: top two indicates the percentage of companies who have rated one or two on the scale from 1 (extremely effective) to 6 (not effective at all).
c: scale ranging from 1 (extremely effective) to 6 (not effective at all).
Source: Fraunhofer ISI Survey 2002

6.2 Comparative analysis of KM effects

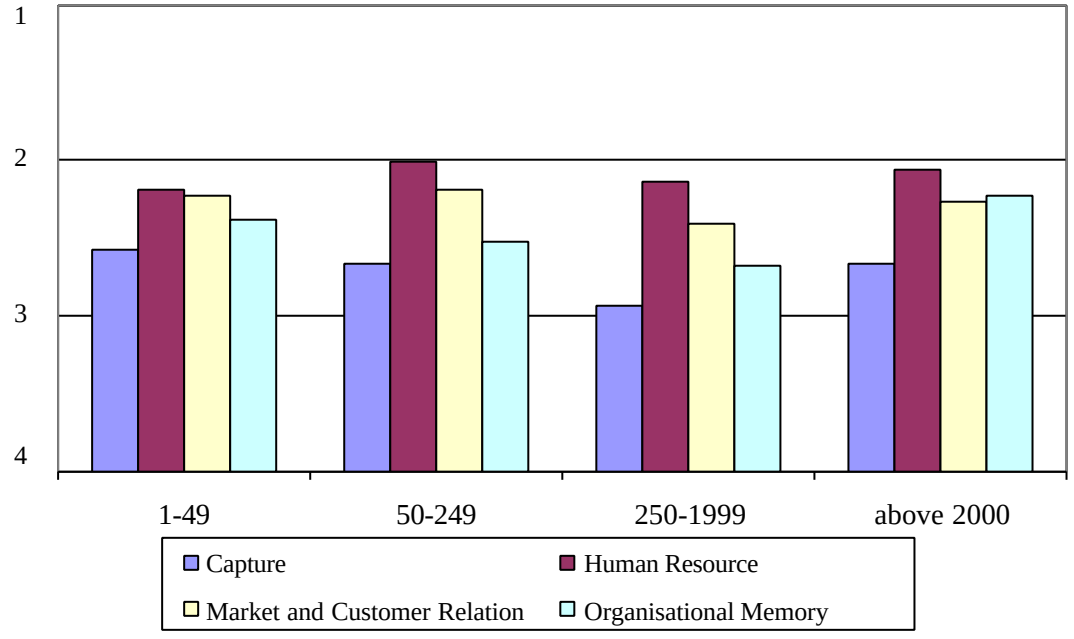
The comparison of size groups and sectors is again based on a clustering of the nine factors in order to reduce complexity. As with the motives above we conducted a principal component analysis, which resulted only in two factors, one for the two variables „capture", one for the rest of the variables. Therefore, the nine variables have been grouped *intellectually* –

35 One major reason for the reluctance to acquire *technological* knowledge is, as mentioned above and shown below, fear of losing critical knowledge; the same might be true for sharing knowledge with clients.

rather than with the support of a statistical tool – in the four clusters already indicated above (see table 6: market and customer relations, human resources, organisational memory and capture). The overall mean values have been calculated for these clusters. Not surprisingly, for the whole sample the effects on human resources are biggest, followed by the market effect, while the direct KM functions organisational memory and capture of knowledge from outside were rated considerably lower, especially knowledge capture is – relatively speaking – rather poor. As the practices to capture knowledge are used rather broadly (see above), there is obviously ample room for improvement as to their *effectiveness*.

What is somewhat surprising, however, is the rather uniform pattern for the different size groups, the order of effects are the same and the absolute mean values are very similar (figure 7). The only obvious deviation from the general pattern is the fact that large companies report a higher average score for effects on the organisational memory; a second, minor, deviation is a very low score for the effect on knowledge capture from outside for the second biggest group of companies. This high degree of uniformity in effect patterns between size groups agrees with the uniformity in the motivation dimension (see above). Consequently, the need for and the results of drivers to employ KM do not systematically differ with size – at least at the level of the basic dimensions that resulted from the clustering approach.

Figure 7: Cluster of KM Effects - size

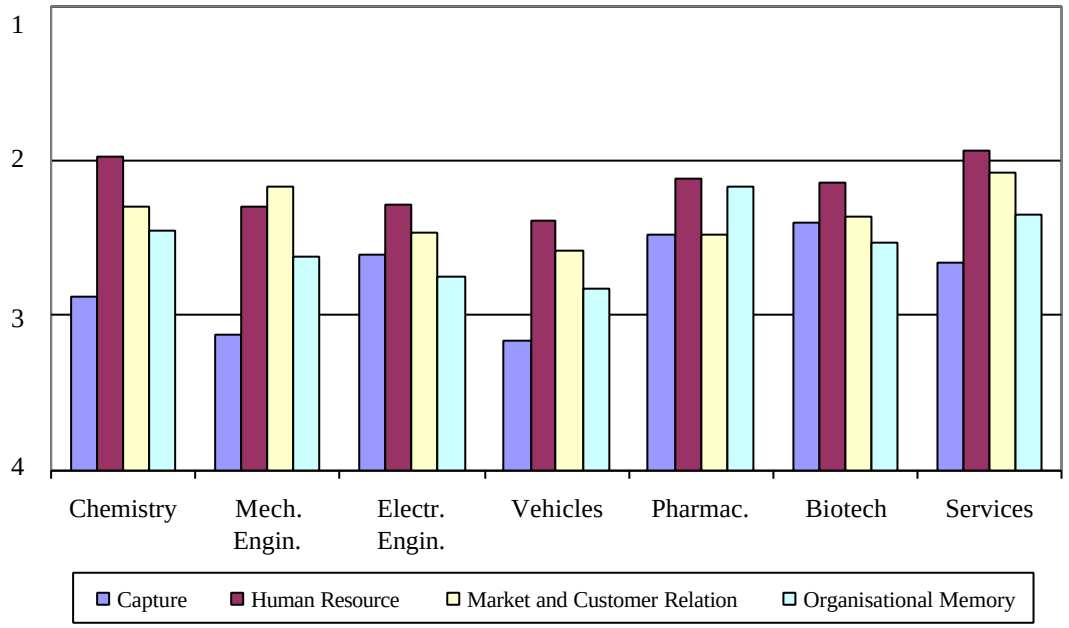


1 = extremely effective, 6 = not effective at all

Source: Fraunhofer ISI Survey 2002

While size does not matter much, the sector makes a difference regarding the prevalence of the impacts of KM (figure 8). The variation is rather small in the two most effective functional dimensions human resources and market. In all sectors except for mechanical engineering, the companies are most effective in promoting their human resources through KM practices; while market and customer relations are rated second for all but mechanical engineering and pharmaceuticals. However, there are considerable differences as regards effects to be seen within the knowledge capture dimension. Apparently, there are three sectors that severely lag behind in their ability to capture knowledge from outside the company (chemicals, mechanical engineering and vehicles), while the knowledge-intensive biotechnology sector is situated best. Finally, the sectors differ considerably in their ability to build up and improve organisational memory. Here the pharmaceutical sector is by far the most effective (mean 2.2), while the vehicle sector – again - lags behind most.

Figure 8: Cluster of KM Effects - sectors



1 = extremely effective, 6 = not effective at all

Source: Fraunhofer ISI Survey 2002

Finally, the clustered effects make again possible to explore the meaning of the usage of KM practices (clustered) on the effects. Across the board, the more instruments are used, the higher the effects reported.[36] The relation is significant for each pair of clusters, however, capture and human resource effects are correlated higher than the other effects with the usage of KM. In other words, an increase in the usage of KM measures impinges upon

[36] Effects and practices were correlated on the level of clusters, the overall relationship is statistically highly significant (1% level), the coefficient is 0.20.

the abilities to capture knowledge and to increase the capabilities of the workforce most significantly. Similar to the relation of usage and motivation, the usage of strategies and policies has the highest impact on all clusters of effects, especially as for the ability to capture external knowledge and to improve human resource.[37] The meaning of a systematic KM management and related incentive structures and value systems cannot be overestimated.

To sum up the effects of KM as reported by German companies:[38] *First*, the challenges and opportunities posed by a sector rather than the company size influence the effect of KM. *Second*, while the human resources dimension is not the key driver, the effects related to human resources are rated highest across the board. *Third*, there is a also striking mismatch regarding motivation and effects in the relations with the environment of the companies. On the one hand, the companies report high market effects of their KM activities, but these are accompanied by rather low motivation to *share* knowledge with clients. Knowledge sharing with customers is not regarded as a priority for companies in order to reach market objectives. The opposite is true for the effects as regards the capture of external knowledge. Although the use of practices to do this is distributed very widely (see above, table 3) and the motivation is at least of medium importance, the effects are reported to be rather low. As said before, the companies have recognised the importance to *capture* external knowledge, but the processes are still to be improved considerably. *Finally*, there is a strong correlation between the usage of instruments and the effects reported, and to improve performance it is most functional to try to install related strategies, policies and value systems, as these impinge upon effects strongest.

7. The Institutionalisation of KM and its Meaning for the Use of KM

7.1 Different levels of dedication towards KM

It would not be possible to fully trace the organisational design of KM in our broad understanding in a survey, given the multitude of practices and context variables – and their complex interplay. What can be done, however, is to identify the institutional commitment to KM. Three proxies for institutionalisation – or dedication – as regards KM have been asked about: (1) *dedicated budget for KM,* (2) *organisational unit or a specific manager mainly responsible for KM* and – as an additional question in the German questionnaire – (3) the *responsibility for KM at the top management level*.

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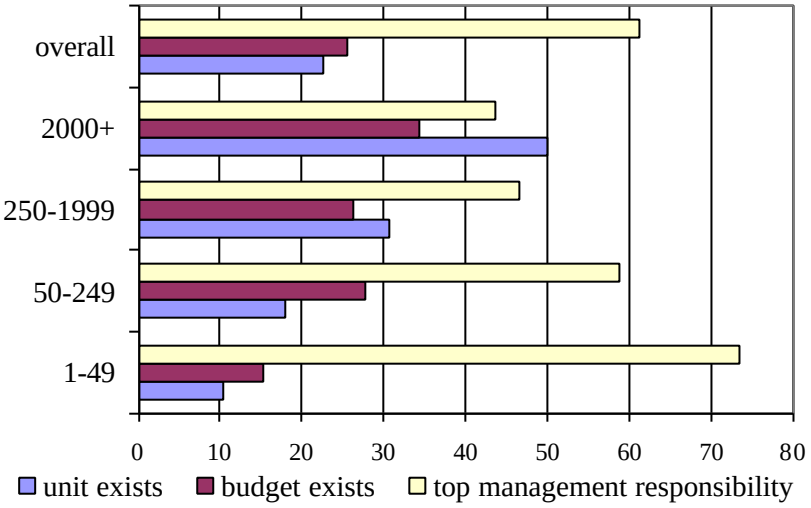
37 The correlation coefficients for the relation of policies/strategies with the effects are above 0.20 for all clusters of effects and are even higher than the effects of the overal usage of all instruments.

38 Given that nine effects have been aggregated into four clustered effect, a comparison at the level of single effects is not necessary here. The annex provides again all necessary deviation patterns and a table with the mean values for each sector and size group (annex, figure A25-A35, Table A3).

For the whole sample, top management responsibility is by far most important, indicated by more than 60% of the companies, while a quarter of the companies have a dedicated budget and slightly fewer a functional unit or responsible manager for KM (figure 9).[39]

Regarding the institutional commitment, it is obviously the size that matters rather than the sector (figure 9). There is a negative correlation between size and top management responsibility and a positive correlation for specific KM functional units and size on the other hand. This is of course to a large degree structurally determined, as the functional differentiation, especially for a relatively horizontal task like KM, is more difficult – or less necessary – for small companies. Therefore, it is hard to assess the explanatory share of the dedication for KM as compared to the minor necessity for small companies to create functional units for each specific task.

Figure 9: Institutionalisation of KM - size[a]



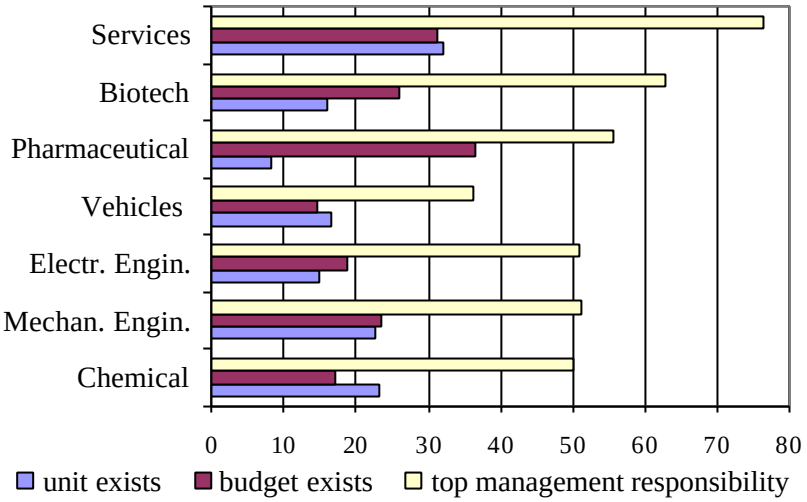
a: Percentage of companies employing the practices indicated

Source: Fraunhofer ISI Survey 2002

The sectoral patterns (figure 10) therefore reflect to some extent the size distribution of the sectors – with the notable exception of the pharmaceutical sector, which contains a very large share of companies with more than 250 employees, but still shows a very high level of top management responsibility.

39 A further indication of a rather low formal commitment is the fact that only 16% of the companies provided formal training related to KM (see above, table 2).

Figure 10: Institutionalisation of KM - sector[a]



a: Percentage of companies employing the practices indicated

Source: Fraunhofer ISI Survey 2002

Given the size bias for top management responsibility and functional units, the dedicated budget might be a better proxy for the institutionalisation of KM. The connection between KM budgets and size is not as clear-cut, as the two middle categories show rather similar values. The sector distribution shows, first, the overall importance of KM for the service companies and, second, the importance of budgets for – next to the service sector – the pharmaceutical and biotechnological sectors. As explained above (chapter 3) these two sectors are based on very knowledge-intensive technologies and on average high R&D intensity, requiring high investments in intellectual capital.

