

Attitudes of the European Printing Industry towards Innovative Combinations of Print and Digital

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Abstract

The present study reports a European industry survey of the state and future of innovative printing. In this study, we have defined innovative printing as printed electronics, printed intelligence, printed functionalities, combining print with digital (e.g. providing digital solutions for Quick Response codes or augmented reality), and similar products and services. Experiences and inputs from industry representatives were collected through a survey to provide viewpoints on how print media and packaging could be developed and used in the future and how the industry can utilize this knowledge from the academia for the benefit of their customers and the consumers.

Based on the results, it may be concluded that (1) European graphical companies do see a possible future in innovative printing, (2) besides the possibility of increased costs, the lack of market demand is the most important factor preventing companies embracing this technology, and (3) in general the approach and vision of the industry is similar across all of Europe. However, Western European printing houses appear to be more active in the field of innovative printing as defined here, whilst in Eastern Europe the technology is currently focusing on special effects and personalized printing, suggesting a possible delay in the implementation of innovative printing technologies as a whole.

Keywords:

Innovation, Printing, Europe, Prospective study

1. Introduction and background

Innovation has long been recognized as a key element of economic development. Today there is a great need for understanding the state of the printing industry and providing further direction on this topic that entails both technological and strategic dimensions (Intergraf, 2011). This is due to digitalization and digital transformation and their effect on the consumption of printed products and innovations in printing production. In printed electronics, for example, many segments are not profitable despite having more than ten years of development; however there are some profitable sectors identified such as electroluminescent displays, sensors and conductive inks (IDTechEX, 2015). Information technology (IT) innovations, such as the Internet, social media, mobile phones and apps, cloud computing, big data, e-commerce, and the consumerization of IT, have already had a transformational effect on products, services, and business processes around the world (Bojanova, 2014). Everything that can be digitalized will be digitalized (Confederation of European Paper Industries; CEPI, 2015a). This affects dramatically all businesses and entire industries – and the printing industry is not an exception.

No organisation can opt out from the digital transformation taking place at the moment (Viljakainen, 2015). Companies need to build their own business strategy for digitalization – how to react and benefit from it and what are the concrete actions they should take. Potentially, digitalization will strengthen the existing business, create new business and increase the value of the products and services (Nurmi, 2015). The winning companies and industries will be those most quickly able to adapt to the digitalized world and fully exploit its opportunities (CEPI, 2015a). The outlook is to move from producing one single product (e.g. a newspaper) towards services and a new value creation and also to relationship building (Viljakainen, 2015; Chan-Olmsted, 2000). For example media companies are increasingly adopting service based strategies as a way to differentiate a firm from its competitors and create new value for their customers. Technological development has led to changes in media consumption habits and eventually it also affects customer needs. The media are experiencing demassification and moving away from homogeneous mass audiences into niche markets (Viljakainen, 2015).

The academic literature concerning innovation is plentiful; many research contributions exist that characterize different aspects and originate from different disciplines, as summarized by Connolly, Gauzente and Dumoulin (2012). They state that in the economic literature the focus has been ‘technology push’ (attempts to commercialize and increase diffusion of the innovation) rather than a ‘demand pull’ (user need for the technological innovation). Uncertainty and perceived risk play are important considerations in the perspective of potential adopters and the benefits compared to the existing status quo are not always obvious. Unknown consequences due to the innovative change and general inertia and resistance to change also add to the perception of risk and uncertainty. As far back as 1964, Bright observed that ‘Anyone introducing a technological innovation is implicitly or explicitly predicting acceptance and a rate of adoption. Yet a fact of technological history is that many innovations are subject to frustrating delays and deliberate resistances to adoption’ (1964: 171).

Nowadays, the European printing industry has around 120,000 (mainly small sized) companies, employing around 750,000 people for a turnover of about €85 billion (Eurostat, 2015). According to CEPI (2015b), its members produced 91 million tonnes of paper and board in 2014, out of which 40.5 % is printed. Next to paper and board mills, there are around 630 companies active in the pulp, paper and board industry in Europe (i.e. printers and converters), generating a turnover of approximately €75 billion and more than 180,000 workplaces (CEPI, 2014).

While the paper and board industry is struggling with stagnation or very slow growth in some countries, many printers are currently facing overcapacity problems, price competition and replacement of print by digital (Intergraf, 2011) which they try to overcome by cutting costs, investment in new technologies and equipment. All respondents of the Intergraf study agreed that the main investment in the near future needs to be put into gaining new knowledge. New opportunities are seen in the maturing of several important innovations which emerged with time, such as digital printing, printing on demand, 3D printing, augmented reality, and printed electronics. Numerous aspects of printed electronics, important for developments in paper and board as well as printing industry, are discussed in the literature (e.g. Bollström et al., 2014; Pettersson et al., 2014; Määttänen et al., 2010). Adoption of new technologies enables increased productivity, new markets, products and services and opens up opportunities to integrate services along the value chain, and eventually even reduces costs (PMG, 2012).

According to Vehmas et al. (2011), printing houses have not been willing to move to completely new business areas due to large investments and R&D needed for old printing machines to produce totally new products and the risk is seen to be too high to enter new customer markets. There are limited drivers for significant change and new business cannot therefore evolve. However, many actors in the European printing industry recognize the need to develop. Three approaches to survive in the future have been identified in the study: (i) efficient web printing production via flexible production and effective materials usage; (ii) added value for the printed product; (iii) printed non-media products. In all cases customer service, cooperation throughout the print production chain and open communication are needed to succeed.

To be successful, novel innovative solutions must take into account opportunities provided by new technology, but they cannot lose sight of the customers and users (Thomke and von Hippel, 2002). User involvement and co-design have a central role when developing e.g. novel digital services for customers (Vehmas et al., 2015). The shared roles of companies, cooperation partners and stakeholders is also essential – ecosystem thinking has been shown to be very useful e.g. for sharing and piloting the novel innovations. A report by Aistrup (2009) states that collaboration is important as companies cannot handle the cascade of complex knowledge and they should cooperate in complementary innovation networks to expand value rather than simply improving their existing value share.

In addition to digital transformation, also environmental awareness influences the innovations within paper and printing industry. The discussion on mineral oils in packaging has led to an increase in interest in organic printing inks. This focus can also be seen in printed electronics; both organic inks and renewable base materials are part of recent innovations. As an example,

Burgués-Ceballos (2014) states that ‘the challenge of our generation is to move towards a cleaner and sustainable energy model’, and illustrates this by the development of organic solar cells including green solvents and sustainable processing to enable industrial scale-up.

