WP 5.3 – Market Study

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Main objectives

Identify potential markets for the development of three new products made from new manufacturing processes developed as part of the NoAW project

Products selected

Polyhydroxybutyrate/ valerate PHBV

PHA is a family of biodegradable biopolymers, namely polyesters with thermoplastic properties (most frequently).

In NoAw their production is presently investigated starting from manure/straw with possible extension to winery waste

Polyhydroxybutyrate-co-valerate (PHBV)/vine shoots composites

PHBV-based composites are biphasic materials allowing to optimize the functional properties and the final cost of materials, while valorizing lignocellulosic residues.

In NoAW, the production of micrometric size vine shoots fillers is done by dry fractionation (use of successive dry grinding processes).

Highly functionalised Epoxy Prepolymer

The epoxy prepolymer is a fully biobased chemical, composed of functionalized phenolic flavanoid momomers, including some bearing a furan moiety. It is prepared by a one-step or a two-step process, depending on the starting raw materials. The starting raw material is either a condensed tannin extract or a co-product containing condensed tannins (first patent). The Epoxy prepolymer is highly functionalised owing to the 4 phenolic hydroxy groups available on the flavanoid moiety (second patent). The number of epoxy function can be reduced if required (second patent). The tannin extract is depolymerized, then the depolymerized extract is reacted with epichlorohydrin to introduce the epoxy functionalities.

Methodology

Iterative qualitative expert interviewing (out of the method-family called “DELPHI”), using **C**omputer **A**ssisted **T**elephone **I**nterviewing.
These method-family permits to test the market acceptability of a technological innovation.

Central research question:

What are market opportunities for products out of NoAW valorisation routes ?

Information to be identified:

Substitution product
Market segmentation and type of potential customers
Customers’ needs
Promotional factors
Market barriers
Success factors

Key elements of the survey:

10-15 experts per product

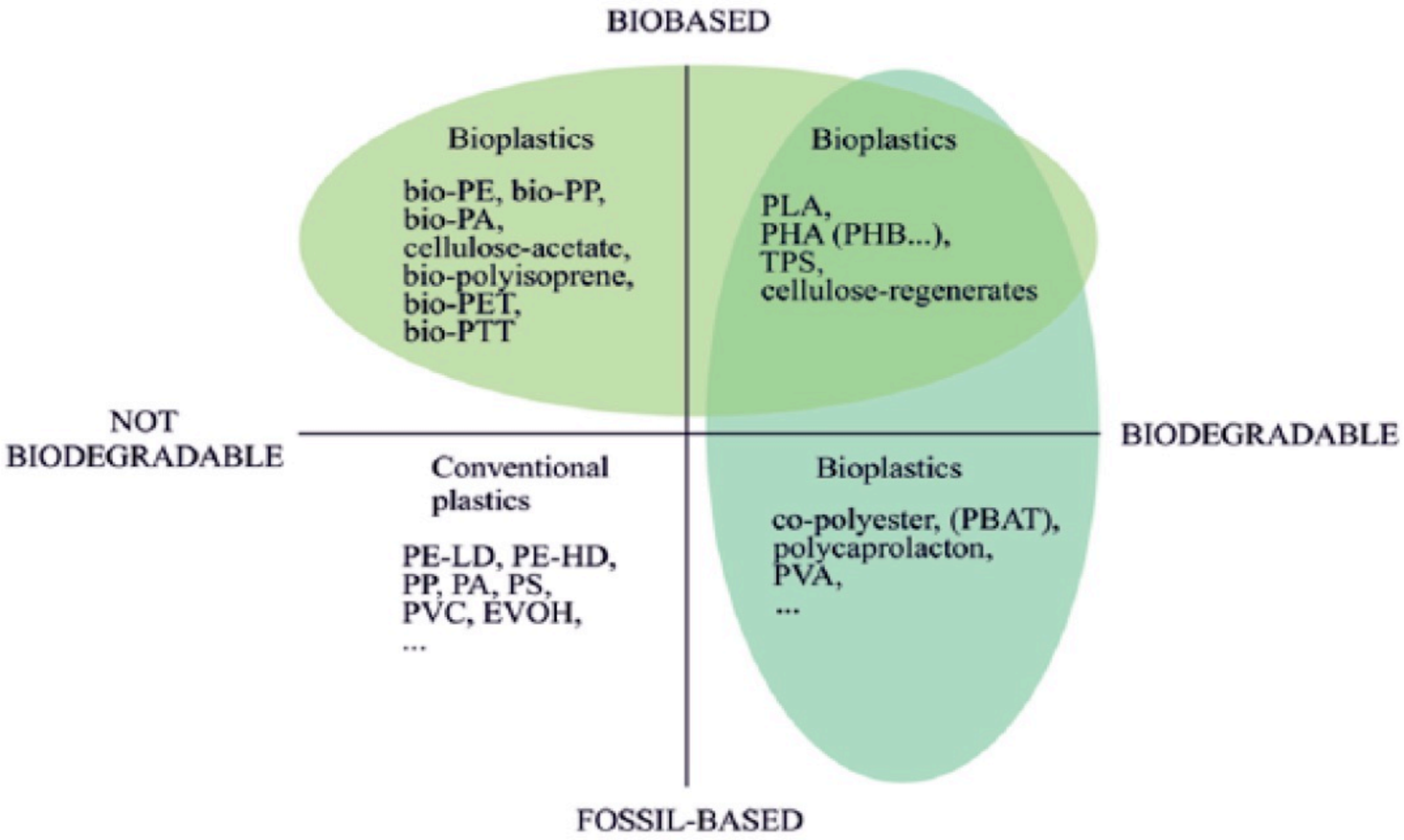
45 interviews altogether (not necessarily 45 different people because some may be competent in several domains and some can be interviewed twice, in the 2 rounds)