7.2 The effects of institutional commitment

Do the three different forms of organisational dedication towards KM make a difference to the effects of KM? To find out, the mean values for the nine effects can be compared between those groups of companies that report to have a budget, top management responsibility or central unit for KM and those that do not.[40] It is clear that the results derived from this comparison must be interpreted in the light of the fact that in many cases the top manager or a member of the central unit have answered themselves, and thus might be inclined to overrate the effects of their own responsibility. Apparently, *top management* commitment to KM makes the biggest difference. The mean values for *all nine effects* asked for are higher for companies with top management responsibility for KM, and these results are highly statistically significant.[41]

40 The mean values between two groups of companies were compared with the help of a T-Test (for a short explanation see the methodological annex).

41 Significance below 1%, the only exception being the avoidance of duplicate efforts in R&D, where the significance is below 5% (for the meaning of „statistical significance" see the methodological annex).

The analysis of the effect of a budget dedicated to KM is shown in Figure 11. It shows that companies with a *dedicated budget* for KM also report higher values for all effects, albeit with only four out of five differences being statistically significant[42]. A budget for KM seems to be most influential for the organisational memory (e.g. databases), the avoidance of duplicated R&D (e.g. monitoring systems) and the relationship with customers (e.g. customer knowledge management in marketing).

Figure 11: The meaning of KM budget for KM effects

1 = extremely effective, 6 = not effective at all,
* significant at the 10% level, ** significant at the 5% level, *** at the 1 % level

Source: Fraunhofer ISI Survey 2002

A different picture appears if one compares companies that have a special functional KM unit or at least a dedicated manager for KM. At first sight, the majority of reported effects are also higher (figure 12). The major effect of a centralised KM organisation is on organisational memory of companies, that apparently benefits from centralised storing, processing and sharing of information and knowledge. The same is true for the skills of the workforce being improved through centralised human resource measures. However, centralisation of KM has one major pitfall. The effects for the management of knowledge interfaces with the environment (capture of knowledge from public research institutes or other businesses, relation to customers and suppliers) are *lower*.[43] The centralisation of KM

42 With a statistical significance at the level of at least 10%.

43 For the two dimensions „capture of knowledge from public research institutes" and „relation to customers" these differences are statistically significant at the level of 5% and 10%.

through organisational units in fact hampers the openness to the outside world, as the interface function itself is reduced to – or can be delegated to – a core KM group rather than placed within the responsibility of the whole workforce. While this might improve the central overview on external effects – and support the control function – it reduces the number of possibilities for knowledge exchange with the environment.

Figure 12: The meaning of centralised KM organisation for KM effects

1 = extremely effective, 6 = not effective at all
* significant at the 10% level, ** significant at the 5% level, *** at the 1 % level
Source: Fraunhofer ISI Survey 2002

This finding in our survey strongly confirms earlier findings on the basis of cases studies on knowledge transfer between research institutes and companies (Schmoch et. al. 2000). If research institutes have a central transfer unit, the transfer of knowledge is often too indirect and those members of the organisation that are most capable of transferring or absorbing knowledge – the researchers themselves – are not involved in the communication with potential recipients, they have few possibilities and incentives to do so. The same is true for the receiving companies. On the other hand, if institutes and companies have organised their research and development in order to enable or even demand exchange of the researchers themselves, transfer is much broader, more direct and thus more effective. Thus, it is obvious that while KM centralisation within an organisation leads to efficiency and effectiveness on key dimensions relating to internal KM, in order to improve exchange with the environment companies may think of organisational and incentive structures enabling their workforce to communicate directly with outside actors. Ideally, this de-centralised

approach would have to be integrated with the more centralised internal knowledge management systems.

8. KM and its Role within Innovation Management

8.1 Employment of Knowledge Management: Innovators vs. Non-Innovators

As a consequence of three major trends sketched out already at the beginning of this study, a comprehensive analysis of KM must take into consideration the meaning of KM for the innovation process. *First*, there is no doubt that the capacity to innovate is the major precondition to withstand the competitive pressure, and companies are increasingly geared towards efficiency gains in order to speed up innovation and maximise the realisation of its innovation potential. *Second*, the catch word of „knowledge economies" points to the fact that the importance of knowledge for competition as well as innovation has grown. Consequently, and the analysis so far supports it, strategic and especially operative management is increasingly employing KM tools. *Thirdly*, companies are more and more at their limits when it comes to providing the necessary input for innovation, especially for innovation based on in-house research and development (R&D). What is increasingly called for is to absorb knowledge from external sources and integrate it within the knowledge stock and flow of the company. Together, these three trends make the connection of KM and innovation management sensible, if not indispensable.

One key hypothesis derived from these considerations is that there is a relationship between the employment of KM and the innovation activities. To test this hypothesis, the responding sample can be grouped along the dimension innovation performance (product and process innovation) and R&D activities. Thus the sample was divided into

- innovators (N=294) and non-innovators (N=203) for products,[44]
- innovators (N=380) and non-innovators (N=90) for processes,[45]
- companies with (N=267) and without an R&D department (N=222).

For all three innovation dimensions we compared the mean value for both groups in the usage of KM, the motivation for and effects of KM.[46]

First of all, there is no statistically significant relation for the motivation to use KM and the effects reported, innovators are not motivated to use KM differently from non-innovators nor do they report higher effects. However, they use more KM practices, the relationship between KM usage and innovation are positive and significant. In terms of the four clusters of KM practices (table 3 above), the *product innovators* show a significant positive rela-

44 Product innovators are defined as companies that in the period from 1999 to 2001 had a share of turnover with new or considerably improved products above 10%.

45 Process innovators have introduced a new internal process within the same period.

46 By means of a T-Test.

tionship for the two clusters communication and, extremely significant, knowledge capture.[47] Successful innovation for the market therefore has to do with the ability to store and communicate knowledge internally and, above all, to tap into the knowledge sources outside the company.

For *process innovation* the relationship is even stronger, the process innovators use significantly more KM in each of the four KM clusters than non-innovators.[48] Without claiming causality, we can nevertheless conclude that the ability to change processes goes hand in hand with the willingness to employ KM practices broadly.

Finally, *companies performing R&D* are also more active in employing KM, both for the total number and for the two clusters communication and capture. Especially for capture, the difference is significant: Out of the five instruments in the category capture, the companies that are active in R&D on average employ 4.4 KM instruments, those without R&D employ 3.8 instruments.

8.2 The Capture of Knowledge for the Innovation Process

8.2.1 Introduction

A major purpose of this study is to analyse the changing meaning of capturing knowledge from outside the company. Up to now several preliminary – and somewhat contradictory – conclusions about the capture of knowledge can be drawn. *First*, it has become clear that practices to capture knowledge are crucial, in fact, of all four dimensions analysed above, they have the highest distribution rate. *Second*, the capture of external knowledge in general has only a medium importance as a motive of KM. One explanation might be that companies feel they have enough practices in place to capture knowledge and intensifying this line of knowledge management is no longer a major concern. However, this might be shortsighted, since at the same time – and this is the *third* conclusion – the effects of capturing knowledge are lowest of all effects asked for in this study. A thesis derived from these observations, which needed more analysis at the basis of case studies – might Apparently, companies do have practices to capture, but it is not their major concern (i.e. motive) and therefore these practices are rather unsuccessful. Finally, those companies which are innovative or perform R&D are significantly more likely to utilise instruments to capture knowledge, although they report no higher effectiveness in doing so.

The questions to be answered in the following chapters are: To what extent do the companies actually acquire *external* technological knowledge? What are the special motives for knowledge capture as regards the innovation process. What are sources and practices of the

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47 Tested with Chi-Square-Test, level of significance for communication is 10%, for capture it is 1%.

48 Level of significance is below 1% for all categories.

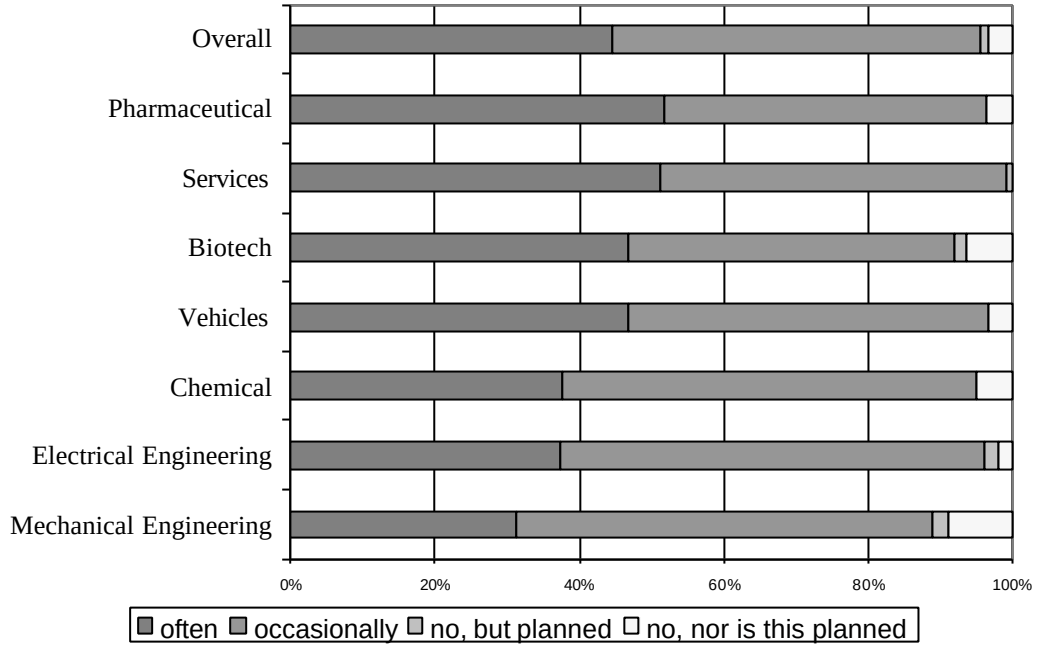
capture? Given the impact of science as a knowledge source the focus is somewhat on research institutes, but not exclusively. Furthermore, how is the process to define demand and monitor supply for external knowledge organised and what hinders a better capture performance? How are these dimensions related to each other, for example, how do practices to use and manage external technological knowledge impinge upon innovation performance or the knowledge about external knowledge? The remainder of this study will try to shed some light on these aspects, first in describing and differentiating them as for size and sectors, second by analysing some key relations between the variables.

This special relation between capture and acquisition instruments, on the one hand, and innovation – respectively R&D – activities on the other hand, confirms and further specifies a hypothesis made earlier, according to which *the absorption of external knowledge is a key activity for innovative companies*. However, given the somewhat puzzling picture of the overall motives and effects of knowledge capture, this crucial relationship of innovation and capture needs further analysis and qualification. As the interest here is on the innovation (and R&D) dimension rather than organisational or market knowledge, the focus is on external *technological* knowledge which is defined as *external knowledge that directly impinges upon the innovation process.* In the questionnaire this definition was accompanied by examples such as „knowledge about technologies, methods, scientific results etc.“.

8.2.2 The – growing – meaning of knowledge absorption

First of all, the vast majority of companies use external technological knowledge. 46 % of all companies use it „often”, 51% of all companies use it at least occasionally (figure 13). This is true for all size groups, i.e. small companies rely as much on external technological knowledge as big ones. While the occasional use of external knowledge is true for all sectors, it is clear that some sectors – especially pharmaceutical and services – use external technological knowledge more often than others (especially electrical and mechanical engineering) (figure 13).

Figure 13 Usage of external technological knowledge[a]



a: percentage of companies

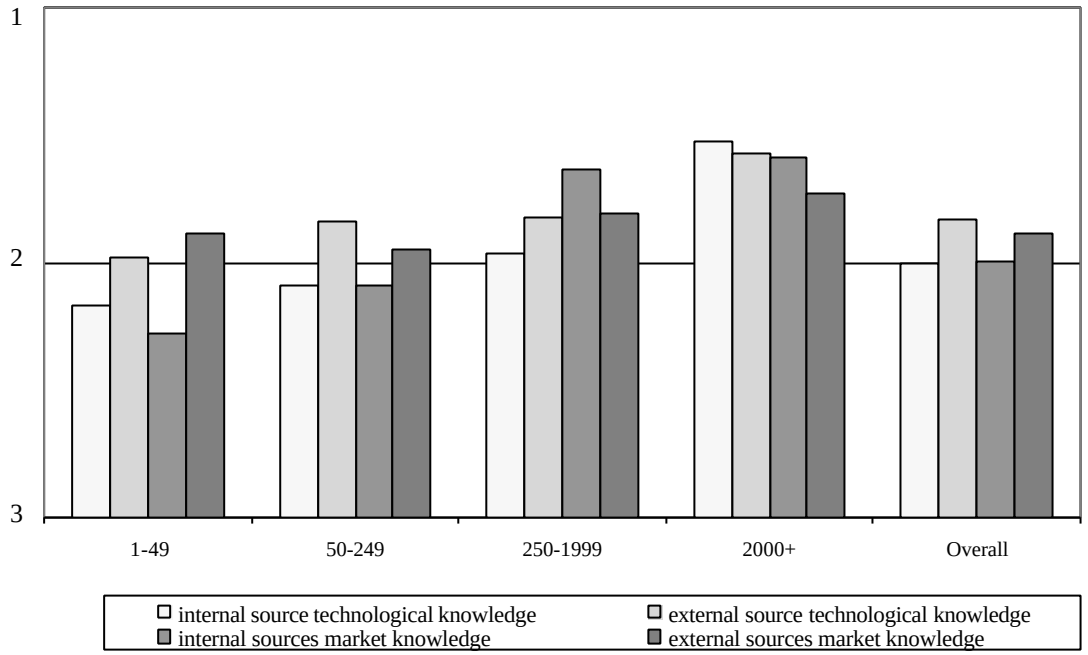
Source: Fraunhofer ISI Survey 2002

Usage in itself does not reveal the whole story of the significance of external technological knowledge. Therefore, the companies were asked about the *importance* of internal and external sources of knowledge. Furthermore, for the sake of comparison, they should indicate this importance not only for technological knowledge, but also for market knowledge.

First of all, external sources are no minor complement, but a major source. For the whole sample, external knowledge sources are more important than internal ones. (Figure 14). Secondly, as regards *technological* knowledge external sources are even slightly more important for the whole sample than external sources as for *market* knowledge. This finding again confirms on of the underlying hypotheses of this study that the interface for knowledge transfer related to the innovation process of companies is of overwhelming practical relevance for the companies.