In this study, the goal was to gain a better understanding of the industrial viewpoint, while also promoting discussion between industry and academia on the benefits that may arise from combining print and digital. Because the term ‘combining print and digital’ turned out to be perceived ambiguously during a preliminary stage of an investigation, the focus of the study was defined as ‘innovative printing’, referred to meaning printed electronics, printed intelligence, printed functionalities, combining print with digital (e.g. providing digital solutions for QR codes, augmented reality...), etc., and used throughout the study.. Several examples already exist where successful combinations have been applied e.g. through the use of image recognition, augmented reality or printed electronics to bring interactivity into fibre based products. Experiences and inputs are gathered and collated within the study to provide different views on how print media could be developed and used in the future. This should lead to an understanding of how the industry can utilize the information for the benefit of their customers and how the academia can effectively support these efforts, and to an increase in the industry awareness of the possibilities for innovative printing.

2. Methods

A questionnaire was set up to assess industry’s opinion on innovative printing, specifically referring to printed electronics, printed intelligence, printed functionalities, and combining print with digital.

Eleven countries representing the different parts of Europe and having the different printing industry characteristics have been selected by convenience for the study, out of which four were categorized as Western European (Finland, The Netherlands, Portugal and United Kingdom) and seven as Eastern European (Czech Republic, Hungary, Lithuania, Poland, Serbia, Slovenia and Slovakia). The questionnaire was distributed to printing companies in their local language in order to overcome any language barriers and to maximize their understanding. In addition, the English version was distributed to respondents in several other countries (including Belgium, Germany, Ireland, Italy, Norway, and Sweden) that were originally not included in the study. The responses from these countries and from Poland are jointly marked as “Other” in the following text as the number of responses per country was too low to analyse them separately. The decision as to which countries were analysed separately (10 countries) and which responses were grouped as “Other” (from 7 countries) was based both on the absolute number of responses and on its ratio to the number of enterprises listed within Printing and reproduction of recorded media category according Statistical Classification of Economic Activities in the European Community, Rev.2 (Eurostat, 2015), for given country.

2.1 Survey instrument – questionnaire

The questionnaire consisted of six “open and closed” questions (see the Appendix). The first question was designed to define the companies based on for example company size and printing technology. The second question concerned their use of innovative printing

techniques, and questions three and four tried to identify the most important limitations in developing such printing solutions including a discussion of any competitive and financial advantage. Question five gave the opportunity for the industry to express their interest and opinion concerning cooperation with the academia. Finally, the last question requested the opinion of the industry as to which are the fastest growing markets in the area of innovative printing. Intentionally, the questionnaire remained brief in order to increase responses and willingness of companies to participate.

Various ways were employed for gathering results (as summarized in Table 1) to optimize the effectiveness of the study and to receive the maximum amount of responses, especially in countries where the target group was relatively small. More detailed answers were possible in personal or phone conversations, on some occasions. In all cases, however, the questions remained the same.

Table 1: Survey instrument

Country	Online questionnaire	E-mail questionnaire	Phone conversation	Personal conversation
Czech Republic (CZ)	✓ (B, C)		✓	
Finland (FI)	✓ (C)			
Hungary (HU)	✓ (A, C)			
Lithuania (LT)			✓	✓
The Netherlands (NL)	✓ (A, C)			✓
Portugal (PT)	✓ (D)	✓ (D)		
Serbia (RS)	✓ (D)		✓	
Slovenia (SI)		✓		
Slovakia (SK)	✓ (A, C)			
United Kingdom (UK)	✓ (A, C)	✓		
Other	✓ (A, C)	✓		

A – Posted on a web portal, B – Link distributed by e-mail to general contact addresses,

C – Link distributed by e-mail addressed to company representatives,

D – With a previous phone contact with the company representative

2.2 Sample size and characteristics

The study aimed at a well spread sample size across the European countries. A total of 217 companies participated out of which 77% originated from five countries (Czech Republic, Hungary, The Netherlands, Portugal and Serbia) as presented in Figure 1a. Size variation of the companies is presented in Figure 1b. Predominantly, the sample was random, and distributed to any printing operation although in some cases it was known beforehand that the printers are working on innovative printing.

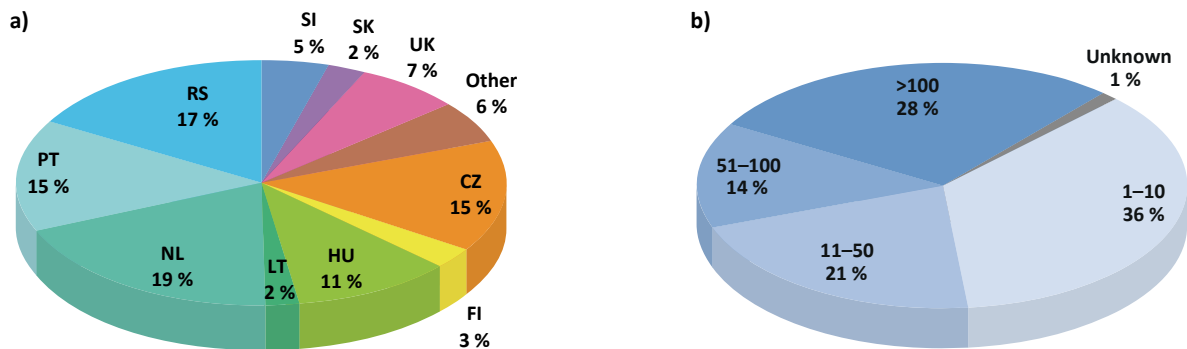


Figure 1: Respondents' country of origin (a) and number of employees amongst the respondents (b)

Respondents were asked for their industry type by means of an open question. The answers were analysed and grouped into categories. With respect to the aims of the study, *Digital printing*, *Security printing* and *Innovative printing* were treated separately. This separation was done to stress that our interest was especially in innovative printing as defined above and not in digital printing or security printing as such. In addition, there was a separate group for *Packaging*, covering packaging production and printing. The *General printing* category groups all the other types of printing production, from commercial printing over books, magazines and newspaper printing to textile, decoration and other printing. Furthermore, the *General trade* category represents sales offices, wholesalers and all kinds of printing industry suppliers, while *Services* include advertising, marketing, mailing, e-commerce, design, media and publishing. The final two separate categories are dedicated to *Paper and board production and converting* and to *R&D and education* including consultancy. The *Other* category mostly encompasses brand owners and other manufacturing. In *N/A* respondents who did not specify the industry type are classified or where the specification is not clear.