2 rounds DELPHI:

- 1st round 10-11 interviews per product group, 30 minutes, by telephone, open interview guideline regrouping 10-12 main questions
- Intermediate results: coding using Maxqda software
- 2nd round 5 interviews per product group, 20 minutes, telephone, double interviewing of at least 1/3 of the sample of round 1.
- Final results: coding using Maxqda software and synthesis

Overview on different bioplastic solutions and their origin and biodegradability traits

(Rujnic-Sokele und Pilipovic 2017)



Main Results

<table>
<tr><th>Product</th><th colspan="2">PHA</th><th>PHBV-based composites</th><th>Epoxy Prepolymer</th></tr>
<tr><td rowspan="2">Main characteristics</td><td colspan="3">PHAs is a large variety of polymers.
Coming from fermentation process
Derived from crops
The NoAw product derived from agrowaste</td><td rowspan="2">Epoxy is a copolymer formed of an epoxy “resin” and a polyamine “hardener.
Usually produced from bisphenol A
NoaW resin 100% bio-based and is not biodegradable.</td></tr>
<tr><td colspan="2">PHBV are PHAs with a short chain length.
Depending on the valerate content, the properties can vary importantly</td><td>PHBV composites are made of PHBVs and lignocellulosic fillers produced from vine solid residues or olive pomace.</td></tr>
<tr><td>Main USES</td><td colspan="3">Injection moulding applications
Thermoforming applications
Fibre applications
Foam applications
Semi-transparent applications
Short usage applications
Long term applications, provided that the material is not exposed to bacteria.</td><td>Coating
Structure adhesives to mechanical joints
Surface protection
Encapsulation
Laminating/icing
Reinforcement material
Inclusion resin
Shrinkage casting resin</td></tr>
</table>

Interesting markets and applications for PHBV and PHBV composite as identified in the expert survey

Most of the markets or applications are interesting for PHBV and PHBV composite.

- PHAs have an overall production volume of 5000 tons on the world market, because of limited properties and, mainly, high costs.
- The legislation is a big issue. The properties of the PHBV and PHBV composite are not a problem, but certifications need to be provided, as food contact approval is a prerequisite for a lot of applications.
- The availability is another big issue. Producers need a minimum supply of 1000 or 2000 t per year.
- The packaging market is limited for PHBV or PHBV composite, because the market demands for high quality products and, furthermore, is a market characterised by low prices.

Sector	Field of application
Food sector	Food packaging
	Cheese coating
	Chewing gum
Cosmetic industry	Cosmetic packaging
	Particles in cosmetic products
	Lubricants
Agricultural industry	Fertilizer coating
	Animal nutrition
	Flexible films
	Carrier polymer for pesticides
	Plant clips
	Planting pots
	Yarn
Biomedical sector	Surgical applications
	Host for antimicrobial drugs
	Coating for drugs
	Pharmaceutical packaging
Automotive industry	Glues and adhesives
	Engineering plastics
	Car interior
Stationary	Synthetic paper
	Pens
Water applications	Saltwater marine
	Sweet water marine
	Aquaculture
	Fishing hooks
	Plastic baits
Other applications	Cigarette filters
	Fireworks
	Training ammunition
	MIP (molecularly imprinted polymers)
	Paint coating
	Coatings
	Single use applications
	Commodity applications in general

[1] This list is not exhaustive. Applications outside the mentioned areas are of course possible.