As regards a differentiation of the sample, just as with the employment of KM practices in general, the importance of sources for knowledge correlates with size. The bigger a company, the higher the rating for the importance of external technological knowledge. Interestingly, however, compared to internal sources external ones have a relatively higher importance for smaller sized companies. As small companies are not able to produce the knowledge inside their company to the same degree as bigger ones and also use external knowledge very often (see above), it is obvious that interface management is a crucial dimension, not only for big companies, but especially for SMEs.

Figure 14: Importance of sources for technological and market knowledge - size



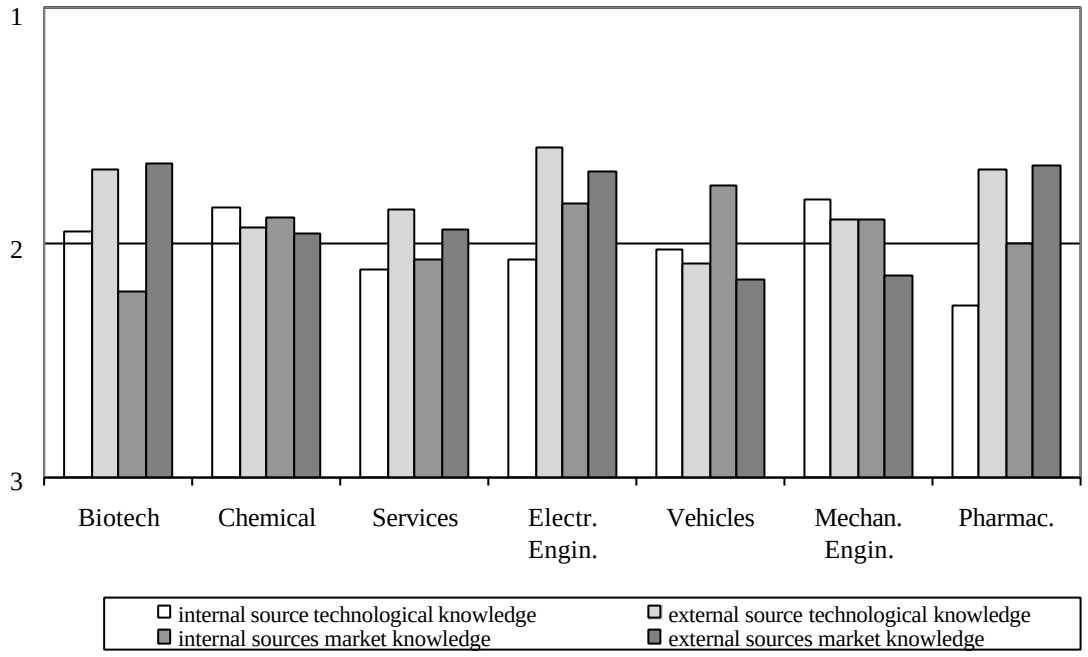
1 = extremely important, 6 = not important at all

Source: Fraunhofer ISI Survey 2002

The sector differences are less clear-cut (figure 15). For four sectors – services, pharmaceuticals, biotechnology and electrical engineering – the external knowledge sources are much more important than the internal ones, while the companies of the remaining three sectors rate internal sources as more important.

As for *technological knowledge*, the pharmaceutical and electrical engineering sectors are extremely outwardly oriented. This is in strong contrast to the two traditional sectors mechanical engineering and vehicles, which are still less outwardly oriented, while the chemical sector is somewhere in-between.

Figure 15: Importance of sources for technological and market knowledge - sector



1 = extremely important, 6 = not important at all

Source: Fraunhofer ISI Survey 2002

To benefit from external sources, companies need to have adequate absorptive capacities. Next to the time and money a company can afford, it is the technological or scientific competence that determines absorptive capacities most, as has been shown in case studies on knowledge transfer from public research institutes in Germany (Edler 2000) as well as on firms (Reinhard 2000). These findings can be confirmed and further specified. The companies claiming a technological competence level that is above the average of the sample rate the meaning of external sources higher[49]. The direction of causality is not clear, but a mutual dependence of internal competence on the one hand and absorptive capacity on the other hand is obvious.

Not only is the external sourcing of technological knowledge important *now*, the importance is evolving very dynamically. More than 75% of the companies indicate the meaning of external technological knowledge has grown in the past, and 78% of all companies expect the meaning of external technological knowledge to grow in the future (table 7).

[49] For companies with a higher competence in technological areas peripheral to the core business the relation is highly significant, for the companies with above average competence in the core areas the mean is still higher, but not statistically significant way.

Table 7: Growing meaning of external technological knowledge - size

Percentage of companies indicating that the meaning of external technological knowledge....

	Total	1-49	50-499	500-1999	2000+
...has grown in the past	73.1	68.5	74.9	71.0	78.3
...will grow in the future	77.6	73.8	77.7	75.7	86.4

Source: Fraunhofer ISI Survey 2002

While again the meaning of external sources will grow most for the very big companies, the tendency is true for all company sizes. As for sectors, only the vehicles sector deviates to some extent from this pattern, with 64% indicating more future importance (table 8).

Table 8: Growing meaning of external technological knowledge - sectors

Percentage of companies indicating that the meaning of external technological knowledge....

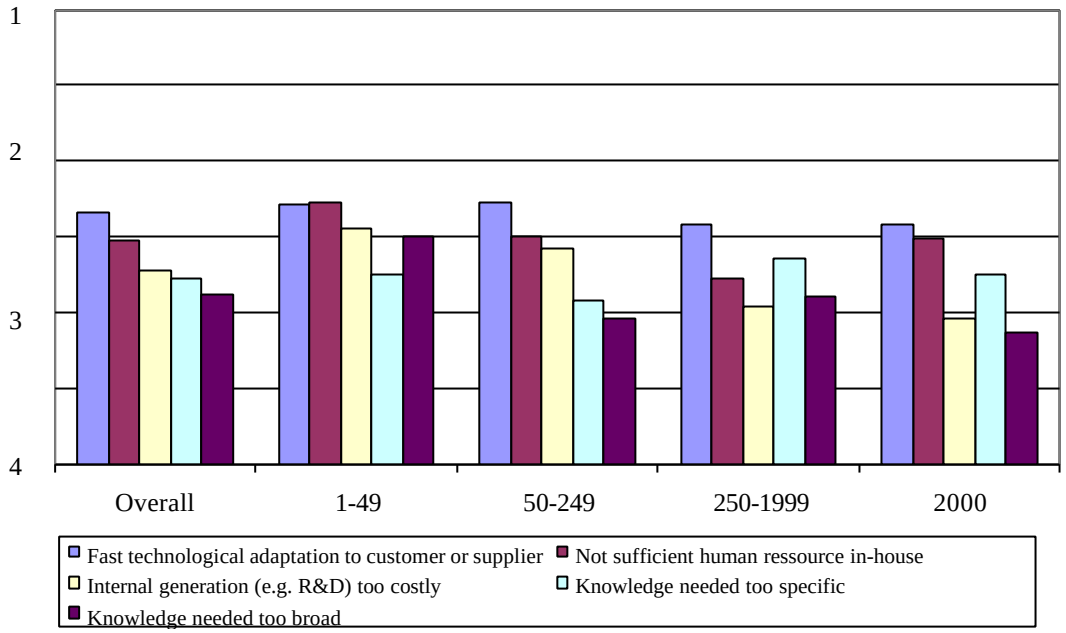
	Chemistry	Mech. Eng.	Electr. Eng.	Vehicles.	Pharmac.	Biotech.	Services
...has grown in the past	76.2	76.7	77.2	74.2	85.7	72.1	73.5
...will grow in the future	85.0	84.8	87.5	63.6	89.7	78.3	73.0

Source: Fraunhofer ISI Survey 2002

8.2.3 Drivers to utilising external technological knowledge

The companies were asked to rate the importance of 5 selected motives to use external technological knowledge. *Increasing speed* and the *lack of sufficient in-house R&D resources* are key drivers for the quest for external technological knowledge (figure 16). While the former is a consequence of intensified competition in all markets, the latter not only reflects the financial limits of employing R&D in-house, but may also point towards a possible shortage of researchers in given fields. The assumption that knowledge has become too broad (respectively too specific) to be generated internally is not false, but relative to the other obstacles only the small companies, having limited resources to cover all knowledge competences needed, rate the width of knowledge as a prime motive and almost as high as speed and in-house resources (figure 16).

Figure 16: Importance of reasons to use external technological knowledge - size

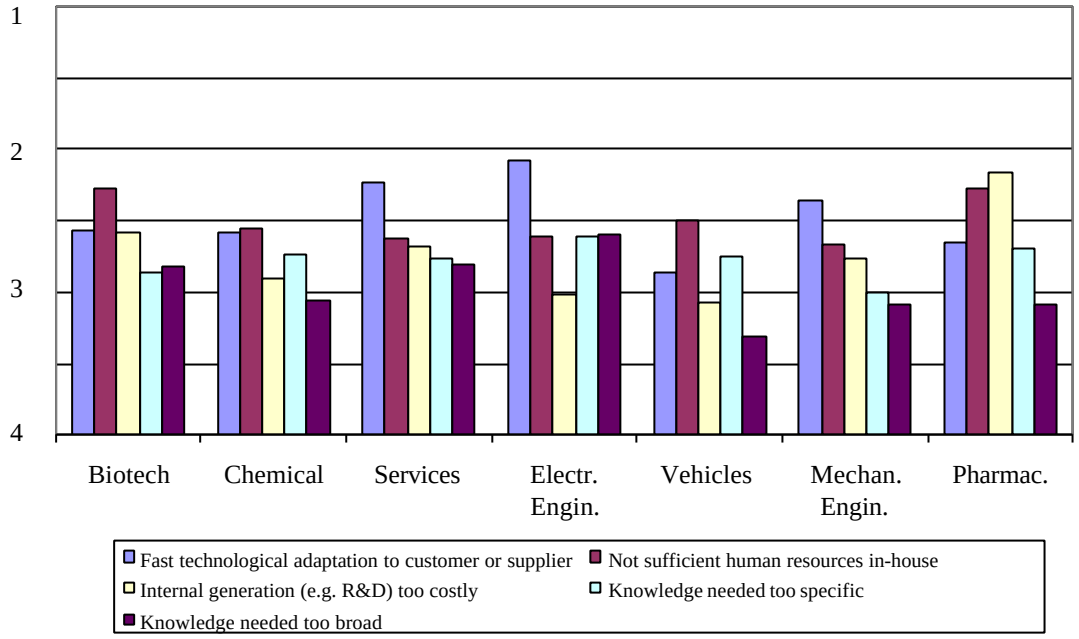


1 = extremely important, 6 = not important at all

Source: Fraunhofer ISI Survey 2002

The sectoral differences are stronger (figure 17). While the companies from the service sector and mechanical engineering sector reflect the overall pattern, the companies from the biotechnology and especially the pharmaceutical sector are driven by cost and human resource aspects. They seek external knowledge mainly because the internal generation in these knowledge-intensive sectors is too expensive and the necessary R&D workforce is scarce. This latter motive is also the most important driver for the vehicles companies. For them, however, the obvious fusion of technologies – especially the increased importance of electronics – is apparently no major driver for the technological sourcing. This is different from the electrical engineering sector, where the consequences of increasing technological fusion are the second most important motive. However, the market in this sector is extremely contested, the necessity to be quick is by far most important factor for the absorption of external technological knowledge for electronic companies.

Figure 17: Importance of reasons to use external technological knowledge - sectors



1 = extremely important, 6 = not important at all

Source: Fraunhofer ISI Survey 2002

8.2.4 Usage and meaning of sources for external technological knowledge

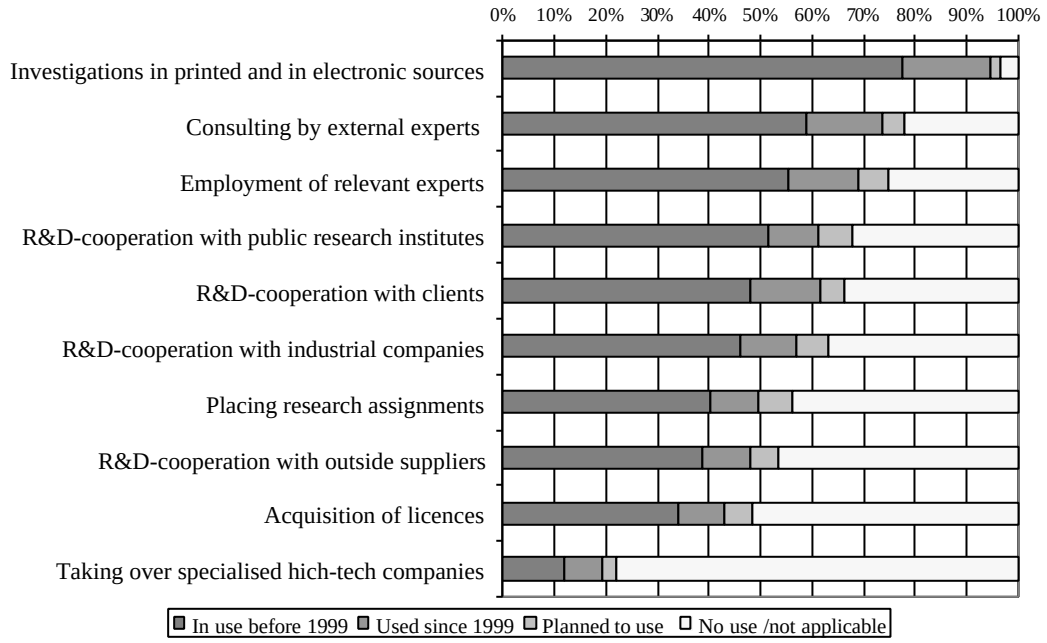
8.2.4.1 The overall picture

The companies have been asked two questions as regards the actual usage of external sources: What sources do they use, and what is the relative meaning of these sources? Figure 16 presents the diffusion of practices to acquire external technological knowledge. From what we have learned above about KM practices in general, it comes as no surprise that printed material and, more and more, electronic sources are used by almost the whole sample. Secondly, almost 60% indicate they already buy knowledge of external experts and only slightly fewer companies hire external experts, if needed, to complement the knowledge stock of the company. The practice to turn to external expertise has diffused rapidly in the last 3 years, as more than 10% of the companies have done so only recently. R&D co-operations are diffused almost equally within the sample, practiced by approximately 60% of companies. Given that only 54% of the companies have an R&D department, co-operation has an extremely high significance and is also practiced by companies which do not perform much R&D themselves. In these co-operations research institutes play a somewhat more important role as partners, however, co-operation with clients has recently increased its meaning. Co-operation with suppliers is still a bit less common, the same is

true for placing research contracts and acquiring licences. Therefore, co-operation is not only more important than buying contract research, it is also diffusing more dynamically through German industry. This reflects the fact that getting into contact with outside researchers directly is more important than simply buying solutions in the market. The most radical version of buying in technological knowledge is the acquisition of high-tech companies, which is least common; still, almost 20% of all companies have already done so (figure 18).