2.3 Representativeness of the sample

The total amount of responses is considered to be insufficient for quantitative analysis. However it was decided that it would probably be impossible to reach the target number of respondents from each country, as the target responders were busy industry personnel. Nevertheless, as the authors monitored the survey progress it appeared likely that a larger sample size would give similar results as the patterns in the current results for 217 respondents are very close to those obtained with half of this number at an earlier stage of the research. It can be concluded that the survey results are a fair representation of the printing industry throughout Europe. The method of assessing the representativeness of a sample is very similar to the method that Greener (2008) recommends. In cases where there are concerns with the representativeness of the sample, it is possible to test the statistical difference between the sample and a larger data set. When no relevant statistic difference exists, the representativeness of the sample is more robust (Greener, 2008). Further, the relative sample size in individual surveyed countries has a good correlation with the number of enterprises listed within the "Printing and reproduction of recorded media" category according to Statistical Classification of Economic Activities in the European Community, Rev. 2 (Eurostat, 2015), with the exception of responses from the countries grouped under *Other*, UK responses and partly the Czech Republic responses.

With regards to the size of the companies, the respondents came mainly from small companies with 1–10 employees (36 %). Nonetheless, other categories of company size are also sufficiently represented. In absolute numbers, Serbia, The Netherlands, Portugal and the Czech Republic had the highest representation of smaller companies (1–10 and 11–50), while the larger companies were mainly from Hungary, and from the Czech Republic (Figure 2).

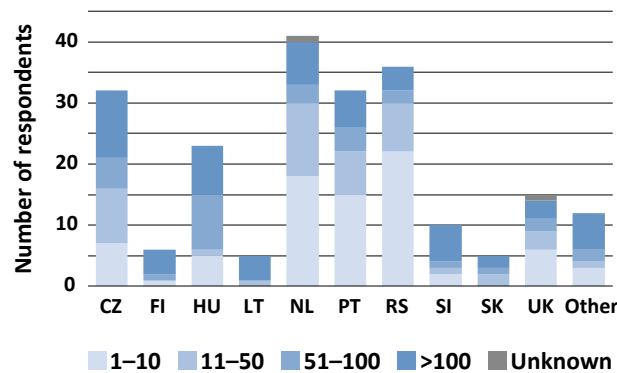


Figure 2: Representation of the participating companies per size (number of employees) per country

The respondents also provided a diverse representation of industry types, ranging from different areas of printing, through packaging and paper & board, to general trade, services, R&D and education. Figure 3 shows the variety of printing technologies that the survey participants employ. This clearly identifies digital printing (named in general or as electrophotography or inkjet printing in particular, in total listed by 134 respondents) along with offset lithography (used by 128 respondents) as the most popular printing techniques. From the main printing technologies, gravure printing is shown as the technique that the participants use the least. Further, the respondents listed the use of pad printing, sublimation printing, letterpress, intaglio, heat transfer printing, plotters, nozzle deposition, slot-die coating, CNC (Computer Numerical Control) cutting, laser engraving and cutting, hot embossing, and hybrid technologies. In case of 10 % of respondents, the question concerning the printing technology employed was not applicable or they did not answer.

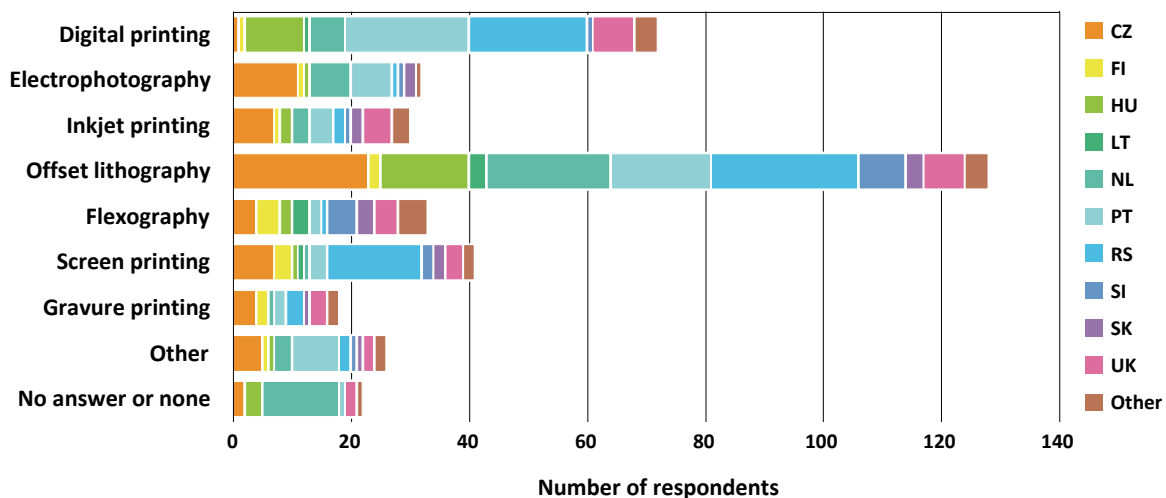


Figure 3: Printing technologies employed by the respondents

In respect to the substrates used, the most common was printing on standard paper grades, employed by two thirds of respondents, followed by plastics and flexible foils, card and board, specialty papers and other. Slightly more than one third of respondents use special printing inks, generally various “effect inks” were listed when specified, with conductive inks being the least common.

3. Results and Discussion

3.1 Involvement in innovative printing

During the past years, the printing industry has experienced many changes, such as consolidation and closing overcapacity. However, printing houses still have a strong belief that printed media products will prevail, but they also understood that some changes need to be implemented to survive (Vehmas et al., 2011).

Based on the results from this study, 41 % of the respondents offer innovative printing, while 48 % not yet do so (Figure 4). The results indicate that printing houses in Western Europe are more active in this field, with 66 % of respondents claiming involvement in innovative printing, while innovations utilized today by printers in Eastern Europe mainly comprise “special effect” and personalized printing and only 20 % of respondents declared the implementation of innovations related to combining print with digital, printed functionalities and similar. The result shows a considerable delay in implementing technologies related to printed functionalities and combining print with digital in Eastern Europe.

When analysing the responses in more detail, the products listed as innovative in some cases do not conform to the definition of innovations surveyed, and vice versa – some respondents listed products fulfilling the definition although they did not claim involvement in innovative printing. There is no clear reason why this was the case; it might be that the term is ambiguous and more discussion on the term or demonstrators are needed to increase understanding. If these definition corrections are considered, the splitting into Western and Eastern countries becomes less obvious and, in total, only 21 % of respondents are active in innovative printing. It is possible that the real number can be higher due to the reluctance to list the innovative products, possibly due to confidentiality issues. On the other hand, it is also important to note that – with only a few exceptions – the innovative products are not the respondents’ core business, regardless of the location of the company.