Market readiness and expected properties

Estimation of market readiness

The opinions on this topic were very mixed. Some experts agreed, that the product was ready for industrial roll-out with two minor limitations

- The availability has to be assured: quantity, quality, constant supply
- The costs should not be too high.

Expected promising product properties

- Tear resistance
- Biodegradation speed
- Increase of bio content in the formulations
- Recyclability
- Biodegradability under natural conditions
- Good feeding performance
- Good printing performance
- Versatile application

How to improve PHBV and PHBV composite markets?

NoAW products will not be price-competitive with fossil-based products and therefore need to be differentiated from them to justify the higher price.

- Changes in the legislation (e.g. Bans on fossil-based polymers in different applications)
- Product declaration as “biodegradable product under natural conditions”
- Taxes on fossil-based polymers
- Increased availability: quantity, quality, constant supply
- Informing producers and users on unsustainability of fossil-based applications
- Communication: Providing the public and the customers with information regarding the advantages of the product
- Identification of the unique selling points
- Improvement of the mechanical properties
- Improvement of the appearance (colour, odour)
- Supply of the raw material for testing (e.g. one expert stated to need at least 25kg for the first rounds of testing)
- Identification of applications where biodegradation is needed

Interesting markets for Epoxy Resin as identified in the expert survey

- Sport industry (high performance sport and water sport)
- Automotive industry
- Potability and food sector (high interest for the material in contact with food and water; e.g. paints for water pipe)
- Boat and ship building
- Paint industry (industrial paint, varnish and DIY paints)
- Aeronautic industry
- Construction and engineering industry
- Floor covering industry
- Niche markets in furniture sector (e.g. current trend for river table)

Compared to PBA-based epoxy resins, all experts agreed on the ecological advantage of the product. The two main arguments were: the bio-based source compared to petrol-based source and the possibility to avoid the use of BPA (non-toxicity and easier handling). Furthermore, the use of bio-based epoxy is in accordance with the legislation evolution and there is a push for safer materials by the general public.

Main Weaknesses identified of Epoxy Resin identified in the expert survey

Risk of technical weaknesses:

- Thermal properties and temperature resistance
- Mechanical resistance
- Reactive monitoring product: Reactivity can be controlled
- Adhesion potential
- Chemical resistance
- Stability over the time
- Fire resistance

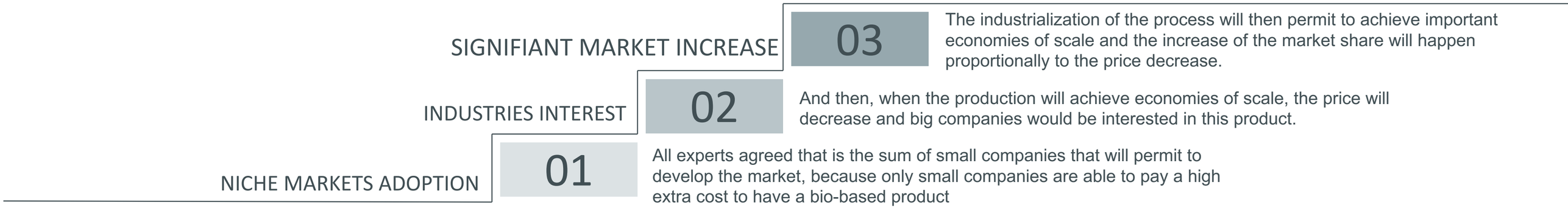
High cost due to formula and process adaptation and potential others costs:

- Purification process
- Purchase of special equipment
- Purchase of new technologies
- Purchase of new installations
- Training of staff
- Investment in new technologies
- Additional cost for the product application

Promotional factors and assessment of market potential

Promotional factors:

- The legislation evolution and public incentive (for supporting bio-based product and/or forbidden BPA use)
- Information about exact composition, traceability to the source, non-toxicity evidence and detailed LCA.
- Improvement of general public information
- Chain reaction, both top-down and bottom-up will increase the product acceptance