Figure 18 also indicates the share of companies that have used external sources only since 1999 and those who plan to use it. The only major trend is that the usage has increased for each of the sources around 10%, with more common instruments having gained even more importance. The overall pattern has not changed. The share of companies that plan to introduce in the future, however, is relatively low. Again – as with many KM measures in general – a strong minority of companies will do without it for the time being.

Figure 18: Usage of practices to acquire external technological knowledge[a]



a: in percent of the all companies answering to the various items, ranging from 386 (co-operation with suppliers) to 425 (printed and electronic sources).

Source: Fraunhofer ISI Survey 2002

In addition to the usage of practices, the companies were asked to rate the meaning of these sources in order to get a clearer picture of the importance of sources used (Figure 19).[50]

50 Here we asked for the institutional source rather than the instrument to take advantage of the source. Therefore, the items are slightly different from the previous question on the usage of instruments.

The range of sources that can be grouped under printed material/electronic sources (literature, database, Internet) are most important, only the expert exchange made possible at fairs, conferences etc. get similar values. Of all external institutions, universities[51] are most important as sources of technological knowledge, followed by other research organisations. This means that public research is more important than industrial, such as clients, suppliers or even competitors. Interestingly, private companies specialised in providing knowledge to industry are of least importance for the sample.

Figure 19: The meaning of sources for external technological knowledge

1 = very important, 6 = not important at all Source: Fraunhofer ISI survey 2000

51 „Universities here encompass „Universitäten“ and the German „Technische Hochschulen“ (technical universities).

8.2.4.2 Differentation as to size and sectors

Size

We have seen above that there is a correlation between size and the number of KM practices used in general. Therefore, a further hypothesis is that the usage of instruments to acquire external technological sources as well as the meaning of external sources are increasing with the size of companies as well. Indeed, while the *ranking* of instruments is *rather similar* in all groups, the *rate of diffusion of instruments*, as a rule of thumb, *increases with the size* of the companies. The differences as to *the meaning of sources* between the different size groups of the sample is in accordance with this usage pattern. In general, there is a correlation between the rate of usage within the groups and the meaning attributed to the sources. The bigger the companies, the higher – on average – the mean values for the importance of sources. Therefore, it is sufficient here to point only to the most striking deviation from the overall patterns just discussed for each of the size groups. More detailed material is provided in the annex..[52]

Within the group of the *smallest companies* there is only one practice which is diffused as widely as with the overall sample, i.e. the usage of printed material and electronic sources, while the rate of diffusion of all other practices is at least 10% lower. Especially the employment of relevant experts (21% lower) and R&D co-operations (on average 15% lower) are much less common for small companies. As for the importance of the sources, the rule of thumb according to which with decreasing size the importance attribution of importance is diminishing, is *not true* for companies below 50 employees. The very small companies are relying more on and dependent from external sources than medium-sized companies and thus rate their importance a bit higher than the medium-sized companies. This applies especially to literature, Internet and databases.

For companies with *more than 49 and less than 250 employees*, the pattern is similar, all practices are less common than for the sample, however, the deviations are much smaller. The three practices that deviate most are the acquisition of licences, the placing of research assignments and takeover of specialised high-tech companies. As compared to the sample, the companies attribute significantly lower values for almost all sources.

The companies with *more than 250 but less than 2.000 employees* use all practices more often than the overall sample[53] and deviate only marginally from the overall pattern. However, for them the external sources are less important than for the overall sample, the only

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52 The annex provides for each size group a table with values (table A4) and the deviation patterns at the level of single items, both for the usage of instruments (Annex A 48 – A 51) and the importance of sources (Annex, figures A 37 – A 40).

53 The only exception being investigation in printed material and Internet, which is slightly less common within the group of companies with 250 to 1999 employees.

positive deviation for these companies is the high importance of management consultancies.

The *very large companies* (above 2.000 employees) are not only extremely more active, their ranking of practices also differs most. The rate of diffusion is for all instruments but printed material/electronic sources at least 17% higher compared to the sample. Most strikingly, almost 90% of the very large companies place research assignments to outside R&D providers, compared to less than 50% for the overall sample. Research assignments are the fourth most important source for external companies. Similarly, more than 70% have acquired licenses (sample: 42%) and more than 50% have already taken over specialised firms (sample: 19%). As for R&D co-operations, the most important partners are public research institutes, that have cooperated with 85% of the very large companies (sample: 61%). Co-operation with clients (80%) and suppliers (76%) are slightly less common, but still much more so than for the rest of the sample.

In sum, the bigger the companies, the more widely and intensively do they use external technological sources, taking advantage of financial capabilities as well as paying tribute to their broad technological needs. Regarding the importance of the sources used, the very big companies attribute much more importance to management consultancies and public research institutes, respectively universities, than the overall sample.

Sectors

The differentiation for sectors is, again, less clear-cut, but some overall patterns can be identified.[54] The *service* companies use all but two instruments much less than the sample, i.e. consulting by external experts and printed material/Internet.[55] This is fully in line with the attribution of importance, as the Internet and literature are also the most important sources, the latter is also the only source that the service companies rate more important than the sample overall. As only 23% of the service companies have an R&D department – most likely confined to development rather than research – they place much less research assignments and co-operate much less in R&D than the sample. If they co-operate, it is mainly with clients and – to a lesser degree – with suppliers.

The sector which is most active in using instruments to acquire external technological knowledge is the *chemical sector*. While the ranking of instruments (according to their rate of diffusion within the sector) is almost identical to the overall sample, the chemical companies use all instruments asked for more widely than the sample. On average, the percentage of companies using the instruments is 10% higher than for the sample as a whole. The

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54 The annex provides for each sector a table with values (table A4) and the deviation patterns at the level of single items, both for the usage of instruments (Annex A 52 to A 58) and the importance of sources (Annex, figures A 41 - 47).

55 This confirms Blind et. al. 2000, who have analysed the innovation sources for service companies in Germany.

greatest deviation from the overall sample is to be observed for the placing of research assignments, more than 70% of the chemical companies have already outsourced the generation of technological knowledge needed. However, at the same time, compared to the overall sample the chemical companies attribute less importance to most of the instruments they use. This is especially true for universities and other public research institutes as knowledge sources.

The comparison of the other sectors with the overall sample shows no regular pattern. Therefore, it may suffice to point to some „highlights" as for each sector. The companies of the *biotechnology* sector concentrate their efforts very clearly on the R&D co-operation with public research institutes (more than 76% of companies) and with industrial companies (72%), as well as on placing research contracts, while the co-operation along the vertical axis (suppliers, clients) is less common. However, universities and other public research institutes[56] are rated much higher in their importance as sources as compared to other organisations. Interestingly, management consultancies have significantly less importance as knowledge sources.

The *pharmaceutical* companies use, similar to the chemical companies, almost all of the instruments more widely than the sample, but in contrast to the chemical companies, put extreme emphasis on the acquisition of licences, the placing of research assignments and the R&D co-operation with industry, while R&D co-operations with public research institutes are only slightly used above average, and the R&D co-operations with clients and suppliers are much less common. As for the importance of sources used, the pharmaceutical companies have a deviating pattern. Compared to the overall sample, management consultancies, other companies and, above all, private research institutes are much more important in the pharmaceutical sector. The public research institutions, in contrast, are rated lower.

The companies from the mechanical engineering, electrical engineering and vehicle sectors show the least deviation from the overall pattern. The *electrical engineering sector* is more active if it comes to the acquisition of high-tech companies and co-operation with suppliers. As for the importance of the sources, the knowledge sources as regards codified knowledge are a bit less important, while advanced technical colleges and other firms are rated higher.

The *mechanical engineering* companies strongly deviate from the sample in one respect, they co-operate much more broadly along the vertical axis, i.e. with suppliers and clients, while co-operation with research institutes is only slightly more common. This agrees with the attribution of importance, as other firms, both related and not related to the company, and management consultancies are rated above average, while universities and sources for codified knowledge are less relevant.

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56 Advanced technical colleges have less relevance for the biotechnology sector.

In their usage of instruments, the *vehicles* companies deviate strongly from the sample only in co-operating much more with suppliers than the sample as such (while their co-operation with clients and research institutes is in accordance with the overall sample). Furthermore, for the vehicle companies it is very common to place research assignments, almost 75% have done so, compared to around 50% of the sample. As for the importance of sources, advanced technical colleges, as application-oriented higher education organisations, and management consultancies get significantly higher values, while – like in the mechanical and electrical sector – sources for codified knowledge are much less important.

8.2.4.3. The relation of using different knowledge sources to the innovation performance

We have seen above that the share of frequent users of external technological knowledge within the group of product innovators does not differ from the share of frequent users within the group of non-innovators. However, this is true for the acquisition of technological knowledge *in general*. If one distinguishes between the various instruments – respectively sources – of external technological sources, the picture changes completely. If companies are asked specifically as to what source they actually use – rather than asking for general acquisition of knowledge –, innovators are significantly more likely to exploit external knowledge sources than non-innovators. Table 9 displays the percentage of innovators within the groups of companies which have used or are using the various instruments to acquire external technological knowledge. The share of innovators is significantly higher for the companies that are able to internalise external knowledge altogether (take over, employment of experts) or directly co-operate with external knowledge providers, while it is only marginally higher in companies using external printed sources. It is the kind of source and, equally important, the mode of sourcing, that make the difference, not the quantity.

While the exploitation of the two most significant sources (taking over of high-tech companies, placing research assignments), is biased towards the big companies (see above), R&D co-operation with industry in general, research institutes and suppliers as well as the acquisition of licences are significantly related to innovation for the whole sample.

Table 9: Meaning of different instruments to source external technological knowledge

Percentage of product innovators out of...

the overall sample	40.8%
the groups of companies...	
Taking over specialised high-tech companies***[a]	54.2%
Placing research assignments***	49.8%
R&D-cooperation with industrial companies***	49.6%
Acquisition of licences***	48.9%
R&D cooperation with public research institutes***	47.6%
R&D cooperation with suppliers**	46.3%
Employment of relevant experts**	45.4%
R&D cooperation with clients*	44.8%
Investigations in printed and in electronic sources**	42.6%
Consulting external experts	42.5%

a = the overall number of – mainly big – companies using this instrument is only 83 (16.7%).
* significant at the 10% level, ** at the 5% level, *** at the 1 % level

As for the *importance* attributed to various external sources, innovators differ only slightly from non-innovators. They rank 5 out of 11 sources as more important, and only three of these in a statistically significant way: universities (!), databases and Internet. At the same time, other firms as private knowledge suppliers are rated even less important by innovators than by non-innovators, although this is not statistically significant.

8.2.5. Obstacles to use external technological knowledge

The overwhelming majority of companies in all sectors have reported that the importance of external technological knowledge has grown in the past and will continue to grow. Still, we have seen for many instruments that the rate of usage is far lower than the percentage of companies indicating growing importance of external sources. Improving external knowledge sourcing not only needs internal processes – see below – but also information about the kind of obstacles companies face in trying to acquire knowledge. The companies were asked to rate the meaning of 8 different possible obstacles. The choice of these obstacles covers internal procedural impediments (resistance, costs) as well as obstacles perceived on the side of the knowledge providers. This was guided by the hypothesis that there are several internal causes that act as an obstacle to better acquisition of knowledge.

So far, in most analyses – and certainly in the perception of companies – the obstacles are mainly searched for within the knowledge suppliers. For example, a survey of German industrial federations by Nicolay/Wimmers (2000) asked German companies about their satisfaction with research institutes as providers of knowledge and technical solutions. That survey did not ask about the possible problems within the enterprises themselves. While Nicolay/Wimmers had seven variables in the survey as regards public research institutes,

our survey asked one, i.e. „the lacking appropriateness" of research institutes without further qualifying it.[57] This means whatever reasons the company had to be dissatisfied with public research could influence the grade given. A further external obstacle asked for was the readiness of other companies to co-operate. The other six obstacles all have to do with internal demand and procedures for the acquisition of external technological knowledge, i.e. with their absorptive capacities. To analyse these capacities in detail follows the conclusion of a previous study on sources for innovation (Janz et. al. 2000), according to which the knowledge absorptive capacities of companies are a crucial determinant of the success of knowledge transfer.

The overall result is striking, and strongly confirms the assumption that it is worthwhile to have a second look at the internal processes of companies. By far the most important obstacle is the reservation about revealing the sensitive knowledge of the company (figure 20). This is true regardless of size and sector of the companies and no matter if a company has an R&D department or not. However, those companies that have a R&D department are even more worried. They rate the importance of this obstacle with 2.6 on the scale from 1 (extremely important) to 6 (not important at all), while those companies without R&D rate it 2.99.[58] The lack of internal processes to discover external knowledge is the second most important obstacle. There is a clear and significant relationship between the number of contacts between firms and research institutes on the one hand and the meaning of internal processes as obstacles on the other hand. If one distinguishes between the companies that have frequent contacts with research institutes and those that do not, those having frequent contacts report lower values for the meaning of inappropriate internal processes to detect external knowledge.[59] The third most important obstacle is the unappropriate willingness of other industrial companies to co-operate, followed by a range of three internal reasons with very similar values.

The most important finding here, however, is that the inappropriateness of research institutes is – next to having any (great) need – the least important obstacle. This is true for all companies, no matter if they have already had many contacts or not or if they perform R&D or not. Therefore, an improve transfer of knowledge from public research into industry must be achieved by putting more emphasis on the internal procedures of firms. This does not mean to deny the necessity of improvements also on the part of the institutes, as Nicolay and Wimmers (2000) have done, but one should think of increasing the awareness of companies that many problems might be internal rather than external.