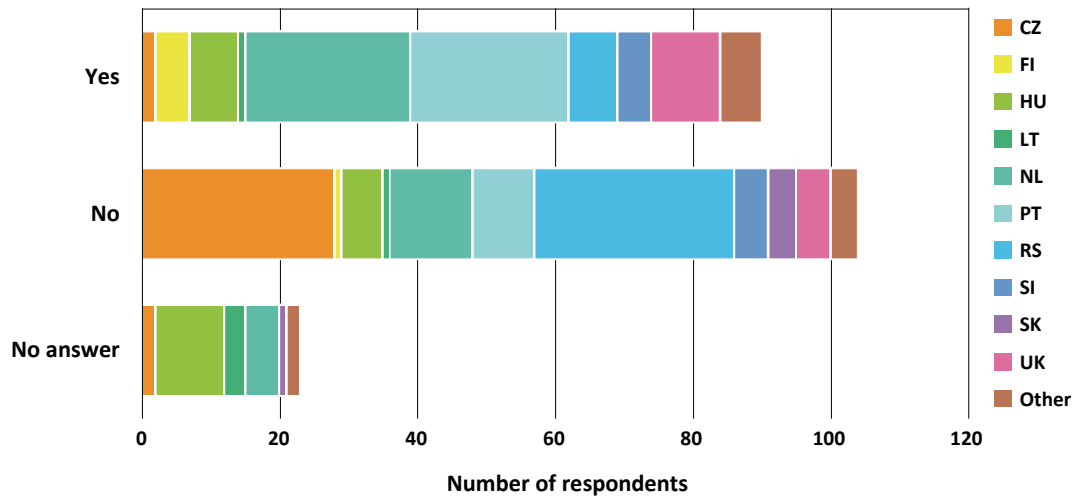


Figure 4: Responses to the question 'Are you involved in innovative printing?'

When examining the declared involvement in innovative printing from the viewpoint of company size (Figure 5a), the most active are the biggest and the smallest ones with 48 and 47 %, respectively. If the above mentioned corrections based on listed innovative products are applied (Figure 5b), the pattern is similar, but the differences across individual company sizes are less pronounced and the values representing respondents active in innovative printing are close to 20 % for all sizes.

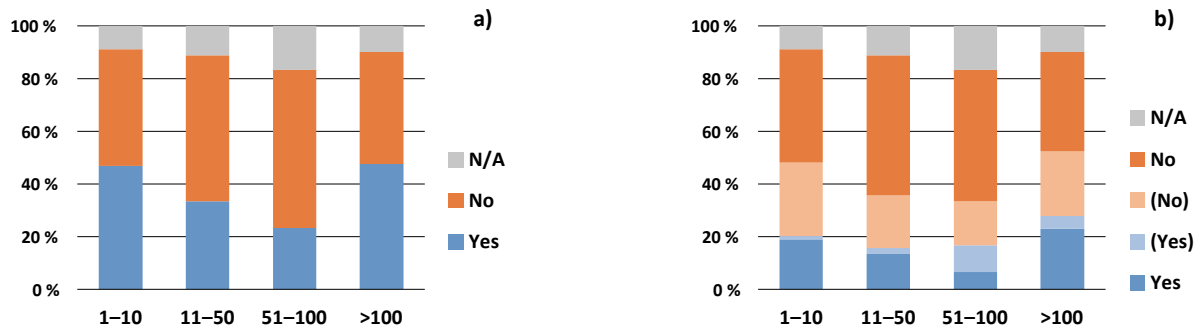


Figure 5: Responses to the question 'Are you involved in innovative printing?' according to company size (number of employees) (a) and these claims corrected on the base of innovative products listed by respondents – designated in round brackets (b) where (Yes) indicates a negative answer but innovative products, and (No) indicates a positive answer whilst the products listed show no innovative printing

The engagement of enterprises in innovative printing was also analysed from the perspective of the type of industry (i.e. how the respondents characterized themselves) in order to assess whether certain industries are more prone to using innovative printing (Figure 6).

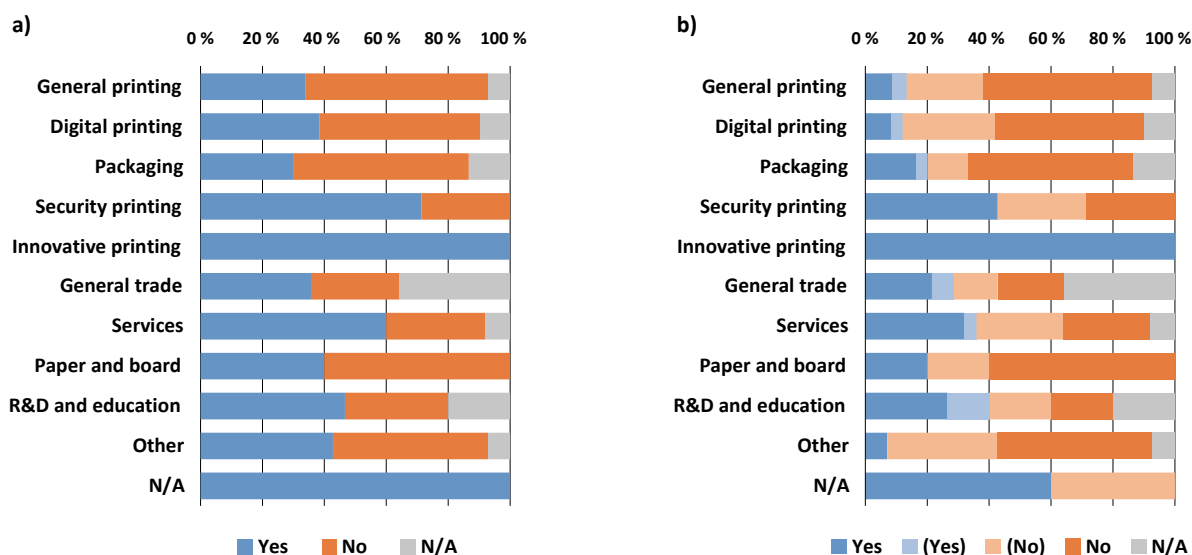


Figure 6: Responses to the question ‘Are you involved in innovative printing?’ according to self-stated industry types (a) and these claims corrected on the base of innovative products listed by respondents – designated in round brackets (b) where (Yes) indicates a negative answer but innovative products, and (No) indicates a positive answer whilst the products listed show no innovative printing

By examining Figure 6a it is possible to determine an irregular distribution of the use of innovative printing among different industry types. The data show a higher involvement in innovative printing by companies who categorize themselves as offering *Innovative printing*, *Security printing* or *Services* with percentages of 60 and more. This is not surprising because these companies are considered to be forerunners compared to the others, and they know better to which category to put their products as they are more familiar to the definitions. Along with *Innovative printing* category, also all of the respondents who did not specify which industry they represent claimed involvement in innovations. On the other hand, *General printing* and *Packaging* industries register the lowest rates (circa 30 %) of engagement with innovative printing. Especially in the case of packaging, the result was not expected, as there are some examples on the market especially on innovative printing and packages. When again applying the above mentioned corrections based on the listed innovative products (Figure 6b), the companies classified as *Other* and *Digital* as well as *General printing* are the least active in implementing innovations with circa 10 % response. However, *Packaging* industry remains on a very low level in Figure 6b as well.