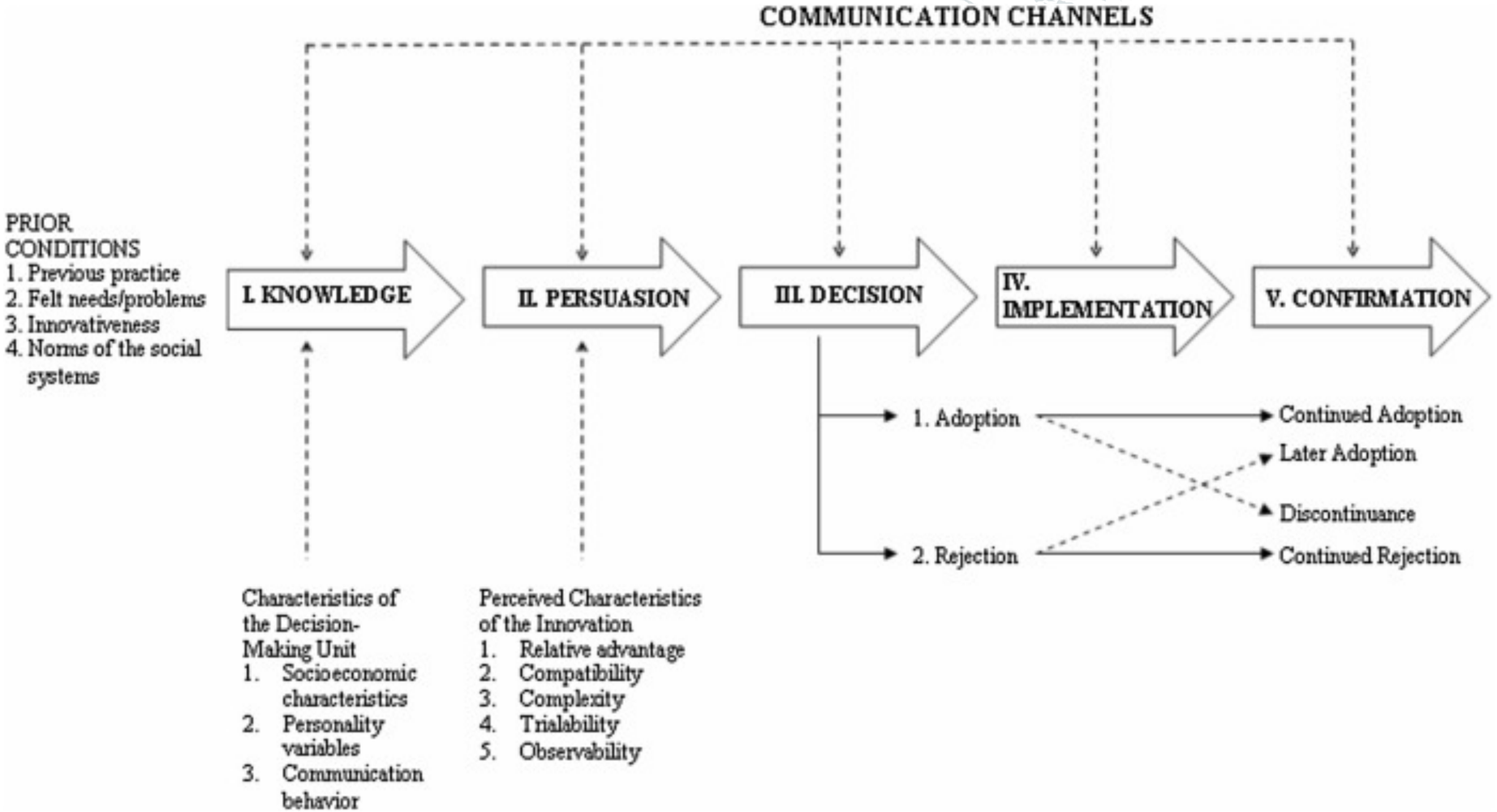


Experts identified **four activities for industrializing** the bio-based epoxy and considered that these activities **will stay separated** because the competences needed for each player are really different. :

- the biomass treatment to make tannin extracts,
- the chemistry industry for converting the extracts into pre-polymer,
- formulators to develop epoxy resin from pre-polymer; and
- professional users who apply the product.

Conclusion

Rogers' (2003) Five-stage Model of the Innovation-Decision Process.



Conclusion

Innovation is recognized as an essential component of sustainable developement. But the chalenges is about the adoption process of new clean technology.