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57 In increasing order of satisfaction, following variables were included: „support with the implementation of results" (which received the lowest grade), „to be on schedule", the „cost-performance ratio", the „efforts" to be taken by the companies to co-operate, the „results" delivered, the „accessibility" of the researchers and finally, with the highest performance grade, competence.

58 The difference is statistically significant at the level of 10% (T-Test).

59 Level of significance is 10% (T-Test).

Figure 20: The meaning of obstacles to use external technological knowledge

1 = very important, 6 = not important at all Source: Fraunhofer ISI survey 2000

Before turning to these internal processes in more detail, a short differentiation between size groups and sectors is necessary. The order of the items is – generally speaking – similar for different size groups and sectors. However, several deviations are striking.[60] The smallest companies are struggling, more than the sample, with the cost for the search of external knowledge and with the willingness, respectively appropriateness of industrial and research partners. Small companies have bigger problems to find appropriate partners at reasonable costs. Interestingly, the fear of losing sensitive knowledge is not bigger for the small companies. This is somewhat counter-intuitive, as small companies often possess a small range of specific knowledge as key asset, the protection of which is often cited as a major obstacle for external knowledge sourcing. The pattern for the companies with up to 250 employees is similar, however, these companies indicate slightly more problems with internal procedures to actually detect external knowledge.

The pattern for the larger companies is converse to the one of the smallest companies. The companies with more than 249 employees see less problems at the side of external partners (industry and research), but more internally. Most obviously, the reservations of becoming dependent on external knowledge and giving away own sensitive knowledge are bigger for

60 For both seize groups and sectors a table with the mean values (table A 5) and the deviation figures are given in the annex.

the large companies. This reflects the fact that large enterprises increasingly perceive knowledge stocks as key competitive assets that need to be protected rather than shared.[61]

The sectors show different patterns as regards obstacles of knowledge absorption. The first group are the *biotechnology* and especially *pharmaceutical* companies, which across the board rate the obstacles lower than the sample.[62] The *service* companies show a similar pattern, but indicate high search costs as being more important. A converse pattern to the pharmaceutical companies is shown by the *mechanical engineering* companies, which sense higher obstacles across the board. They show the highest deviation in three internal dimensions: internal resistance, reservations about giving knowledge away and reservations about becoming dependent on external knowledge. This sector certainly is the most closed to the knowledge environment, and the solutions for problems of acquiring knowledge are certainly to be found within the companies to start with. The remaining group shows a mixed pattern, the *chemical* companies resemble the overall pattern most, while the *electrical engineering* as well as the *vehicles* companies sense greater obstacles internally, similar to the mechanical engineering sector, but in contrast to those companies, rate "inappropriate" research institutes and search costs as less important.

8.2.6 Diffusion and meaning of knowledge about external technological knowledge

The precondition for companies to acquire knowledge is to be informed about what possible sources have to offer.[63] To what extent do the companies feel informed about the supply? Three different sources were asked for: public research institutes in Germany, public research institutes in the region of the headquarter and, finally, private knowledge providers. For the whole sample the share of companies claiming to know about the supply in these three dimensions is rather similar (figure 21). Just above 79% of the companies know about their regional research institutes, only slightly less know about relevant research institutes throughout the country and again only slightly less about private suppliers. Again, the increasing importance of external sourcing is striking, approximately 20% of the companies indicate to have gained knowledge recently or to intend to obtain the knowledge on external knowledge supply in the future.

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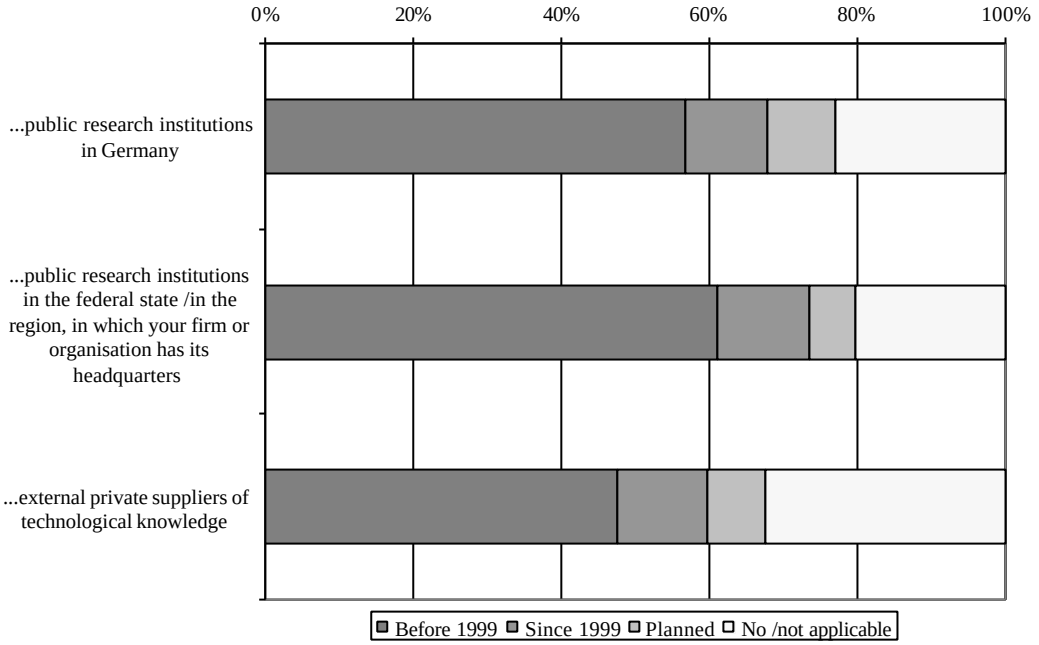
61 Fraunhofer ISI is currently conducting a study on behalf of the German Federal Ministry for Education and Research on the protection strategies of German industry. A preliminary result is that the protection of technological knowledge through patents has grown enormously in the 1990s, and a key driver is the new perception of knowledge as a strategic asset.

62 The only exception being the reservations of giving sensitive knowledge away within the biotechnology sector.

63 One criticism of companies in the past has been that the research institutes especially do not adequately inform about their competencies (Nicolay/Wimmers 2000).

Figure 21: Knowledge about external knowledge[a] – whole sample

Percentage of companies being adequately informed about external technological knowledge within...



a: in percent of the all companies answering to the various items, ranging from 340 (public research institutions in Germany) to 369 (regional public research institutions).

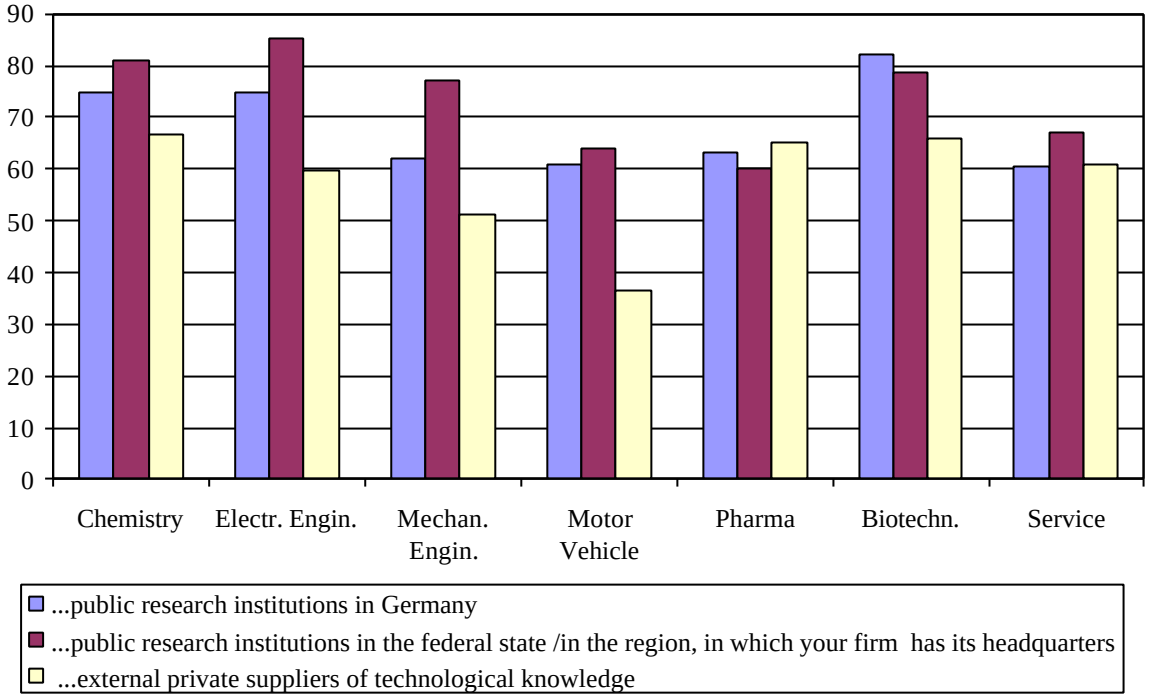
Source: Fraunhofer ISI Survey 2002

For the information on external knowledge again, the rule applies that smaller companies know less than bigger ones. The highest deviation from the overall sample can be noted with the largest companies and the share of companies claiming to know about the relevant knowledge within their region, i.e. 90 % and thus 17 percent above the sample.

The sectors again show rather different patterns (figure 22). The companies from the *biotechnology* and the *chemical* sector claim to know more on all three dimensions than the overall sample, the biotechnology companies reach out for knowledge across the country most extensively, as by far the highest share of them claims to be well informed about the research institutes in the country in general (plus 14% compared to sample). For the companies of the *electronical* sector, it is the other way round, the share of companies informed about the regional supply is greatest for them (plus 12% compared to overall sample, national supply: plus 7%). The *vehicles* companies are least informed, the share of companies is way below average in all three dimensions, most significantly as regards private knowledge providers (minus 23% as compared to the sample). The share of companies within the *pharmaceuticals* and *service* sector informed about public research in Germany as well as in the region/state they are located is lower than for the sample, as already seen above; both sectors apparently rely more on private knowledge sources.

Figure 23: Knowledge about external knowledge[a] – sectors

Percentage of companies being adequately informed about external technological knowledge within...



a: in percent of the all companies answering to the various items in each sector.

Source: Fraunhofer ISI Survey 2002

Knowing about external supply is not an intellectual practice, but impinges upon the uses of other KM instruments and has implication for the innovation performance. First, there is a strong relationship between the knowledge about external supply and the usage of KM instruments, in particular as regards the two general KM clusters communication and especially capture[64].

Second, there is a positive relationship between the knowledge about external supply, and therefore the knowledge about current trends, on the one hand, and the innovation performance. The percentage of innovators for the whole sample is 40.8%. The percentage of innovators among the group of companies that claim to know the supply of external technological knowledge in research institutes in Germany (45%) is significantly higher. The same is true for the companies informed about the supply of knowledge from private sources (47.2%).[65] There is, however, no statistically significant relationship for the information on

64 For these two dimensions the relationship is highly significant (1% level). We have conducted a comparison of the mean values of the index for the KM clusters (ranging from 1 (meaning full use) and 0) between the group of companies claiming to know more than average (across all three dimensions) and those knowing less about external supply.

65 Tested with the help of a Chi-Square test, this relationship is statistically significant at the level of 10% (public institutes) and 5% (private suppliers).

the supply of *regional* public research institutes, which might indicate that if companies source externally, they look for relevant institutes across the country rather than concentrating on the regional environment.

8.2.7 Practices to manage the usage of external technological knowledge

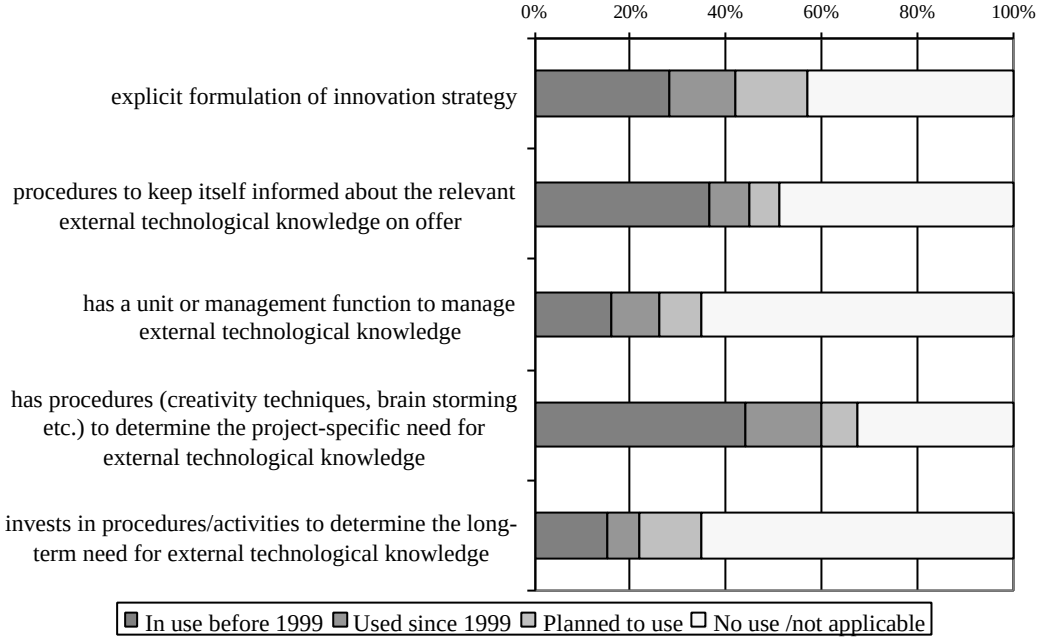
Since it has become obvious that most companies, to a different degree in the various sectors, sense that the greatest obstacles to acquire knowledge from their environment lie within their company, it is important to analyse, which kind of strategies and practices they perform in order to manage the knowledge interface to the outside world. What are the knowledge management practices to take care of the opportunities posed by the supply of external knowledge sources? If external knowledge becomes more important, one should think that the related practices are widely distributed.

Four dimensions can be distinguished. First, an explicit innovation strategy implies that the companies systematically think about their knowledge needs and the processes to satisfy them. Secondly, the companies may have procedures to monitor the external supply of technological knowledge. Thirdly, the companies need procedures to define the needs for external technological knowledge, both short-term and/or long-term, strategically oriented. And finally, the companies must organise this management and may do so with the help of a central unit or management function.