Among the products of the companies dedicated to *Innovative printing*, products such as transistors that can be used for displays or sensor applications, smart packaging and labels, toys, microphones, (biological) sensor strips, strain gauges, photonics, batteries, NFC (Near Field Communication), hybrid structures with conventional electronics, light emitters, freshness indicators, safety gas detectors, printed batteries, printed antennae, printed sensors, printed thermogenerators and other printed electronics were listed. It must be pointed out that only five respondents fall into this category, which highlights the versatility of their production. In case of respondents without a clearly specified industry type, e.g. RFID labels and products with electronic properties were listed. Overall, the implementation of innovations combining print and digital was very rare.

3.2 Limitations to innovative printing

The perception that companies have of the limitations of these innovations seems to be generally homogeneous throughout the participating countries. The most important limitations to utilizing the possibilities offered by technology development are the increased costs, related namely to new equipment, new skills or training of employees, and the lack of market demand (Figure 7). In this context, the costs on customer side were mentioned as well as previously identified by Vehmas et al. (2011). The lack of market demand was stressed by many respondents as the key factor. The responses of the participants showed that in the great majority of cases, the companies expressed that their customers are exerting little or no pressure for innovative printing.

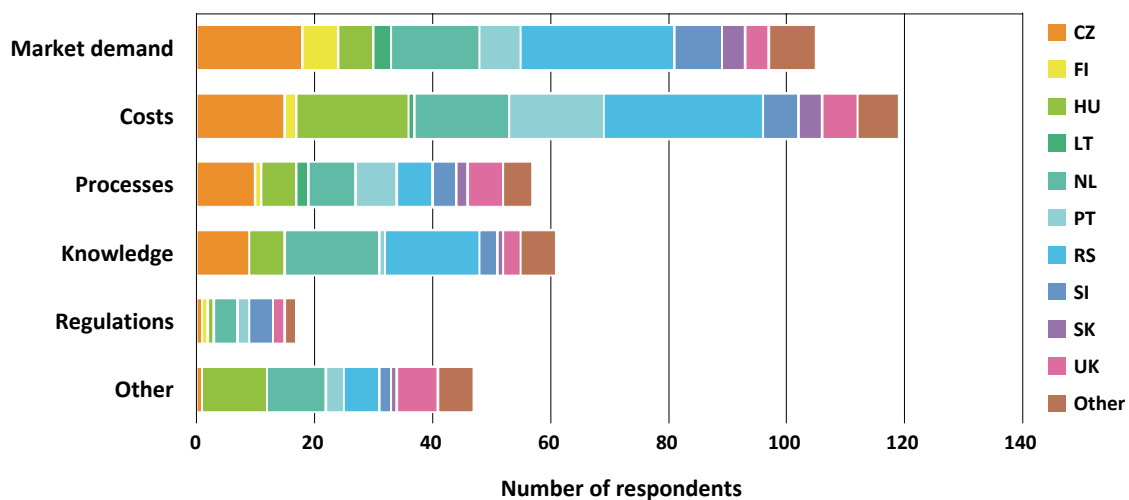


Figure 7: Limitations to use innovative printing as perceived by the respondents

About one third of the respondents (35 %) did answer that the specialties are beneficial to the company's turnover through gained competitive advantage and increased margins, while slightly more respondents answered they are not (38 %) and 27 % left this question unanswered.

3.3. Future potential

The last question of the survey, asking about the fastest growing markets in this sector, was answered by two thirds of respondents – however, often expressing their uncertainty. Therefore, in addition to the one third who did not respond at all, almost 40 company representatives were simply answering that either they do not know, have no opinion/idea or are not sure, or in some cases replied they don't see any potential growth. A typical answer being *'I do not see really innovative products on the market – just in the research companies.'* [country: SI; number of employees: 51–100; main technology: offset lithography and flexography; in the following text, the company characteristics are given in the same format]

When analysing the input from the rest of the respondents to this last question of the survey, some answers were nonspecific, for example *'Exciting, offering new added value opportunity to those who engage.'* [USA; >100; N/A (supplier)] From the other respondents, packaging and labels were mentioned most often, sometimes specified as functionally enhanced, smart,

small scale, personalized, many times as food packaging, also for pharmaceutical industry, cosmetics, alcohol and supermarkets. [CZ, LT, NL, PL, PT, RS, SK, UK; all size categories; various printing technologies or their combinations or N/A (R&D)] Printed electronics was the second most frequent one, where e.g. printed active circuits, flexible electronics, biosensors, printed photovoltaics, the wearables market for flexible displays, RFID or product identification in general, as well as NFC were listed among markets perceived as growing. [CZ, FI, NL, PT, SI, SK, UK; all size categories; various printing technologies or their combinations or N/A (R&D)] Further, security issues, such as product security properties and protection and authentication documents were named in a few cases. [CZ, FI, PT; 1–10, 11–50, >100; various combinations of all main printing technologies except screen printing] Applications, which were listed only once, comprise e.g. special effect inks, hydrophilic, conductive or heat resistant coatings, graphene/silicene applications, nano taggants and medical industry products. In addition, the production and use of intelligent paper (paper with intelligence inside or on the surface that can be read by smart phones) was listed by one respondent, as well as cloud printing, augmented reality, QR codes, valued information and big data tools, or more generally digital media and multichannel communication. On the other hand, one response says ‘*While ago I thought AR but that doesn’t seem to get popular due to lack of standards.*’ [NL; 1–10; N/A (services)] Several respondents mentioned different marketing applications, among which printing technologies, 3D printing and inkjet, or generally digital printing appeared more often.

