



European
Commission

Advanced Manufacturing Activities of Top R&D investors: Specialisation & Internationalisation

Workshop on
Development of KETs for industrial
modernization, their regional dimension
and their link to emerging technologies

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Joint
Research
Centre

AMTEC- KEYTEC



- Complement to the (Industrial Research and Innovation Monitoring Analysis) IRIMA project:
 - Assess the innovation capability of EU R&D Scoreboard companies.
 - Focusing on Key Enabling Technologies KETs and especially Advanced Manufacturing Technologies.
 - Attempt to identify converging and emerging trends in AMTs and KETs.
 - Patent analysis

Why Patents

- *Patent documents contain a wealth of information about the invention and the different actors involved in the innovation process:*
 - *Applicant (owner), inventors, useful dates etc*
 - *Technological fields to which it pertains (IPC)*
- *IPC: International patent classification scheme*
 - *tree-like, hierarchical structure.*
 - *contains about 70000 entries (IPC codes) allotted to patent documents*
 - *updated annually and revised every 3 years*
- *Complex Patents: contain IPC codes to correspond to AMT and KET related fields.*
 - *Assumed that can represent AMT applications used for the development of KETs, or vice versa they can represent other KETs applications that can be incorporated into AMT systems*

Methodology

- Patent analysis of the EU R&D Scoreboard companies
- Patent families filed at USPTO- EPO between 2010- 2012.
- Focusing on IPC codes that are related to Advanced Manufacturing Technologies and KETs from KETs observatory
- Internationalisation of research activities proxied by patents (use of applicant vs inventor information)
- Specialisation in a specific **field**: Proportion of total patents in the portfolio that pertain to that **field**

Main Barriers

- Patent data from PATSTAT (relational database bi annually updated by EPO).
- R&D data from the EU R&D Scoreboard.
- Matching entries from the two databases necessary for establishing links between the two.
- Problem: Entries in PATSTAT in 'raw' format, misspellings, legal terms, abbreviations etc.
- Matching based on string matching computer algorithms.
- List of complex patents not exhaustive of technologies possibly important for AMT or KET development

AMT related patents across sectors

- Industrial sectors (ICB-4) with the highest number of AMT related patents

Sector (Number of AMT Patents)	Ratio of AMT patents
Industrials (5540.8)	21.6%
Electronic & Electrical Equipment (5095.7)	19.9%
ICT producers (4280.2)	16.7%
Automobiles & parts (3559.5)	13.9%
Aerospace & defence (1926.2)	7.5%

- Development of AMT technologies concentrated within a few industrial sectors.
- 80% of AMT developed by companies in 5 sectors

AMT Specialisation by Sector

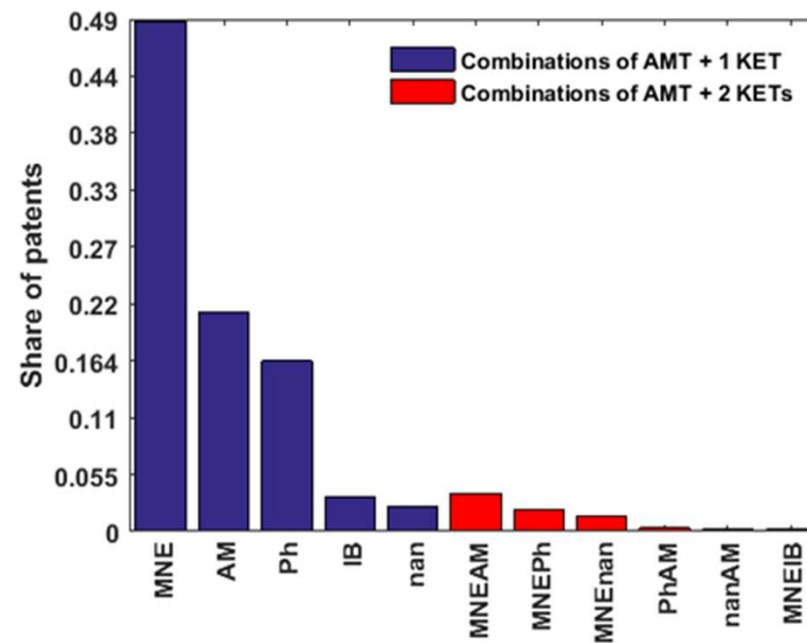
- Share of AMT related patent families with respect to the overall patent portfolio of each industry