Figure 24 displays the percentage of companies using the management practices. It is obvious that the management of external technological knowledge is not diffused very broadly within industry. Slightly more than 40% of the companies (169 companies) that answered the question have an explicit innovation strategy and procedures to keep themselves informed about external knowledge (157 companies), 25% of all companies (104) have a central unit or management function. Just above 20% (73) invest in procedures to determine long-term demand for technological knowledge, while about 60% of all companies (238) at least claim to determine project-specific demand.

To a certain degree, companies are reacting to their own estimate that external technological knowledge is becoming more important. Although the rates of usage are rather low, there is a certain dynamic, since the percentage of companies which have only recently introduced or will introduce in the future is rather large.

Figure 24: Companies employing practices to manage the usage of external technological knowledge[a]



a: in percent of the all companies answering to the various items, ranging from 350 (procedures to keep itself informed....) to 401 (innovation strategy).

Those companies that already use practices to monitor the external supply of knowledge were asked in an open question to indicate which processes they use. 129 companies have done so. Table 10 below shows that the processes used are still rather traditional. Systematic research in printed material and Internet research are most important, followed by more informal networking activities and database research.

Table 10: Practices used to monitor the external relevant supply of technological knowledge[a]

	Count	Percentage of	
		responses	cases
Research in printed material	41	20.2	31.8
Internet research	38	18.7	29.5
Expert networks, informal exchanges	24	11.8	18.6
Conferences	23	11.3	17.8
Database research (e.g. patent databases)	21	10.4	16.3
Cooperations, research contracts	15	7.4	11.6
Other	41	20.2	31.8

a: open question, N= 129, multiple answers possible

Source: Fraunhofer ISI Survey 2002

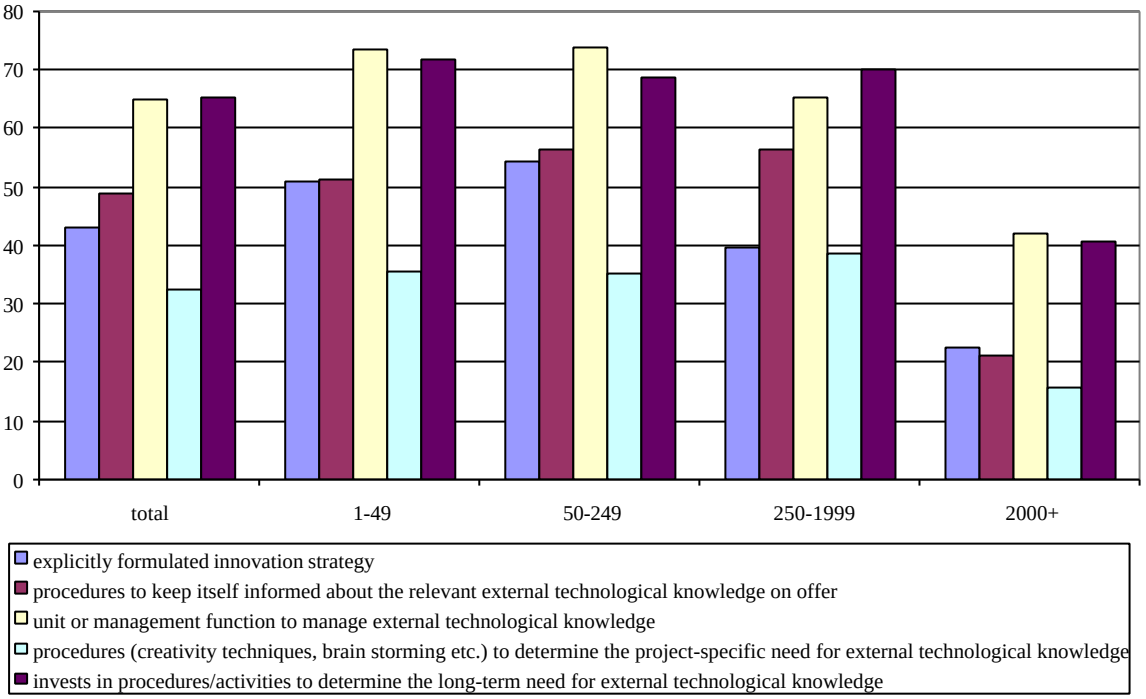
Furthermore, companies that have processes to define long-term demand for external knowledge were asked to name them. 50 companies out of 73 that have such procedures did so. The processes are very diverse and cannot be grouped into specific approaches. Processes mentioned several times include internal databases, innovation and research planning procedures, R&D co-operations, profiles of competencies, internal audits and organised discourse between researchers and management. There is no clear tendency in the employment of processes, no „new fashion", and some advanced tools such as technological road maps (3 companies) and foresight activities (no company!) are not common at all. Although the vast majority of companies indicate they will need more external knowledge in the future, the level of engagement in systematically defining the demand for knowledge is rather poor.

The size of companies determines the usage of practices to manage external technical knowledge as strongly as with knowledge management practices in general, albeit not exactly in a linear fashion. Within the group of companies that have between 50 and 249 employees the share of firms employing the practices is lowest, these companies are especially not keen to formulate innovation strategies and to install relevant central KM units. The large companies, conversely, use the practices very broadly. Three quarters of them report to have procedures to determine short-term needs and almost three quarters have procedures in place to inform themselves about external supplies. Two thirds have an innovation strategy and half of the companies have a central unit and/or invest in procedures to determine long-term needs. The dynamic is enormous, especially for the last two practices more than 10% to 15% of all companies have introduced the practice not before 1999, another 10% indicate to introduce it in the future, or plan to use it in the future. While large companies have the advantage of being able to produce in-house knowledge much more broadly and in a more interdisciplinary way, they have, in addition, managed to set up practices to process external knowledge as well. However, as smaller companies have to stand the same market tests as big ones, and often lack in-house resources to react quickly enough, a way to improve their situation would be to invest more efforts in the management of external interfaces.

As we will see below, the management of external technological knowledge is critical. Therefore, it is telling to display the share of companies that *neither use nor plan* to use these management practices in the future. Figure 25 demonstrates for the size groups that two thirds of the companies will neither have a responsible unit or management function nor will they have procedures to detect the long term demand for external technological knowledge, while two thirds at least determine their short term needs. Innovation strategies and procedures to be informed about external knowledge supply will be diffused through half of the sample.

Figure 25: The non-usage of specific practices to manage external technological knowledge

Percentage of companies **neither using nor planning** to use management practices related to external technological knowledge – size



Source: Fraunhofer ISI Survey 2000

From the overall meaning of size for the usage of the specific management instruments, it derives that the sector differences are less spectacular. Again, only the strongest deviations from the overall patterns need to be reported. The most active companies stem from the *chemical* sector, which have a larger share for four out of five practices,[66] they are especially strong in determining long-term needs. This is in line with the broader *usage* of instruments to acquire external technological knowledge in this sector (see above). This is not simply a size effect, as the *vehicle* sector, which contains even more large companies, only equals the overall sample for four practices and is extremely (!) weak in monitoring the external supply of knowledge. The *service* sector and the *mechanical engineering* sector resemble the overall sample very much. Almost the same is true for the companies from the *electrical engineering* sector. However, these companies have explicit innovation strategies much more often than the sample, without having more of the other four practices in place. Apparently, for these companies external knowledge management is no integrative part of their innovation strategy. Finally, the *pharmaceutical* companies have one strong positive (procedures to be kept informed) and one strong negative (determine the project-specific need) deviation. Since these companies use the instruments to acquire knowledge more broadly than the sample, the monitoring of supply is an important means to enable companies.

66 The share of companies having procedures to determine short-term needs equals the overall share.

8.2.8 Characteristics of users of external technological knowledge

The companies that frequently use external technological knowledge can be further characterised by analysing the relations of the key variables as regards technological knowledge just described. This paragraph focuses on the use of external technological knowledge in general, i.e. it does not yet differentiate between different knowledge sources. A series of statistical tests have been conducted in order to tackle a couple of important questions: What determines the acquisition of external technological knowledge? Is there a clear connection between innovative activities and external sourcing? Do the instruments related to the management of external knowledge have effects on the frequency to actually acquire external technological knowledge at all? Is there a positive relation between knowledge about external sources and actually sourcing external knowledge? And finally, do frequent users sense lower obstacles to acquire knowledge?

The basic idea is to compare the percentage of companies of the overall sample using external technological knowledge *frequently* with the percentage of frequent users in several sub-samples that show certain characteristics, such as having an innovation strategy or not, performing R&D or not etc.[67]. Therefore, the reference is the overall percentage of 43.5% of all companies using external knowledge frequently. The results of the percentage comparison are presented in table 11.

First of all, the mere existence of an R&D department or an innovation strategy makes no difference whatsoever, i.e. the sourcing of technological knowledge is not more common in companies that have an R&D department or an innovation strategy than in those which do not. At the same time, however, sourcing of external technological knowledge is also no substitute for R&D performance, as it is *not* more common for non-R&D performing companies than it is for those performing R&D, or having an innovation strategy. Furthermore, the mere *frequency* of sourcing external knowledge is not linked to the *innovation performance*, in other words, the sample of innovators is not using external sources more often than the sample of non-innovators. Although at first sight this is puzzling, it is nevertheless in line with the conclusion made earlier that it is the *kind of sourcing* (full internalisation, direct placement of research contracts or co-operation) that *leads to better innovation performance*, not the quantity.

Finally, although almost all companies have reported that external knowledge has become more important in the past, it is clear that many companies still innovate without relying on external technological knowledge.

However, while the innovation and R&D performance does not discriminate as to the use of external technological knowledge (in general), the practices to monitor supply of, and define demand for, external technological make a difference. Of the companies employing

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67 The statistical tool to detect significant differences in percentages was in each case a Chi-Square test.

practices to monitor the supply of external knowledge, 59% use external technological knowledge frequently – as compared to 43.5% for the whole sample – while of those companies without practices to monitor external knowledge, only 34.2% use external technological knowledge.[68] This relationship between institutionalised monitoring and actually using external technological knowledge is also true – but slightly weaker – if there is a special unit responsible for the management of external technological knowledge. A strong relationship also exists between the practices to define long-term *demand* for technological knowledge and the related sourcing activities.

In sum, it is obvious that specifically defined attempts to care for the sourcing needs and supplies – as well as the direct contacts to external actors (see above) – make the difference in benefiting from external sources, the mere existence of an innovation strategy or the ad hoc definition of project-specific demand does not significantly increase the likelihood of actually sourcing external technological knowledge frequently.

Table 11: The meaning of using external technological knowledge *frequently*

Percentage of companies using external technological knowledge frequently out of...

the overall sample	43.5%
the groups of companies...	
...using practices to monitor relevant external supply***	59.2%
...using practices to define longterm demand**	56.4%
...having a unit to manage external technological knowledge***	55.6%
...claiming to know the supply of private knowledge providers***	51.0%
...claiming to know the supply of regional public research institutes**	49.3%
...having an innovation strategy	48.2%
...claiming to know the supply of public research institutes in Germany**	47.5%
...using practices to define project specific demand	46.7%
...being product innovators	44.6%
...being process innovators	43.6%
...having a R&D department	43.2%

** significant at the 5% level, *** at the 1 % level

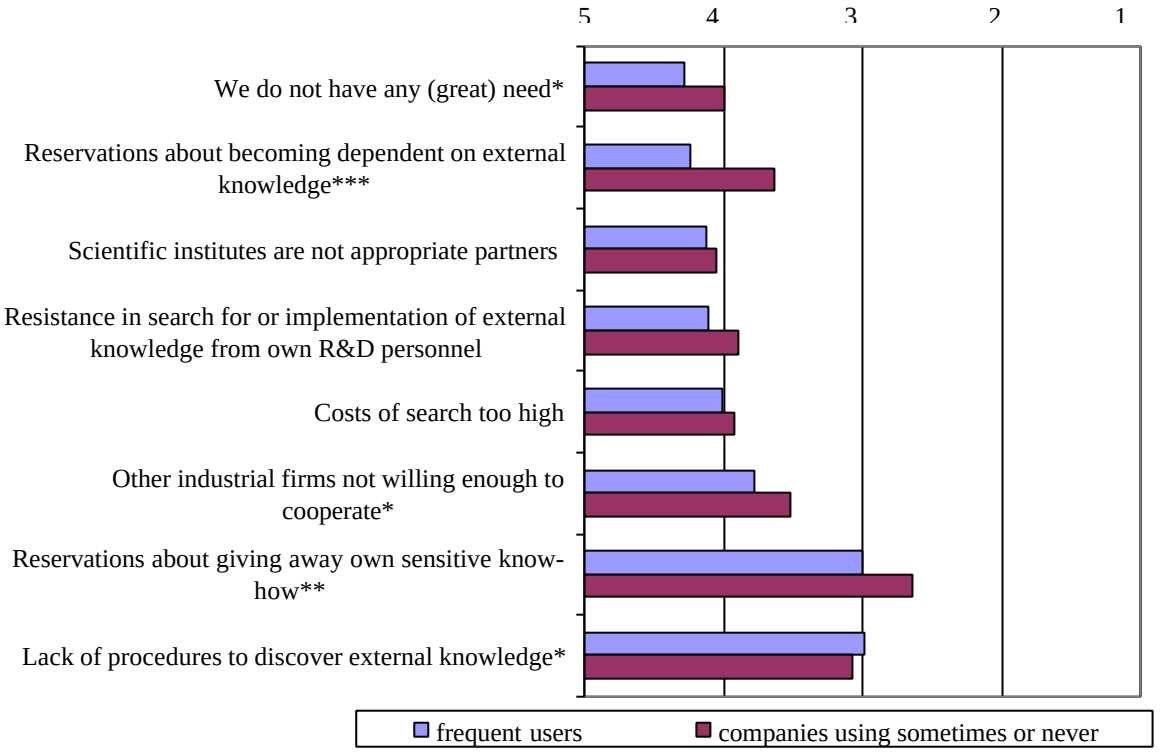
Source: Fraunhofer ISI Survey 2002

Finally, does the use of practices to manage the sourcing of external technological knowledge reduce the hurdles to actually source external knowledge? Comparing the perception of obstacles by companies that use external knowledge often and those that do not, not surprisingly, frequent users rate most obstacles lower (figure 26). The most important difference is that frequent users are less worried, or have made less worrisome experiences, about becoming dependent on external knowledge or giving away own sensitive knowledge. This means that in order to source external knowledge, companies need to overcome the fear of

68 Tested by means of a Chi-Square test, highly significant at the 1% level.

knowledge loss and dependency. Strikingly, the frequent users are even more self-critical than the rest of the companies, they rate the lack of adequate internal processes slightly higher. By using external knowledge, the companies experience that there is ample room for improvement in procedures and practices.

Figure 26: The importance of obstacles – frequency of using external technological knowledge



1 = extremely important, 6 = not important at all,
* significant at the 10% level, ** at the 5% level, *** at the 1 % level

Source: Fraunhofer ISI Survey 2002

8.2.9 The effects of practices to manage external technological knowledge

The final analytical question to be answered is, if the management practices as regards external technological knowledge make a difference. The main hypothesis was that external technological is critical and therefore it is important to care about it systematically, and those who do perform better than those who do not. If this was true, than a major requirement for the future would be to take this dimension more into consideration.

Diminishing of Obstacles

How do the management practices regarding external technological knowledge impinge upon the perception of obstacles?[69] Comparing the mean values for the obstacles between the users and non-users of the instruments to manage external sources, the answer is: Yes, but not across the board of obstacles.[70] Companies with instruments to define the demand of external knowledge see the willingness of other companies to co-operate and internal procedures to manage external knowledge as less relevant obstacles. The same is true for the companies with a central unit to manage external knowledge or with processes to monitor supply of technological knowledge. In addition, for these latter groups the fear of becoming dependent on external knowledge is also less important. Moreover, the search costs play a minor role for companies with a central unit to manage external knowledge and for the ones that have an innovation strategy.

While this picture makes no clear-cut pattern, it is nevertheless obvious that those companies which systematically monitor and manage external knowledge also rate obstacles lower than those companies which do not. What is interesting, however, is the fact that the values for the obstacle that scientific institutes are not adequate partners is not influenced significantly by the instruments to manage external technological knowledge. The explanation seems rather simple, the values for this obstacle are very low for all companies, no matter how they manage – or do not manage – their external sourcing. As stated above, this puts the claim that research institutes are no adequate partners and must alter their policy as regards knowledge transfer (Nicolay/Wimmers 2000) – which in many cases is well justified - into perspective.

Improving information about knowledge supply

There is an extremely strong correlation between the usage of instruments to manage external technological knowledge and the knowledge about the supply of external knowledge within the relevant workforce of the companies. The deviation in percentage of companies indicating they know about the external supply between the overall sample on the one hand and the companies employing the instruments to manage the external knowledge on the other hand is extremely significant (see figure 27).[71] In other words, it pays to invest in practices to take care of the supply of and demand for external technological knowledge.

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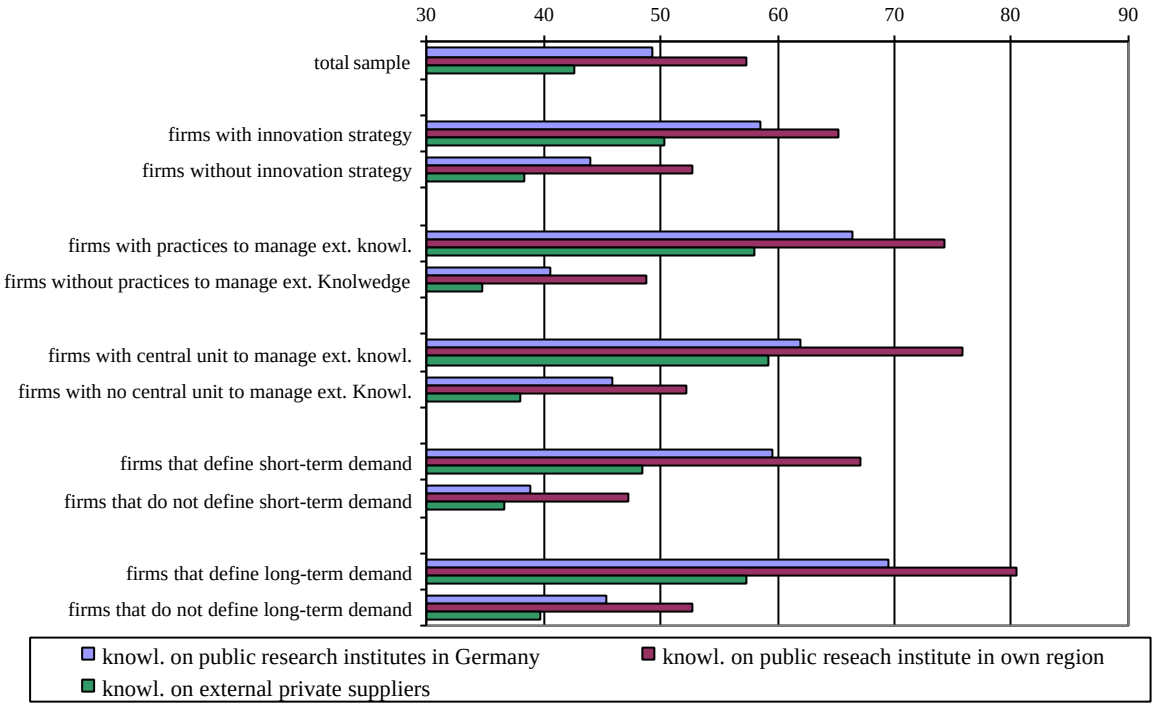
69 We are aware that there is a problem of "chicken and egg" here, as it is not clear if lower obstacles *ex ante* lead to more contacts or if having more contacts reduces the perception of obstacles *ex post*. In any case, the question is if systematic management and low obstacle correlate, and if yes, no matter what the ex ante perception of obstacles is, at least in the long run management would pay off.

70 In the following, only statistically significant (up to the 10% level) differences are reported.

71 Although there might be a response bias since in most cases the persons responsible for the KM have answered, the pattern is extremely clear-cut.

Figure 27: Knowledge about different external sources[a]



a: percentage of companies feeling adequately informed

Source: Fraunhofer ISI Survey 2002

General Innovation effects

The existence of practices to monitor supply and define demand for external technological knowledge is strongly linked to the innovation performance of companies. Innovators have much more often an explicit innovation strategy and en explicit knowledge management strategy. They use significantly more often practices to monitor the relevant supply of, and to define short-term and long-term demand for, external technological knowledge than non-innovators. Interestingly, the mere existence of a unit to take care of the management of external knowledge does not make a significant difference to the innovation performance (table 12). These significant relations do not imply causality, however, the co-existence of practices to manage external knowledge absorption for the innovation process and the success of the innovation process, i.e. innovations, is a convincing argument for the benefit of interfaces management.

Table 12: Innovation effects of practices to manage external technological knowledge

Percentage of product innovators out of...

...the overall sample	40.8%
the groups of companies...	
...having an explicit innovation strategy***	54.1%
...having an explicit knowledge management strategy ***	54.0%
...using practices to define long-term demand for external techn. knowledge**	51.2%
...using practices to define short-term project demand for ext. techn. knowledge **	47.6%
...having a unit to manage external technological knowledge***	47.2%
...using practices to monitor relevant external supply*	46.7%

* significant at the 10% level, ** at the 5% level, *** at the 1 % level

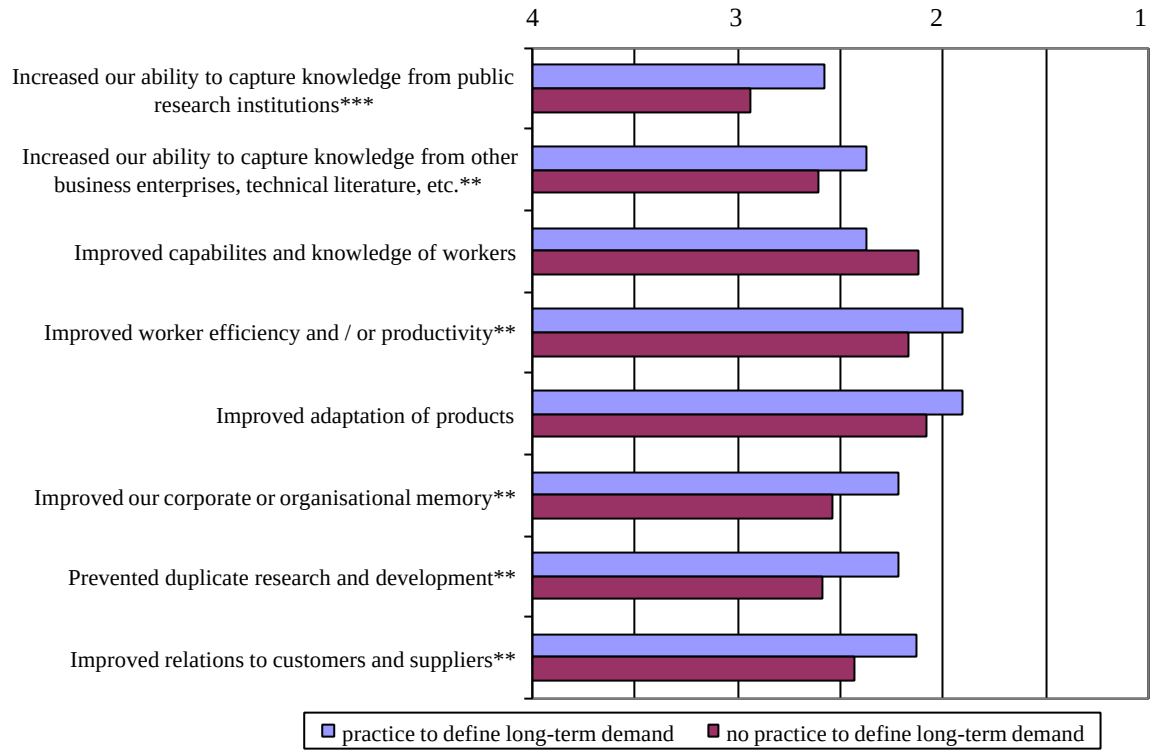
Source: Fraunhofer ISI Survey 2002

General KM effects

The effects of practices to manage external technological knowledge can further be qualified by looking at the overall effects of KM as presented above (chapter 6). Two of the five practices asked for have a highly significant impact on many of these nine effects. The single practices that are related to higher effects of KM most are those to *define long-term demands* for external technological knowledge. The sample of companies which take the effort to do so show significantly higher mean values for all but two effects (figure 28).[72] The strongest impact, as differences of mean values, is on the ability to capture knowledge from public research institutes and private suppliers and to avoid duplication of R&D efforts. Interestingly, the practice to define short-term, project-specific demand does not impinge upon the KM effects to the same degree, only the capture of knowledge from research institutes and the relation to customers and suppliers are reported to be more effective. While the definition of short-term demand is ad-hoc and most likely dependent on individuals, the defining of long-term demand signals a strategic approach of KM.

72 These two effects are „Product adaptation to new requirements“ and „add new products“.

Figure 28 Impact of practices to define long-term demand on selected KM effects



1 = extremely effective, 6 = not effective at all,
* significant at the 10% level, ** at the 5% level, *** at the 1 % level

Source: Fraunhofer ISI Survey 2002

The practices to monitor the *supply* of external technological knowledge are again more influential; companies employing them report five significantly higher KM effects out of nine, including also the capture of knowledge and the avoidance of duplicated research efforts. In strong contrast, the installation of a *central unit* to manage external technological knowledge does *not* lead to improved ability to capture knowledge. Centralised units to manage external knowledge only have one significant deviation as to the reported effect, i.e. the avoidance of duplicated R&D efforts. This impressively confirms the finding above, according to which centralised KM management *in general* (not only as for the management of external knowledge) has detrimental effects on the functioning of knowledge interfaces.

To sum up, practices to manage external technological knowledge make a difference, those companies that employ them do better as regards the perception of obstacles, the information on knowledge supplies, innovation performance and KM in general. A large share of the companies, as shown above in figure 25, do neither use nor plan to use many of these practices in the future. The only group of companies having implemented these practices widely are the very large ones. As especially medium sized and large medium sized companies are often also characterised by high complexity and face similar technological cha l-

lenges as large ones, a better performance as for KM and innovative activities would need more awareness as for management of external technological knowledge.

9. Summary and Conclusions

The starting point of this analysis has been that the demands for a more systematic and broad knowledge management (KM) in industry have been growing for many reasons. Knowledge has become a major asset for almost all industries, it is more and more protected for strategic reasons, and it is the pillar of innovative capabilities in the context of increased competition, shortened product life cycles and fluctuating workforce. The companies are faced with challenges that go far beyond the improvement of internal communication with the help of internal ICT structures. These challenges impinge upon companies in many ways. Firms must complement their human resource management in order to enable their workforce to meet the challenges of the knowledge economy; they need to take stock of, protect, store and share their knowledge internally, they must be able to capture knowledge from outside the company and insert it into the internal knowledge flows and finally – and ideally – they must develop policies and strategies to meet all these needs systematically.

In light of this broad perspective, this study has developed a concept of KM that encompasses 19 instruments within four dimensions: *communication* (mainly ICT, but not confined to it), *human resources* (both relating to the build up of capabilities regarding KM and more general training practices), *strategy and policies* to make KM a systematic corporate practice, and finally *capture* of knowledge from outside the company. Previous studies have shown that the last dimension – capture of external knowledge – has a special meaning for the innovation performance of companies and at the same time there is little knowledge on the related management practices of companies. Therefore, it is the capture of knowledge for the innovation process which was specially focused in this study.

9.1 KM in general

A first major result is that the broad understanding of KM is fully justified. Knowledge Management is a horizontal task that has diffused widely in German industry. Not even the non-response analysis showed a strong diffusion of the idea that KM needs to be focused around ICT applications.

As regards the application of KM practices, the pattern for all size groups and most sectors is very similar at the level of the four families of KM practices. Practices to *capture knowledge* are most widely used, followed by *communication practices* (databases etc.), *human resource* practices (both as for the build up of KM capabilities and general training schemes) and *general policies and strategies*. There is a certain dynamic, however, for many kinds of KM activities, there is a stable minority of companies which will go on doing it without.

Although this pattern is true for all size groups, it is also true that the number of practices used correlates with size. The higher numbers of practices employed by large companies is

especially a consequence of the fact that large companies employ *strategic* KM policies as well as *human resource* activities to build up KM capabilities much more often than smaller ones. As for sectors, two stand out with their average number of practices used: service companies are more active, while the vehicles sector lags behind. The assumption that knowledge-intensive sectors such as biotechnology and pharmaceutical are employing significantly more KM practices in general is not confirmed (although for the biotechnology sector this might very well be a size effect, as the majority of companies in the biotechnology sample is small).

Despite all the diverse activities undertaken by companies, KM is not yet an established strategic function within German industry. Less than half of the companies have a KM incentive system, value system or culture, and almost 80 % of the companies do not have a KM strategy. The ones having one are predominantly large companies. While there is a high dynamic as regards the future plans of companies to introduce systematic KM policies, a large share of companies will remain without an overall KM approach in the future.

The relatively low level of strategic KM approaches is also reflected in the low institutionalisation of KM. Although KM lies within the responsibility of top management in more than 60% of the sample, not even 25% of the companies have a budget or a specific unit dedicated to KM. Again, the large companies have institutionalised KM most. However, it is interesting to note that although they indicate highest motivation scores within the sample and have the most pressing need to manage knowledge at least internally, only somewhat more than 45% of them has a top manager in charge of KM. In other words, for more than half of the very large companies their competition in the „knowledge economy" is not supported by a top management dedicated to manage – and report about – the most important asset the companies have.

Here German companies have room for improvement, and should fill it, since the analysis has shown that the usage of KM in general has a strong relation to the innovation performance. Innovators, both product and especially process innovators, are employing more KM practices. Successful innovation for the market has in particular to do with the ability to store and communicate knowledge internally and, above all, to capture knowledge generated outside the company. A similar relationship is true for R&D performers which on average also employ significantly more KM practices.

In general, the simple rule applies that those companies that are more highly motivated also employ more KM practices. In order to explore motivation structures for using KM, 19 motives were asked for that could afterwards be grouped into five clusters of related motives. The following pattern of importance of these five clusters is the same for all size groups and similar for the sector groups: *integration of knowledge* within the company is the most important driver, followed by the *improvement of capabilities* of the workforce (human resources), the *capture and control* of knowledge, the *knowledge transfer* with *strategic partners* and, finally, the *vertical knowledge transfer* with market partners.

Consequently, although many practices are in place which capture external knowledge, knowledge management is most importantly motivated by the attempt to integrate knowledge within the company, to protect the company from loss of critical knowledge and to train workers. Of least importance are those motives that relate to the sharing of knowledge with partners in the market. This earmarks an important tension within KM in general: for reasons of efficiency and effectiveness companies try to capture and integrate knowledge as broadly as possible. At the same time, they also employ KM in reaction to their constant fear of losing critical knowledge (fluctuation, leakage) or rate those motives that relate to the sharing and transfer of knowledge with the environment rather low. Up to now, the more defensive mode seems to be the dominant model, while the growing importance of external knowledge in the future calls for a more open and interactive model.

As there is still no measurement of KM effects, the solution chosen in this study to assess the impact of KM practices was to let the companies judge. Nine effects were asked for, that could be grouped into four clusters. KM is most effective when it comes to the *market effects* and the *capabilities of staff*, while German industry – even in their own judgement – is performing rather weakly when it comes to building up an effective *organisational memory* and the ability to *capture* knowledge from outside the company, although the practices to do so are in place. This is especially true for the chemical, mechanical engineering and vehicle sector. To improve the effectiveness of these practices is certainly a major task for German companies in the future, the more so as almost all companies expect that the meaning of external knowledge will continue to grow.

The number of practices used correlates with the overall effect reported, put simply: it is effective to employ a broad KM approach. Similar to the relation of usage and motivation, the usage of strategies and policies has the highest impact on all four clusters of effects, especially for the ability to capture external knowledge and to improve human resources. The significance of a systematic KM management and related incentive structures and value systems cannot be overestimated.

Similarly, the institutional commitment to KM – through dedicated budgets, top management responsibility and centralised units – has a strong positive impact on all clusters of effects of KM – with one exception. There is a drawback of setting up a *centralised* unit, as the capability to *capture* knowledge from outside is lower for companies which have centralised their KM. This is perfectly logical, given the decrease in the possibilities and incentives to interchange once a central unit manages external contacts.

From this exploratory findings, a set of first conclusions as relates to industrial knowledge management in general can be drawn:

- Given the overall importance of KM strategies and organisational provisions, KM needs to be put in the focus of strategic activities, on equal footing with other top management activities such as finance, marketing, human resources or R&D. Such a corporate function would have to link the very diverse activities, implement related cultures of open-

ness, install incentives and dismantle disincentives of knowledge sharing, decide upon centralisation and de-centralisation of KM activities and, above all, keep KM on the agenda beyond the current hype on the terminology.

- Defensive models of KM – exemplified most obviously by corporate strategies that maximise the protection of knowledge as a strategic asset – may find themselves locked into a defensive structure and culture that hinders knowledge absorption, since it hinders knowledge disclosure. Public regulation for IPR and related policies must take into consideration the possible detrimental effects of ever more protected knowledge assets, and companies must think of the consequences of a protection culture for the openness needed to share and transfer knowledge, within the company, and across its borders.
- Human resource management needs to integrate measures to build up KM capabilities, as up to now KM training is the exception rather than the rule.
- Most room for improvement seems to lie within the dimension knowledge capture. The related practices are diffused most widely, however, the effects are poor. Companies need to tackle the management of external knowledge strategically (see below).
- Especially for smaller companies and for traditional sectors, the role of policy should increasingly be to help build up awareness and assist in implementing KM systems, against structural and sectoral impediments.
- Above all, given the broad concept of KM in German industry, knowledge management as a *public policy* area must avoid centering on ICT-based approaches, as this sends the wrong signal to industry. Rather it should work on further changing the attitude within industry and evaluate in how far existing policy practices extend to the whole width of KM.

9.2 KM to capture external knowledge for the innovation process

The capture of knowledge directly linked to the innovation process (technological knowledge) received special attention. The selection and separation of this aspect was for analytical purposes only, and must *not* lead to an intellectual separation from KM in general. Above all, it has become clear that management of external knowledge must be an integral part of corporate KM approaches.

The survey has confirmed that external knowledge is widely used and highly important, and this importance will increase in the future. The companies even indicated that external sources for the *technological* knowledge – already used by 97% of the companies – are more important than those for market knowledge. This is true for all sectors and sizes, but especially applies to the pharmaceutical and electrical engineering sector.

The single main driver for the capture of external technological knowledge is the increased speed with which ever new knowledge is needed to adapt to the market and the lack of sufficient in-house R&D. Slightly less important are costs of generating in-house, as well as the specific nature of the knowledge needed. Only for the small companies is the fusion of technologies and thus the need to process broad knowledge another major motive, small

companies are increasingly dependent upon turning towards external sources, given the increasing fusion and complexity of technologies. The sectors show a rather diverse picture, reflecting their specific market and technological contexts. Deviating most from the overall motivation pattern is the electronic sector, in which speed is most important, the vehicles sector, which lacks sufficient in-house human resources, and the pharmaceutical sector, for which in-house generation is extremely costly.

The sources that are used to acquire external technological knowledge are manifold. In the perception of the companies, codified knowledge in its various forms is most important, only matched by the informal exchange with experts. Out of the organisations not related to the company, *universities and other public research institutes are rated as the most important* source. At the same time, however, the companies *use* other firms much more often as a source to capture knowledge in general and the statistical analysis shows a slightly higher correlation between innovative performance and industrial firms as knowledge sources than between innovative performance and universities as sources (see table 9, chapter 8.2.4). Thus, while the finding by Janz et al. (2000) on the crucial meaning of science as external source for the innovation and economic performance is confirmed, this should not mislead us, since inter-industry transfer of knowledge still have a major significance.

Moreover, the survey has brought to the fore that not the frequency of overall usage of external technological knowledge, but *the kinds of instruments* to do so *are decisive for the innovation performance*. The share of innovators is significantly higher for the companies that are able to internalise specific external knowledge altogether (take-over, employment of experts) or directly co-operate with external knowledge providers, while it is only marginally higher for companies using external printed or electronic sources.

As for the obstacles to acquire external knowledge, the highest hurdles are mainly not external, i.e. they are not set up by inadequate suppliers of knowledge. The biggest problems lie *within* the companies and stem from protective attitudes towards the sharing of knowledge – *fear of loss of critical knowledge* – and from *inadequate internal processes*, mainly as regards the processes to discern external knowledge. In contrast, the obstacle of inappropriate public research institutes is rated lowest, much lower than the unwillingness of other firms to co-operate. Again, the smaller the companies, the higher the perception of obstacles to acquire external technological knowledge. As for the traditional sectors, mechanical engineering and vehicle construction sense higher impediments, especially related to their internal processes, while the biotechnology and pharmaceutical sectors rate all obstacles lower.

More than 60 % of the companies feel that the workforce responsible for the innovation processes of the companies are adequately informed about the external supply of knowledge, no matter if regional or national, private or public. Small companies are – again – less informed than big ones, and certain sectors (biotechnology, chemical) know external sources better than others (vehicles). Since only two sectors (service, pharmaceuticals) know private sources better than public ones, the overall meaning of public research as a

knowledge source is again confirmed. The claim that it pays off to discern external knowledge is confirmed, as the share of innovators among those companies that claim to know about external supply is significantly higher than within the group of companies that do not know about the supply.

Everything summarised so far regarding external sourcing of technological knowledge is dependent on the question if and how companies pro-actively manage the requirement to source, such as *processes to discern external supply,* having a *management function* for external knowledge and processes to *define short*-term and *long-term demand* for external knowledge. Above all, these practices are not diffused widely. Except for the short-term definition of needs for external knowledge, none of the four practices asked for is implemented by at least half of the companies. Especially the long-term demand for external knowledge is only defined by 22% of the companies, while a bit above 40% claim to discern external supply and another 25% have a central unit to manage external technological knowledge.

The only group of companies that stick out here are the very large ones, as up to 75% of the companies inform themselves about external supply and half of the companies define their long-term needs systematically. Interestingly, the share of companies in the group with 250 to 2000 employees applying these instruments is not higher than the share within the smaller companies. It is this dimension of managing external technological knowledge which determines the advantage of very large companies most.

Given that the overwhelming majority of companies expect the demand for external knowledge to grow, the overall figures are – however – alarming. The more so – and this is the major result as regards the management of sourcing external technological knowledge – as there is a *strong correlation* between *the employment of these specific measures* and the *performance* of the companies. While the mere frequency of using external sources to get technological knowledge makes no significant difference to the innovation performance, companies *managing* external technological knowledge are much *better informed about sources,* sense *less obstacles,* show *higher effectiveness in their overall KM practices*[73] and, above all, are *more likely innovators*.

In sum, it is not the frequency, it is the ability to *interact* with external knowledge providers or to *internalise external sources fully* (employment, takeover), as well as the *adequacy of activities* to source external technological knowledge achieved and supported by *appropriate practices* to manage external knowledge sourcing that make the difference.

It is true, many companies are beginning to understand this relationship. The percentage of companies that have recently introduced measures to manage external technological knowledge or are planning to do so is high. Still, almost half of the sample indicate they do not

73 Which also means that managing external technological knowledge seems to be an advanced management practice that is done by companies that have effective overall KM in place already.

plan the introduction of adequate management tools in the future, only large companies have implemented them more widely. This perfectly fits the finding on the general KM practices above, according to which general practices to capture knowledge from outside the company are most widely distributed, but the *effect* of the capture of knowledge from institutes and other companies is lowest – due to a lack of appropriate supportive schemes.

The consequences as regards the improvement of the capture of technological knowledge are as follows:

- As using external sources intelligently makes a difference for the innovation and economic performance of companies, in order to capture external knowledge effectively, corporate strategies and public policies to support corporate policies should be geared towards the absorptive capacities of companies much more intensively, rather than demanding yet another change in attitude from the supply side of knowledge. The study has shown that the proof of who is to blame for inadequate knowledge transfer thus lies as much with *each* company as with the suppliers of knowledge, such as research institutes.
- Companies must think about the *mode* to source external knowledge. As a full internalisation (purchase of companies and experts) will only be possible in the minority of cases, the most promising road to take is direct contact in co-operations, rather than taking up codified knowledge. The workforce must be made fit for doing so, and the culture must allow and ask for it.
- Companies need to evolve a culture that is more open to exchange and helps overcome the fear of losing knowledge or becoming dependent on external sources. The current tendency to employ more activities that are specifically geared towards the management of external knowledge must be strengthened and carried into small companies. Especially small companies and companies from traditional sectors (vehicles, mechanical engineering) must come to a new understanding, despite the problems they face in doing so.
- Above all, the *procedural* capacities to absorb external knowledge need to be strengthened. Companies need to invest in *specific* practices. As the sourcing from public research – mainly in form of direct co-operations – has a higher effect on innovation performance, companies must ask themselves if they are fit to play the knowledge game with them in all its consequences: companies must come to define their long-term (!) demand rather than asking ad hoc for technical solutions. They need to monitor the supply of external knowledge systematically and – as with KM in general – they need to *systematically* decide to what degree they set up centralised functions for the knowledge capture. Such a function should not serve as a transfer node, but rather assist in methodologies and services enabling the corporate employees to capture knowledge themselves.
- Public policies geared towards knowledge and technology transfer should go on with changing attitudes and structures in public research institutes and with promoting collaborative schemes, as is rightly done. However, a *knowledge management* policy would need a horizontal approach that integrates attempts of technology transfer in the

research ministries (federal and regional) with policies supporting the build up of capacities in industry, especially SMEs (economic ministries). Such an integrative approach would also ask for the possible merits and pitfalls of strategies to maximise the protection of intellectual property.

9.3 Future challenges for the analysis of KM

A last paragraph may be dedicated to the future challenges for the analysis of KM. What these major findings make clear, above all, is the necessity to go on analysing KM in industry. The causal relations among the many variables for which data have been collected must be analysed more intensively. We need to make the step from understanding practices to manage knowledge to understanding the effective processing of that knowledge by companies. In other words, we need to link KM with organisational learning, in order to understand barriers and carriers of organisational performance based on knowledge processing. Furthermore, the aggregated data must further be checked with qualitative findings on the basis of existing and future case studies. In addition, we must continue comparing countries, as prepared in the on-going OECD study initiative. A prime line of future academic work must be the conceptualisation of a framework that enables us – and most importantly companies – to measure the effects of KM much more accurately than we can up to now, as we are based on estimates by respondents or idiosyncratic case studies. Only if we know systematically what exactly the benefits of individual KM practices and strategies under diverse context conditions are, can we take the next steps, such as, for example, the development of uniform guidelines and frameworks for the analysis and – more importantly – the employment of KM in industry.

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