Some company representatives see the general limitations of growth, mostly connected to the lack of market demand and financial issues, on the side of customers, and this attitude does not depend on company size or country of origin: ‘*It exists only in specific contracts or work.*’ [PT; >100; offset lithography, digital printing], ‘*It will take some time that our customers accept novelties.*’ [SI; 11–50; flexography], ‘*It all depends on the financial power of customers, which however is weak.*’ [PT; 1–10; N/A (equipment sales)], ‘*We think that some of technologies are going to appear quite soon on some products. But of course, depending on financial means, that users will devote for development and usage.*’ [SI; >100; offset lithography, screen printing, flexography, digital printing], and ‘*The cost of new technologies always ends up having an important enemy, which is the policy final product prices that somehow sabotage their swift use.*’ [PT; 11–50; offset lithography, digital printing]

Other respondents answered concerning innovative printing and its consequences for companies: ‘*Faster is better as it will allow greater supply, greater demand and consequently an improved productivity and competitive prices.*’ [PT; >100; offset lithography, digital printing], ‘*All growth must be accompanied by a great knowledge in order to be well supported and consistent. Good training is essential.*’ [PT; 1–10; N/A (trade and services)], ‘*This market is a very competitive market, due to the short margins. We always have to be up-to-date to be competitive.*’ [PT; 1–10; N/A (services)], ‘*As anything that grows too rapidly, we run the risk of not creating enough competences that can generate true gains and added value.*’ [PT04; 1–10; digital printing], and ‘*The field of printed electronics is very interesting. We have to follow trends while in the near future this is going to be our reality. The most important thing is to get appropriate personnel and to find market interesting products for appropriate price. This is the most important for starting new technologies.*’ [SI; >100; offset

lithography, screen printing, flexography, intaglio] These answers show that the attitude towards knowledge as the base of innovation is the same for small and large companies and different industry types.

Both optimistic and pessimistic expectations were presented – ‘*All growth is always interesting because it implies the emergence of niche markets and new opportunities.*’ [PT; 1–10; digital printing, offset lithography, gravure printing], and in contrast ‘*Not a lot as everyone starts a new trend and we all end up in the same boat again!*’ [UK; 1–10; offset lithography, digital printing] Two answers dealt with situation in particular country, one of which belongs to the first group of none or negative responses – ‘*In Hungary we don’t feel that this is growing.*’ [HU; >100; offset lithography, flexography, digital printing] The second one gives more information: ‘*The Portuguese market is very small and the demand for this type of solutions is reduced. Today when we are sought for the use of special inks, use of smells or even the customization of documents, when the customer becomes aware of the price, it backs down most of the times. Universities will have to play a major role in developing solutions and above all work in partnership with the industry in performing tests in real scenarios.*’ [PT; >100; offset lithography, digital printing]

Finally, two respondents provided the most informative answers. One says that ‘*Printed intelligence, in my viewpoint, should be developed and classified in technologies that allow the facilitation and help of informing the consumer about the product/sub-product in itself and its real advantages, and that it will only be valid if the cost/benefit is justifiable, with the exception of people or groups with limitations of a physical or mental nature, in which these technologies allow to facilitate their connection with and their use of the products even if the costs are higher.*’ [PT, 1–10, flexography, gravure printing] The opinions of the second one include ‘*There is a broad front of growth and it would be foolish for any company to be all things to all men. ... Electronics is ubiquitous, it is in every corner of our lives and we do not even think of it as electronics any more...we merely see its function not its technology. Printed electronics is creeping into corners where conventional electronics has not yet ventured or is not suited e.g. disposable applications on biodegradable substrates for food packaging, smart paper...*’ [UK, 11-50, digital printing, screen printing] This respondent also made an interesting point that working with customers to develop their products is a good business model ‘*as many sellers of electronics do not actually manufacture their own products and we believe this will cascade into printed electronics. Other companies are specializing in areas such as transistors, photovoltaic arrays and specialized products such as toys and biosensors. The big markets will not be available to small companies and will be dominated by the likes of Samsung and Apple who will use the technologies in their own products such as televisions, smart phones etc. However, there will be a supply chain that we can all plug into to develop more specialized products using printed electronics techniques.*’

3.4 Cooperation with academia

Printers across Europe are open towards cooperation with academia (see Figure 8), for example by local meetings to discuss relevant topics. The majority of the respondents are interested in training and short courses, would like to participate in research partnerships and

believe that the academia plays a valuable part in terms of the availability of specific measurements.

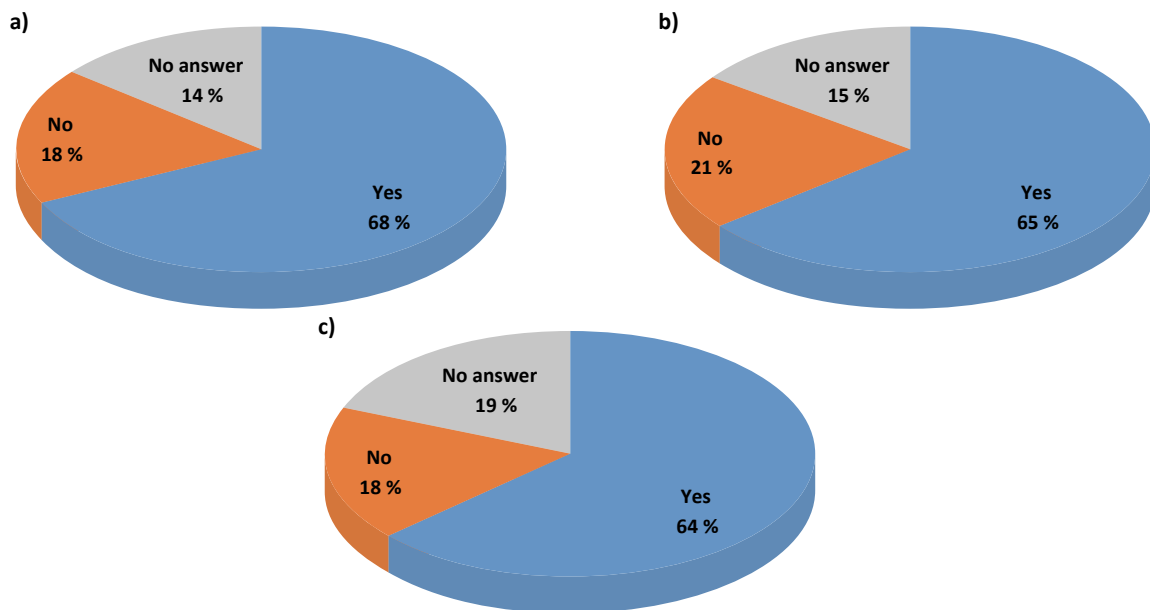


Figure 8: Respondents' attitude towards cooperation with academia – interested in training seminars and short courses (a), in research partnership (b), and in measurements (c)