Sector (Number of AMT Patents)	AMT patents	Total Patents	AMT / Total
Aerospace & defence	1926.2	15004.5	12.8%
Alternative energy	72.0	694.3	10.4%
Industrials	5540.8	57421.5	9.6%
Automobiles & parts	3559.5	41932.6	8.5%
Traditional energy	202.5	2408.6	8.4%

- Top five sectors with highest patent propensity (higher than the sample mean 5.7%)
- Electronic & Electrical equipment also above mean

Complex Patents- AMT & KET(s)

- 1834 families combining AMT with 1 or 2 other KETs found



- 897 (49 %) Micro Nano El and AMT, followed by Adv Mat-AMT and Photonics- AMT
- AMT+ 2 KETs around 8.1% of total complex AMT patents

Main Companies developing Complex AMT related Patents

- Most companies highly specialised (AMT patent propensity above average)
- very high shares of complex patent families with respect to the AMT ones
- US based “Applied Materials”; (1421 patent families) appears among the top 10 in 4 out of the 8 lists of complex patent

Company (Sector)	AMT - MNE	AMT Ratio	Families	Company (Sector)	AMT - AM	AMT Ratio	Families
IBM (ICT services)	33.5	0.10	15938	NIPPON STEEL (Industrials)	28.5	0.35	812
APPLIED MATERIALS (ICT producers)	29.5	0.24	1421	KOBE STEEL (Industrials)	22.5	0.27	573
TOKYO ELECTRON (ICT producers)	27	0.27	1328	GENERAL ELECTRIC (Industrials)	19.5	0.02	9012
RENESAS (Electronic & Electrical eq)	26	0.21	2201	UNITED TECHNOLOGIES (Aerospace & defence)	16	0.03	3219
TAIWAN SEMICONDUCTOR (ICT producers)	25	0.22	3261	APPLIED MATERIALS (ICT producers)	10	0.08	1421
TOSHIBA (Industrials)	24.25	0.08	9550	SIEMENS (Electronic & electrical eq)	9.5	0.01	6712
HITACHI (Electronic & Electrical eq)	24	0.08	6629	DOW CHEMICAL (Chemicals)	7	0.03	4119
HAMAMATSU PHOTONICS (Electronics & Electrical eq)	23	0.77	273	FUJIFILM (Electronic & electrical eq)	7	0.09	5165
SEIKO EPSON (ICT producers)	22	0.10	4505	SUMITOMO ELECTRIC (Electronic & electrical eq)	6.5	0.13	1717
INFINEON TECHNOLOGIES (ICT producers)	21.5	0.20	1473	HITACHI (Electronic & electrical eq)	6	0.02	6629

International location of AMT related patenting activities: Industrials

- 5541 AMT related patent families between 2010 and 2012 with 79% developed "at home" 21% "abroad"

AMT patents - Industrials

Applicant Region (Number of patent families)	Inventor Region			
	<i>EU</i>	<i>Japan</i>	<i>USA</i>	<i>RoW</i>
<i>EU (1152)</i>	80.6%	0.4%	14.0%	5.0%
<i>Japan (1305)</i>	1.8%	93.0%	4.3%	0.9%
<i>USA (2681)</i>	10.8%	0.2%	79.3%	9.7%
<i>RoW (403)</i>	50.2%	0.3%	16.7%	32.7%

- US, EU based firms follow the 4/1 ratio in patents developed domestically over those developed abroad. Activities of Japanese firms very concentrated

International location of AMT related patenting activities: Electronic & Electrical Equipment

- Firms in this sector filed 5096 patent families 76.7% of which by inventors of the "home" region

AMT patents Electronic & Electrical Equipment					
Applicant Region (Number of patent families)	Inventor Region				
	<i>Asian Tigers</i>	<i>EU</i>	<i>Japan</i>	<i>RoW</i>	<i>USA</i>
<i>Asian Tigers (1299)</i>	70.3%	0.3%	0.4%	26.8%	2.2%
<i>EU (1272)</i>	0.3%	70.5%	0.3%	5.3%	23.6%
<i>Japan (1592)</i>	0.4%	3.2%	92.0%	0.5%	3.9%
<i>RoW (187)</i>	6.9%	53.5%	0.8%	16.0%	22.8%
<i>USA (746)</i>	0.5%	11.4%	0.0%	6.6%	81.5%

- Almost 24% of EU owned patents from US.
- Japanese firms least internationalised

International location of AMT related patenting activities: Automobiles & Parts

- 3560 patent families filed from firms in the sector 80% developed at the home region.