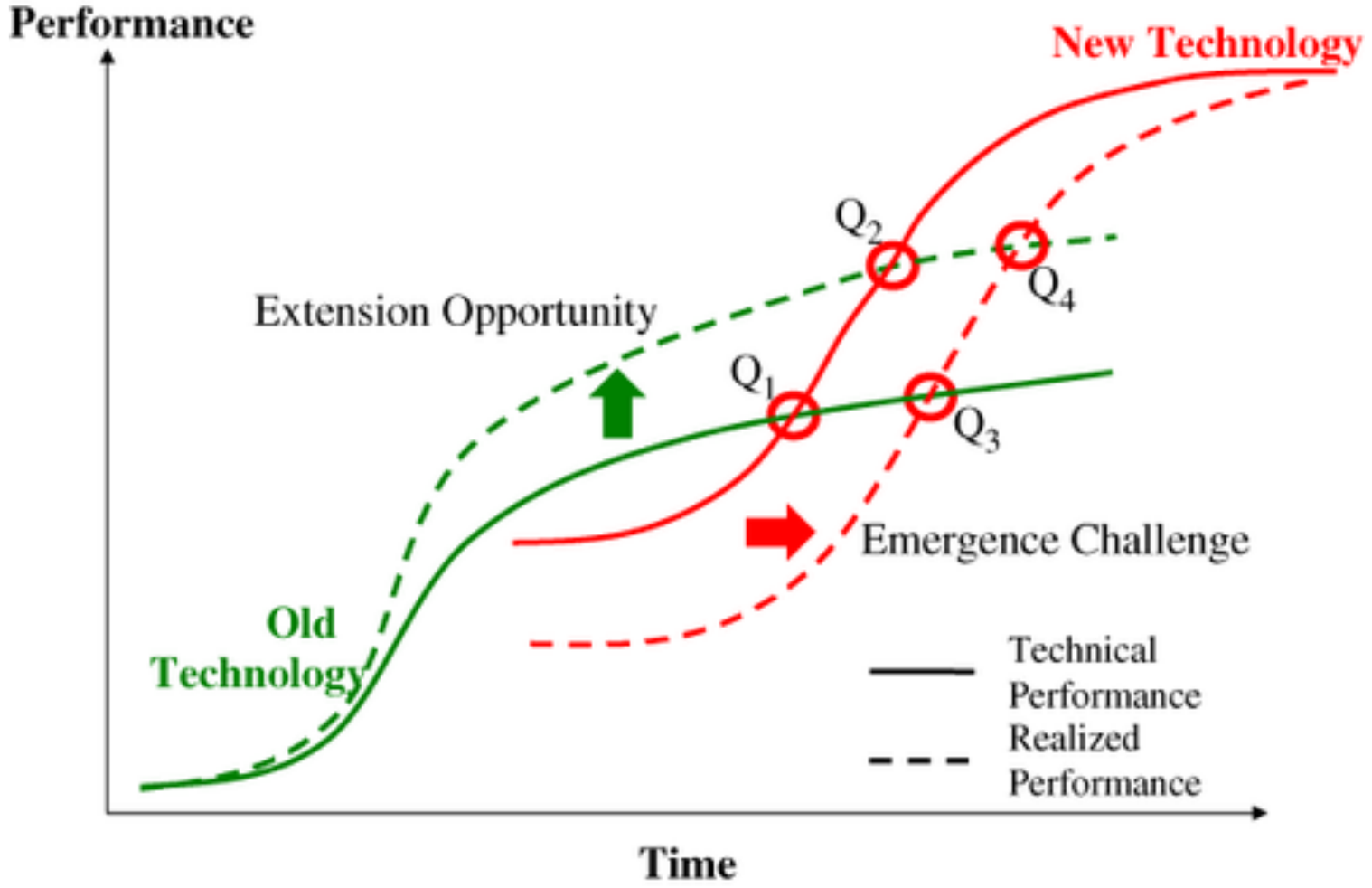
Previous researches show different determinants of innovation diffusion

5 steps are recognized in the adoption process (knowledge, persuasion, decision, implementation and confirmation).

In the NoAW project customers are still looking for information and persuasion.

Conclusion

Technology competition between an old technology with ecosystem extension opportunity and a new technology with ecosystem emergence challenge



Adner, R., & Kapoor, R. (2016). Innovation ecosystems and the pace of substitution: Re-examining technology S-curves. *Strategic management journal*, *37*(4), 625-648.

Conclusion

Ecosystem Emergence Challenge (New Technology)	Ecosystem Extension Opportunity (Old Technology): Low	Ecosystem Extension Opportunity (Old Technology): High
Low	*Quadrant 1* Baseline pace of substitution	*Quadrant 2* Intermediate pace of substitution
High	*Quadrant 3* Intermediate pace of substitution	*Quadrant 4* Slowest pace of substitution

Conclusion

The persuasion should not only concerns the advantages of the new technology

The substitution competition is not only between new and old technology

BUT

The performances that could be reached by the improvment of the old technology and the extent to which technology bottlenecks elsewhere in the system constrain the new technology's realized performance

THANK YOU

FOR YOUR ATTENTION