The companies' attitude towards a possible cooperation with academia was examined also from the viewpoint of their size (Figure 9). As it can be seen in Figure 9a, the interest in training seminars and short courses is more important in smaller companies. Although 61 % of companies with over 100 employees demonstrated their interest, all other categories with less than 100 employees had a percentage of 70 or higher interest in academia. Additionally, the number of negative answers increased with the company size from 11 % up to 25 %, most probably due to the group having internal training. With respect to research partnerships, the results are well in line with the earlier mentioned report by Aistrup (2009), arguing that collaboration is important, is confirmed by the results displayed in Figure 9b. In this case, both positive and negative answers show the companies with 11–50 employees as the most interested, with 73 % and 11 %, respectively. In case of the other-sized companies, around 60 % of the respondents answered positively and approximately 20 % negatively. This may be explained on one hand by the limited (especially human) resources in small companies, more prohibiting them from participation, whereas large companies more often have their own R&D departments, or sometimes don't want to participate due to intellectual property issues. Similarly, the part that academia plays in concrete measurements (Figure 9c) was more valued by companies in the middle categories (11–50 and 51–100 employees) with 69 % and 77 % respectively.

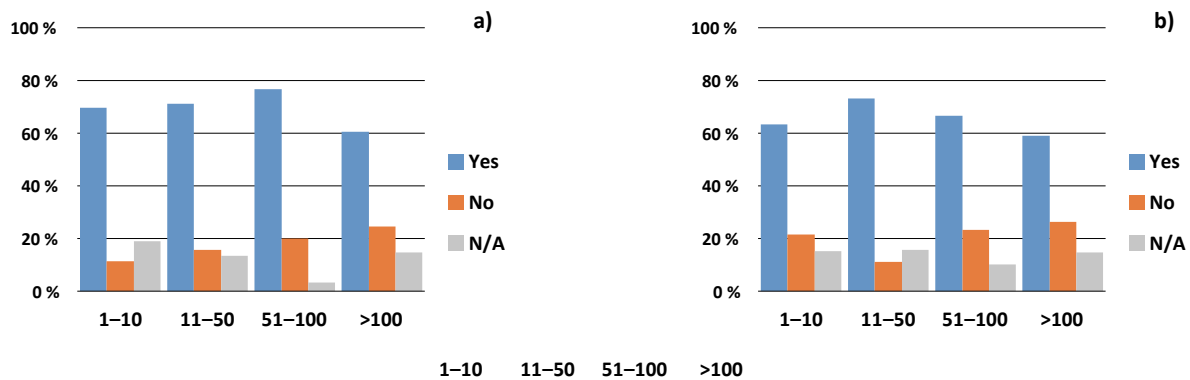


Figure 9: Attitude towards cooperation with academia according to company size (number of employees) – interested in training seminars and short courses (a), in research partnership (b), and in measurements (c)

The fact that a significant amount of companies claimed their willingness to closer cooperate with academia might show that the developments and diffusion of innovations are still at the pre-competitive stage. When cross-analysing these answers, only 18 % of respondents did not express any interest in cooperation, while 33 % answered selectively (17 % interested in one option only and 16 % in some combination of options), with 49 % of respondents being at least partially open to all options.

Overall, the answers indicate that a great majority of respondents (no matter the extent to which they are aware of new technologies) would welcome more information on this subject.

3.5 Further remarks

The manner of execution of this study – a combination of questionnaire and personal conversation – was shown to work best. Even though personal conversation is subjective, it gives more detail and background information to the answers than an online questionnaire allows. The split between the countries' representation seems to be, predominately, the result of different possibilities to reach the target group, and in part also the different instruments for administering the surveys. In addition, since the graphical industry is not the same in each country, it is impossible to target the same amount of responses in each country; on the contrary, it might be considered counterproductive. Finally, some participants just seemed more active and willing to answer. Particularly, participants from Portugal and Slovenia were more open to share their outlook for the future of innovative printing when answering the last question of the survey.

4. Conclusions

This study shows that a combination of lack of market demand with the perception that innovative printing is expensive and complex may be the crux of the investment in this area by the European printing industry. Altogether 217 industrial respondents took the time to reply to the questionnaire, which shows their commitment to the subject and innovation in general. In contrast to the much discussed opinion that the innovative printing market is open mostly for specialized and agile companies outside printing sector or only to the strongest but at the same time flexible printers, it was shown that innovations more or less related to printed

electronics and combining print with digital are considered also by some traditional printers belonging to SMEs. Despite all the limitations associated with innovative printing, one of the main conclusions is the fact that companies are manifesting their interest in education in this area, as well as their willingness to take part in research partnerships. This predisposition towards innovative printing, might, in the long term, work in favour of academic collaborations.

Furthermore, even though all countries differ in the progress they made in innovation or technology, the approach and vision of the industry in general is very similar across Europe. New technology is not the bottleneck. The challenge is to fit new technology to future requirements and business concepts. R&D and cooperation between different partners is needed to reach future goals. Partnerships also outside the printing industry are needed. Digital transformation and technological development enable new value creation and development of innovative products and services for the customers and call for openness in the value networks created. Since most of the respondents use paper and board as a substrate, this willingness to innovate also creates new opportunities for the European paper and board industry.

Cooperation of academia and within different companies in the value network is needed both in innovation adoption and in environmental engagement, as also shown in the discussed comments of the respondents pointing out that working with customers to develop their products is a good business model. For example, industry organisations and larger companies of the supply chain could support the micro companies. Also, improved communication e.g. by promoting best practices is essential in the printing industry where the most of the companies are very small. In case of complex innovation, active support of strong players is crucial to influence the pace of adoption.

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This activity driven by participants of COST Action FP1104 will continue to strengthen the cooperation between printing industry and academia and to gather in depth feedback on the survey results. Within COST Action FP1405, focusing towards active and intelligent packaging, industry will be continuously motivated to invest and develop. This will also enable the researchers to revisit the current studies, get more in-depth feedback on drivers for change, and focus on patterns, relations or discrepancies among the results.