AMT patents - Automobiles & Parts				
Applicant Region (Number of patent families)	Inventor Region			
	<i>EU</i>	<i>USA</i>	<i>Japan</i>	<i>RoW</i>
<i>EU (1333)</i>	79.3%	17.2%	1.0%	2.2%
<i>USA (744)</i>	24.5%	70.1%	0.4%	5.0%
<i>Japan (1321)</i>	2.0%	13.4%	83.6%	1.0%
<i>RoW (162)</i>	6.7%	0.7%	0.0%	92.6%

- European companies first in number of families developed almost 80% in the EU.
- 25% of US owned patents developed in the EU
- Japanese firms in the sector more internationalised than in other sectors

International location of AMT related patenting activities: Aerospace & Defence

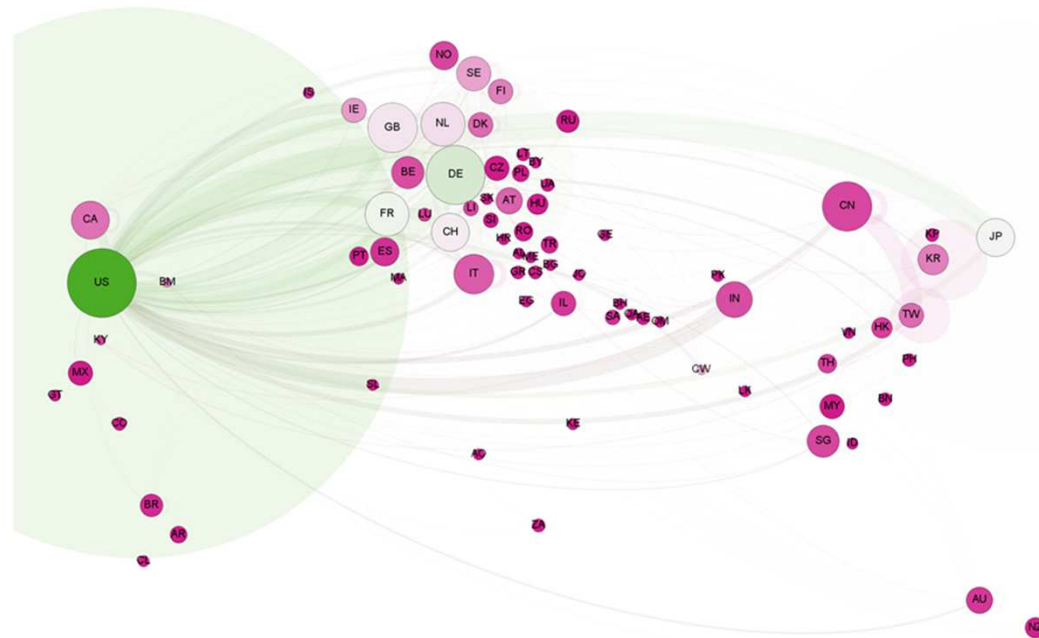
- Almost all (99%) AMT related patents owned by EU and US based companies

AMT patents - Aerospace & Defence			
Applicant Region (Number of patent families)	Inventor Region		
	EU	USA	RoW
EU (894)	92.6%	6.0%	1.0%
USA (1008)	4.8%	91.3%	3.9%
RoW (24)	10.4%	10.4%	79.1%

- AMT related activities highly concentrated (over 90% of patents developed in the "home" region)

AMT international innovation network

- World network of “owner” and “inventor” countries of AMT related patent filings



- Three main clusters (US, Europe, Japan- Korea- Taiwan- China)
- US, Japan, Germany, GB, France important home countries of both applicants and inventors. China and India important inventors countries

AMT related international R&D activities of the world top 10 firms by number of AMT related filings of the Automobile & Parts sector

- Companies ranked by number of AMT related patents
- Countries ranking by share of inventors in patent portfolio of company
- Most of AMT related patents developed at the "home country" (Hyundai 99.5%)
- Fiat- Delphi acquired by Chrysler- parts arm of GM

Automobile & Parts								
Company	R&D 2012 (€ mil.)	Patent Families	AMT	HQ Country	AMT - Inventor Countries			
GENERAL MOTORS	5,584	4608	508	US	US	DE	IT	Other
					76.1%	13.1%	4.4%	6.4%
ROBERT BOSCH	4,924	5044	496	DE	DE	US	JP	
					76.9%	12.8%	2.1%	8.2%
DENSO	2,938	2800	307	JP	JP	US	GB	
					96.9%	2.4%	0.3%	0.4%
HONDA MOTOR	4,906	3096	298	JP	JP	US	DE	
					73.4%	22.9%	2.5%	1.2%
TOYOTA MOTOR	7,071	4312	296	JP	JP	US	CA	
					74.7%	21.9%	3.0%	0.4%
VOLKSWAGEN	9,515	1780	144	DE	DE	SE	FR	
					66.4%	27.2%	2.1%	4.4%
CONTINENTAL	1,827	1084	130	DE	DE	US	FR	
					60.9%	24.4%	8.3%	6.4%
HYUNDAI MOTOR	934	1999	99	KR	KR	DE		
					99.5%	0.5%		
FIAT	3,295	448	86	IT	US	IT	DE	
					52.0%	37.4%	6.4%	4.1%
DELPHI	910	524	67	GB	US	FR	DE	
					67.7%	17.7%	6.7%	8.0%

International R&D activities of the world top 10 firms by number of AMT related filings of the Aerospace & Defence sector

- Development of AMT related technologies mainly in the home country
- Important exception EADS which has been formed by the merger of different European companies
- BAE systems also highly internationalised (US)

Company	R&D 2012 (€ mil.)	Patent Families	AMT	HQ Country	AMT - Inventor Country			
					US	CA	GB	Other
UNITED TECHNOLOGIES	1797	3219	482	US	89.2%	6.0%	1.3%	3.5%
EADS	3630	2438	324	NL	48.3%	32.9%	9.0%	9.8%
BOEING	2253	1899	300	US	94.1%	3.5%	1.3%	1.1%
ROLLS-ROYCE	750	924	167	GB	78.7%	11.1%	6.3%	3.9%
SAFRAN	1109	1145	155	FR	90.3%	5.2%	3.5%	1.0%
MTU AERO ENGINES	161	241	62	DE	98.4%	0.8%	0.8%	
THALES	700	745	61	FR	96.7%	1.6%	0.8%	0.8%
BAE SYSTEMS	189	591	57	GB	62.8%	24.3%	5.3%	7.5%
LOCKHEED MARTIN	467	737	54	US	99.1%	0.9%		
TEXTRON	443	285	46	US	89.1%	8.7%	2.2%	

Conclusions

- Aerospace & defence, the Industrials, the Automotive & parts and the Electronics & electrical equipment sectors own 80% of total AMT patent families.
- The more specialised firms in a sector, the less internationalised the AMT related activities of the firms in this sector appear to be.
- Aerospace & defence most concentrated (90% of AMT patents "home region"), highly specialised.
- European and US based firms are more internationalised compared (70%-80% of patents developed locally) to Japanese and Asian based firms (almost 90% locally developed patents).
- US, Japan, Germany, France and Great Britain: many Scoreboard firms which own and develop large number of AMT related patents.
- China, India, Canada, Italy, Belgium and Spain many inventors of AMT related technologies are based.
- 8% of AMT related patents combine one or more of the other KETs mainly MNE, AM and Photonics



Thank You

Supplemental Material: Companies developing AMT-KET patents

Company (Industry)	AMT + NNE	Complex % on AMT	Patent Families	Company (Industry)	AMT + AM	Complex % on AMT	Patent Families	Company (Industry)	AMT + Photonic	Complex % on AMT	Patent Families
IBM (ICT services)	34	10%	15938	NIPPON STEEL (Industrial)	29	35%	812	PHILIPS (Industrial)	19	15%	3472
APPLIED MATERIALS (ICT producers)	30	24%	1421	KOBE STEEL (Industrial)	23	27%	573	QUALCOMM (ICT producers)	14	9%	5998
TOKYO ELECTRON (ICT producers)	27	27%	1328	GENERAL ELECTRIC (Industrial)	20	2%	9012	APPLE (ICT producers)	7	4%	2930
RENESAS (Electronic & Electrical eq)	26	21%	2201	UNITED TECHNOLOGIES (Aerospace & defence)	16	3%	2219	KOITO MANUFACTURING (Automobile & parts)	6	60%	304
TAIWAN SEMICONDUCTOR (ICT producers)	25	22%	3261	APPLIED MATERIALS (ICT producers)	10	8%	1421	SIEMENS (Electronic & electrical eq)	6	1%	6712
TOSHIBA (Industrial)	24	8%	9550	SIEMENS (Electronic & electrical eq)	10	1%	6712	ACUVITY BRANDS (Others)	5	45%	68
HITACHI (Electronic & Electrical eq)	24	8%	6629	DOW CHEMICAL (Chemicals)	7	3%	4119	CANON (ICT producers)	5	2%	10970
HAMAMATSU PHOTONICS (Electronics & Electrical eq)	23	77%	273	FUJIFILM (Electronics & electrical eq)	7	9%	5165	GENERAL ELECTRIC (Industrial)	5	0.5%	9012
SEIKO EPSON (ICT producers)	22	10%	4505	SUMITOMO ELECTRIC (Electronic & electrical eq)	7	13%	1717	TAIWAN SEMICONDUCTOR (ICT producers)	5	4%	3261
INFINEON TECHNOLOGIES (ICT producers)	22	20%	1473	HITACHI (Electronic & electrical eq)	6	2%	6629	SAMSUNG DISPLAY (Electronic & electrical eq)	5	10%	2724
Company (Industry)	AMT + Ind Biotec	Complex % on AMT	Patent Families	Company (Industry)	AMT + Nano	Complex % on AMT	Patent Families				
ABBOTT LABORATORIES (Pharmaceuticals & Biotechnology)	4	5%	1278	NEUA (Traditional energy)	6	4%	1608				
LIFE TECHNOLOGIES (Pharmaceuticals & Biotechnology)	4	22%	459	IBM (ICT services)	4	1%	15938				
PHILIPS (Industrial)	4	3%	3472	HON HAI PRECISION INDUSTRY (Electronic & electrical eq)	3	1%	9364				
EPENDORF (Health)	3	30%	74	FABRILLO SEMICONDUCTOR (ICT producers)	2	8%	207				
GENERAL ELECTRIC (Industrial)	3	0.3%	9012	FREESCALE (ICT producers)	2	3%	1008				
BIOHERDEX (Pharmaceuticals & Biotechnology)	2	50%	124	QUALCOMM (ICT producers)	2	1%	5998				
DOW CHEMICAL (Chemicals)	2	1%	4119	ROBERT BOSCH (Automobile & parts)	2	0.4%	5044				
JOHNSON & JOHNSON (Pharmaceuticals & Biotechnology)	2	5%	2072	SAMSUNG ELECTRO-MECHANICS (Electronic & electrical eq)	2	2%	1944				
LUNINEX (Pharmaceuticals & Biotechnology)	2	67%	23	NEROX (ICT producers)	2	2%	3026				
QIAGEN (Pharmaceuticals & Biotechnology)	2	67%	102	3M (Industrial)	1	3%	1597				

Supplemental Material: Companies developing AMT-2 KETs patents

Company (Industry)	AMT MNE AM	% on AMT	Patent Families	Company (Industry)	AMT MNE Photonic	% on AMT	Patent Families	Company (Industry)	AMT MNE Nano	% on AMT	Patent Families
LAM RESEARCH (ICT producers)	12	26%	449	INTERFIL (ICT producers)	3	4%	243	ELMOS SEMICONDUCTOR (ICT producers)	4	36%	35
TOKYO ELECTRON (ICT producers)	11	11%	1328	CREE (ICT producers)	2	12%	347	AREVA (Traditional energy)	4	2%	1608
APPLIED MATERIALS (ICT producers)	7	6%	1421	PHILIPS (Industrials)	2	2%	3472	SEIKO EPSON (ICT producers)	3	1%	4505
PANASONIC (Other)	4	1%	9460	QUALCOMM (ICT producers)	2	1%	5998	INFINEON TECHNOLOGIES (ICT producers)	2	2%	1473
NIPPON STEEL (Industrials)	3	4%	812	SAMSUNG DISPLAY (Electronic & electrical eq)	2	4%	2724	ROBERT BOSCH (Automobiles & parts)	2	0.4%	5044
FUJITSU (ICT services)	2	1%	8460	SHARP (Electronic & electrical eq)	2	5%	3828	FREESCALE (ICT producers)	2	2%	1008
JX (Low)	2	22%	221	APPLIED MATERIALS (ICT producers)	1	1%	1421	BOEING (Aerospace & defence)	1	0.3%	1899
ASAHI GLASS (Industrials)	1	6%	809	AREVA (Traditional energy)	1	1%	1608	DAI NIPPON PRINTING (Services)	1	11%	356
BE AEROSPACE (Aerospace & defence)	1	3%	1870	ASM INTERNATIONAL (ICT producers)	1	17%	118	IBM (ICT services)	1	0.3%	15938
BROOKS AUTOMATION (Industrials)	1	6%	56	AVAGO TECHNOLOGIES (ICT producers)	1	3%	291	LOCKHEED MARTIN (Aerospace & defence)	1	2%	737

Supplemental material: More networks