References

- Aistrup Consulting, 2009. *Linking into the Value Chain for the Printed Electronics Industry*. [online]. Available at: <http://www.aistrupconsulting.com/resources/linkingintothevaluechain_printedelectronics.pdf> [Accessed 24 April 2015].
- Bojanova, I., 2014. "The Digital Revolution: What's on the Horizon?" IT Pro, January/February 2014, 12 p. IEEE.
- Bollström, R., Pettersson, F., Dolietis, P., Preston, J., Österbacka, R. and Toivakka M., 2014. Impact of humidity on functionality of on-paper printed electronics. *Nanotechnology*, 25(9), 094003
- Bright, J.R., 1964. *Research, development and technological innovation*, Illinois: Richard Irwin Inc.
- Burgués-Ceballos, I., 2014. *Towards Industrial Viability of Organic Solar Cells: ITO-free, Green Solvents and Technological Aspects for Upscalability*. Ph. D. UAB Barcelona.
- CEPI, 2014. *Key Statistics 2013 European Pulp and Paper Industry*. [online] Available at: <<http://www.cepi.org/system/files/public/documents/publications/statistics/2014/Final%20Key%20statistics%202013.pdf>> [Accessed 24 April 2015].
- CEPI, 2015a. Paper Industry 4.0 – What digital can do for the paper industry, 2015. [online] Available at: <http://www.cepi.org/system/files/public/documents/publications/innovation/2015/LOW_Industry%204.0_170x235mm_20151109.pdf> [Accessed 16 December 2015].
- CEPI, 2015b. *Preliminary Statistics 2014*. [online] Available at: <<http://www.cepi.org/system/files/public/documents/publications/statistics/2015/Preliminary%20Final%202014.pdf>> [Accessed 24 April 2015].
- Chan-Olmsted, S. M., 2000. *Marketing mass media on the world wide web*. In A.B. Albarran & D. Goff (Eds.), *Understanding the Web: Social political and economic dimensions of the Internet* (pp. 95–116). Ames: Iowa University Press.
- Connolly, R., Gauzente, C. and Dumoulin, R., 2012. Adopting IT in public healthcare sector : an institutional research agenda. In: Nunes, M. B., Isaías, P. and Powell, P., eds. *Proceedings of the IADIS International Conference Information Systems*. <http://www.iadisportal.org/information-systems-2012-proceedings>
- Eurostat, 2015. *Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), Most recent data: 2013* [online] Available at: <http://ec.europa.eu/eurostat/web/products-datasets/-/sbs_na_ind_r2> [Accessed 24 April 2015].
- Greener, S., 2008. *Business Research Methods*. Copenhagen: Ventus Publishing ApS.
- IDTechEX, 2015. *Printed, Organic & Flexible Electronics Forecasts, Players & Opportunities 2015–2025*
- Intergraf, 2011. *The Future of the European printing industry-In our own hands, What the industry says*. [online] Available at: <http://www.intergraf.eu/images/SociallyResponsible_Study_ENG.pdf> [Accessed 13 February 2015].

- Masurel, E., 2007. *Why SMEs Invest in Environmental Measures: Sustainability Evidence from Small and Medium-Sized Printing Firms*. *Business Strategy and the Environment* 16, p. 190–201.
- Määttänen, A., Ihalainen, P., Bollström, R., Toivakka, M. and Peltonen, J., 2010. Wetting and print quality study of an inkjet-printed poly(3-hexylthiophene) on pigment coated papers. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 367(1–3), pp. 76–84
- Nurmi, J., 2015. Ideasta uutta liiketoimintaa ennätysajassa. Cisco Connect Helsinki 2015, 19.11.2015.
- Pettersson, F., Österbacka, R., Koskela, J., Kilpelä, A., Remonen, T., Zhang, Y., Inkinen, S., Wilén, C.-E., Bollström, R., Toivakka, M., Määttänen, A., Ihalainen, P. and Peltonen, J., 2014. Ion-modulated transistors on paper using phase-separated semiconductor/insulator blends. *MRS Communications*, 4(2), pp. 51–55
- PMG, 2012. *Print Media in Times of Change, A Key Contributor to EU 2020*. [online] Available at: <http://www.intergraf.eu/images/PMG_WEB.pdf> [Accessed 24 April 2015].
- Thomke, S. and von Hippel, E., 2002. “*Customers as innovators: a new way to create value.*” *Harvard Business Review*, 80(4), pp. 74–81.
- Vehmas, K., Ervasti, M., Tihinen, M. and Mensonen, A., 2015. *Digitalization Boosting Novel Digital Services for Consumers*. *ACSIJ Advances in Computer Science: an International Journal*, Vol. 4, Issue 4, No.16, July 2015, pp. 80–92.
- Vehmas, K., Kariniemi, M., Linna, H., Jokiahho, K. and Torniainen, E., 2011. *Future of European Printing Industry*. Espoo: VTT publication. 9 p.
- Viljakainen, A., 2015. *Exploring the transformation of media sector through the lens of service-dominant (S-D) logic*. Espoo: VTT Science: 79. 146 p. + app. 78 p.
- Viluksela, P., 2015. *Environmental engagement of Finnish printing companies*. Aalto University publication series, Doctoral Dissertations 159/2015, Helsinki, August 2015.

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Questionnaire

Introduction to this questionnaire:

This questionnaire is set-up to assess your opinion on innovative printing. Innovative printing is referred to meaning printed electronics, printed intelligence, printed functionalities, combining print with digital (e.g. provide digital solutions for QR codes, augmented reality...), etc. Focus point is the communication between academia working on these topics, and industry to implement the new technologies.

1.	<p>Please, can you share with us some information on your company?</p> <p>Company name or organisation:</p> <p>Number of employees:</p> <ul style="list-style-type: none">• 1–10• 11–50• 51–100• >100 <p>Industry type:</p> <p>What printing technology do you use?</p>
2.	<p>Are you involved in innovative printing (e.g. printed electronics, printed intelligence, printed functionalities, combining print with digital such as provide digital solutions for QR codes, augmented reality, ...)?</p> <p>Do you use special/functional inks for printing (e.g. IR, thermo chromic, conductive, thermo luminescence, scratch and sniff, scented inks, ...)?</p> <p>What type of substrates do you print on (e.g. plastic, standard paper grades, specialty paper grades, 3D objects, ...)?</p> <p>What are your final speciality products? (Such as RFID antenna, smart labels, holograms, time and temperature indicators, biological sensor strips, freshness indicators, safety gas detectors, other printed electronics, ...)</p>

3.	<p>What are the most important limitations to develop or start to develop innovative printing solutions in your company?</p> <ul style="list-style-type: none"> • Lack of market demand • Costs (new equipment, new skill sets or training of employees, etc.) • Processes (the complexity of the manufacturing process) • Knowledge (lack of information on technology developments) • Regulations • Other (please specify):
4.	<p>Have you increased your margins due to these innovative technologies and do they give you a competitive advantage?</p>
5.	<p>Would you be interested in training seminars and short courses in these areas from academia?</p> <p>Would you be interested in becoming a partner in research efforts?</p> <p>Can academia help with specific measurements?</p>
6.	<p>What are your feelings on the fastest growing markets in this sector?</p>

Please return the questionnaire to: