



Deliverable 2.2

SWOT Analysis



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Summary

The SWOT analysis is a methodological tool designed and widely used for commercial purposes to help entities optimize performance, maximize potential, manage competition and minimize risk. As SWOT analysis have been used to capture the context and identify the key elements of a successful strategy, within the SINO-EU PerMed Project we have adapted this tool to our needs in order to design a consistent engagement strategy that, starting from the information gathered with the mapping, will allow us to reach an optimum level of collaboration with Chinese stakeholders in Personalised Medicine and, specifically, within IC-PerMed.

This SWOT is, therefore, about making better project decisions. It helps us develop effective engagement between European and Chinese stakeholders in Personalised Medicine. It encompasses not only the technical aspects that have emerged during the mapping, but also the understandings gathered at personal and project level by the consortium partners during the implementation of the Work Package 2.

Keywords

Patents, Papers, collaboration, Funding Programmes, Research and Innovation Programmes, Science & technology.

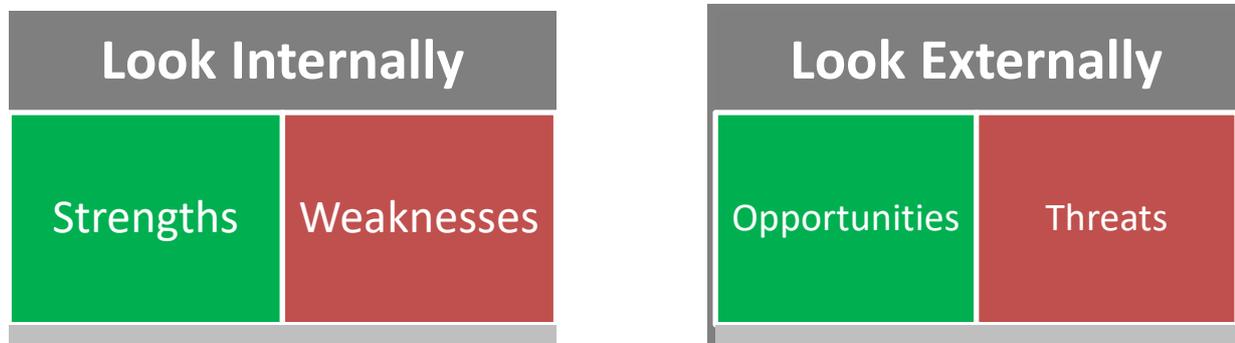
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List of Abbreviations

Abbreviation	Explanation
PM	Personalised Medicine
PPT	PowerPoint presentation
R&I	Research and Innovation
Sino-EU PerMed	Acronym of the Project "Widening Sino-EU policy and research cooperation in Personalised Medicine"
WP	Work Package
PubMed	Free search engine accessing primarily the MEDLINE database of references and abstracts on life sciences and biomedical topics
EPO	European Patent Office
MeSH	Medical Subject Headings
IPC	International Patent Classification
TCM	Traditional Chinese Medicine
NKPs	Chinese National Key R&D Programmes
CM	Complementary Medicine

SINO EU PERMED - SWOT Analysis

The process starts by listing the attributes of the mapping and, in general, the knowledge acquired during the implementation of the WP2 under the four headings: Strengths, Weaknesses, Opportunities and Threats. The four features can be divided into two main dimensions:



Strengths: We look inside the mapping activities and their outcomes and identify which are the aspects that represent positive values to leverage on when developing and implementing an engagement strategy between Chinese and EU stakeholders.

Weaknesses: Weaknesses are intended, in our context, as negative values that might affect the design and/or implementation of the engagement strategy.

Opportunities: are intended as neutral values that can be potentially leveraged to increase/improve the level of engagement and/or collaboration between Chinese and EU stakeholders.

Threats: are intended as risks that, if not mitigated, jeopardise the level of engagement/collaboration between Chinese and EU stakeholders, and even jeopardise the achievement of the project expected outcomes.

Strengths:

We highlight which are the positive aspects that have emerged from the mapping analysis which can be exploited for the implementation of SINO-EU PerMed and the achievement of its expected outcomes

Research (in this context it is represented by scientific publications) in Personalised Medicine is a growing trend (Figure 1).

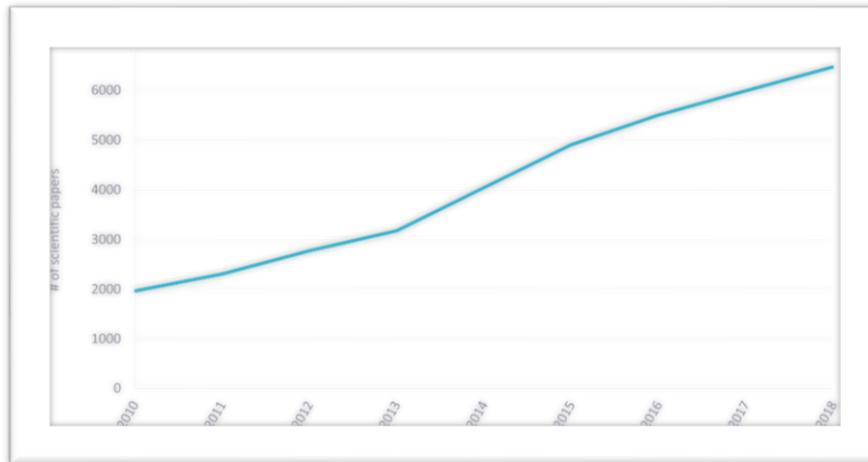


Figure 1: Global Paper Set - trends in papers published on PM globally

The mapping, in fact, highlighted a high level of papers on Personalised Medicine published both in China and in Europe (which means research groups affiliated to China or to European Institutions) which suggests us that PM is seen as a priority in the two Regions (Figure 2).

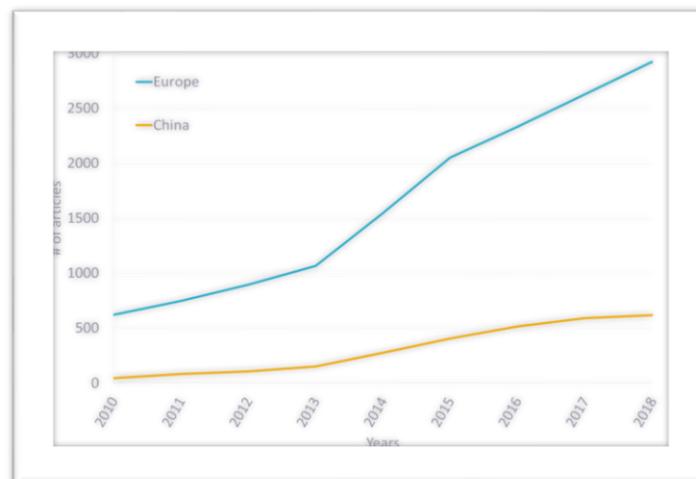


Figure 2: Trends in the publication of articles related to PM in EU and China

This trend is confirmed also in terms of collaboration (which are to be intended as joint publications) between China and Europe. In particular, there are **448** SINO-EU joint papers, participated by **1171** Chinese research groups and **6543** European research groups.

Regarding the Top **24** affiliations participating in joint papers between China and EU, these are:

n.	Affiliation	# of collab	Country
1	Department of Clinical Pharmacology, Xiangya Hospital, Central South University, Changsha, China	115	China
2	Institute of Clinical Pharmacology, Central South University	75	China
3	Engineering Research Center of Applied Technology of Pharmacogenomics, Ministry of Education, Changsha, China	18	China
4	State Key Laboratory of Oncology in South China, Guangzhou	16	China
5	Department of Clinical Physiology and Nuclear Medicine, Turku University Hospital, Turku, Finland.	14	Finland
6	University of Chinese Academy of Sciences, Beijing, China.	14	China
7	Estonian Genome Center, University of Tartu, Tartu, Estonia.	14	Estonia
8	Institute of Human Genetics, Technische Universität München, Munich, Germany.	13	Germany
9	Institute of Genomic Medicine, Wenzhou Medical University, Wenzhou, China.	13	China
10	Research Centre of Applied and Preventive Cardiovascular Medicine, University of Turku, Turku, Finland.	13	Finland
11	Department of Biostatistics, University of Liverpool, Liverpool, UK.	12	UK
12	Icelandic Heart Association, Kopavogur, Iceland.	12	UK
13	Department of Clinical Medicine, Faculty of Health and Medical Sciences, University of Copenhagen, Copenhagen, Denmark.	12	Denmark
14	National Institute for Health and Welfare, Helsinki, Finland.	11	Finland
15	Institute for Community Medicine, University Medicine Greifswald, Greifswald, Germany.	11	Germany
16	Department of Clinical Pharmacy, School of Pharmaceutical Sciences, Shandong University, Jinan, China.	11	China
17	Beijing Institutes of Life Science, Chinese Academy of Sciences, Beijing China.	10	China
18	Department of Clinical Chemistry, Fimlab Laboratories, Tampere, Finland.	10	Finland
19	Centre for Cancer Genetic Epidemiology, Department of Oncology, University of Cambridge, Cambridge, UK.	10	UK
20	Centre for Cancer Genetic Epidemiology, Department of Public Health and Primary Care, University of Cambridge, Cambridge, UK.	10	UK
21	Faculty of Health and Medical Sciences, University of Copenhagen, Copenhagen, Denmark.	10	Denmark
22	Department of Pediatric Pharmacology and Pharmacogenetics, Hopital Robert Debre, APHP, Paris, France.	10	France
23	Wellcome Trust Centre for Human Genetics, University of Oxford, Oxford, UK.	10	UK
24	Department of Epidemiology, Shanghai Cancer Institute, Shanghai, China.	10	China

If we have a closer look at the publications by applying the filter of Medical Specialities, over **38%** of Personalised Medicine research in Europe falls within Oncology, while in China this percentage reaches **50%**; Endocrinology and metabolic diseases represent another field of interest both for Europe and China. Therefore, collaboration within these Medical Specialities already represents a

strong starting point. Within these fields we see a stronger favour for collaborations at Academic level.

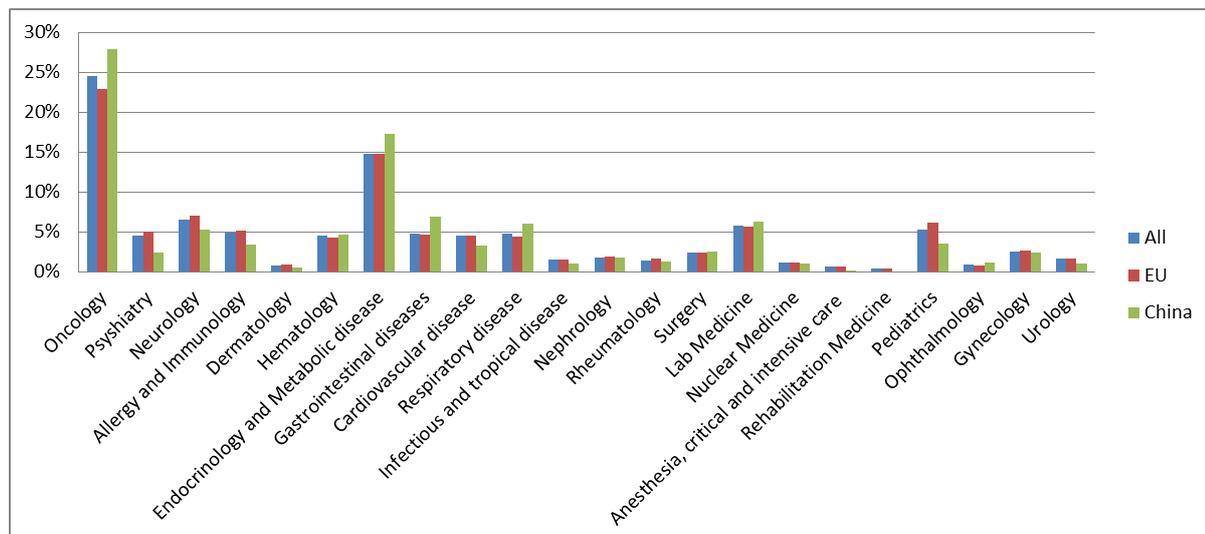


Figure 3: percentage of publication clustered by Medical speciality

For what concerns the “Object of Papers” (Figure 4), most research falls within pharmaceutical research. This suggests that EU and China have similar level of interest in investigating drug therapy research, based on personalised medicine approaches (in preclinical or clinical phase). Moreover, similar interest in Basic research (which is represented by “Other studies” category) is also evident: within this category fall basic research experiments performed to further scientific knowledge without an obvious or immediate benefit (<https://www.ncbi.nlm.nih.gov/books/NBK24660/>), which we can consider preliminary to drug investigations studies.

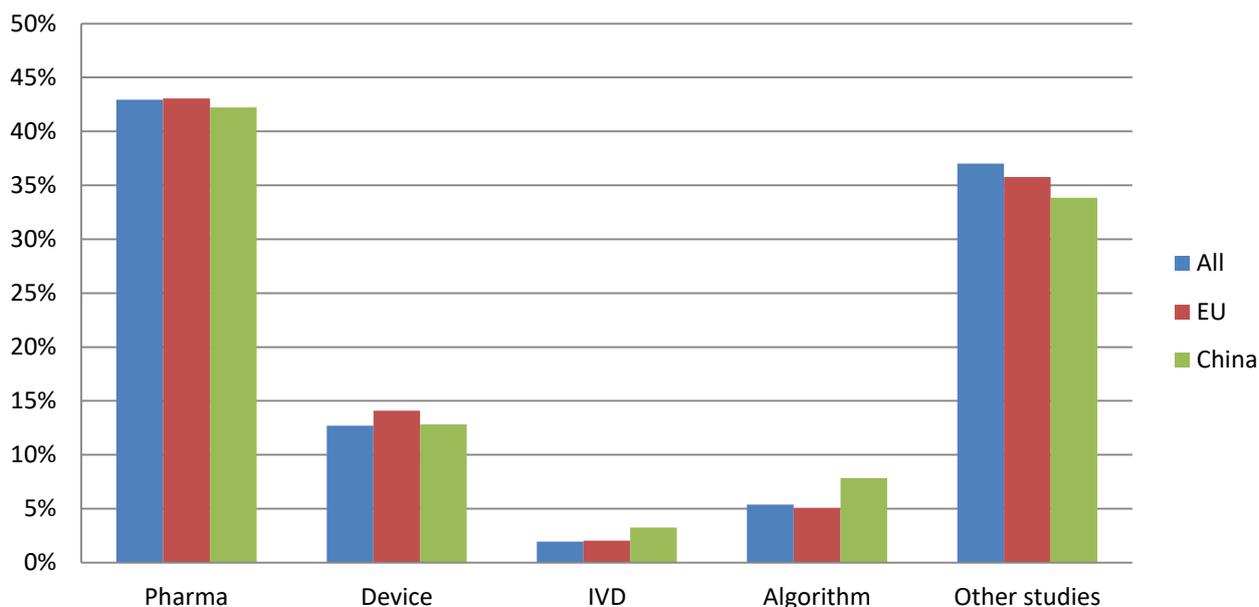


Figure 4: percentage of publication clustered by Object of Paper. In **Other Studies** are collected basic medical research (also known as experimental research) including for example animal experiments, cell studies, biochemical, genetic and physiological investigations

At Country-level, the collaboration between EU Countries and China is well distributed, and many EU Countries have collaborations with Chinese academics, although with different intensity.

#	Country	# of collaboration
1	UK	220
2	Germany	160
3	Canada	154
4	France	136
5	Italy	127
6	Netherlands	127
7	Sweden	104
8	Denmark	93
9	Spain	87
10	Israel	71
11	Finland	70
12	Switzerland	60
13	Belgium	57
14	Austria	53
15	Greece	52

Table 1: Main EU Countries publishing in collaboration with CN

Another positive factor is the growing trend of the SINO-EU collaborations (especially with the most productive EU countries), which is depicted as follows:

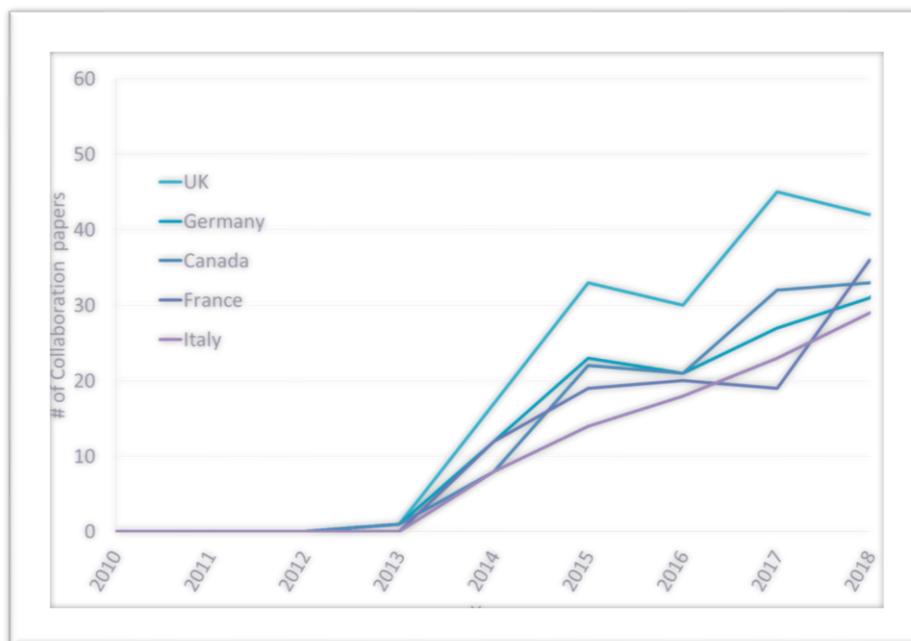


Figure 5 Trends in collaboration between China and UK, Germany, Canada, France, Italy

As for the **patents**, at global level, the patent activity in PM seems to have reached a plateau (see figure 5); a possible explanation is that the main related technologies have already been protected. However, taking this into account, in parallel the level of research papers is growing (See figure 1) it is presumable that this will be the "driving force" for a new wave of patenting

activity in PM in the coming years, although we think that incremental innovation might be prevalent.

Note that patent applications are generally published 18 months after the earliest priority date of the application, therefore the data related to 2018-2020 is not presented.

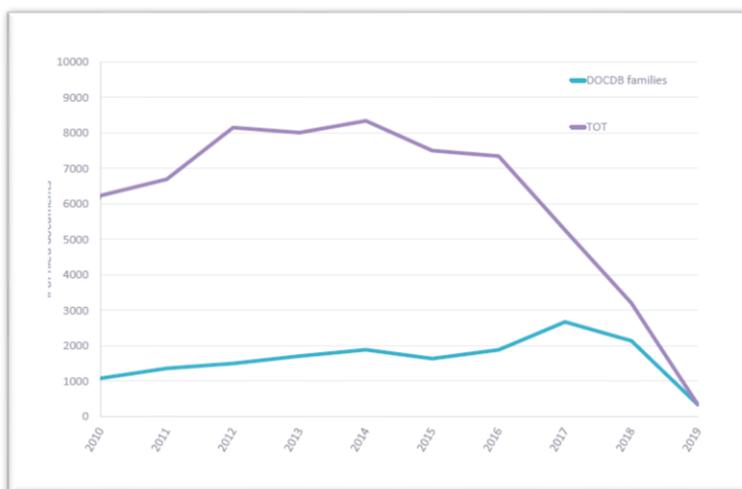


Figure 6: Global Patent Filing on Personalised Medicine between 2010 and 2017

Nevertheless, the patenting activity, in EU and China, is already on a rise (fig. 6)

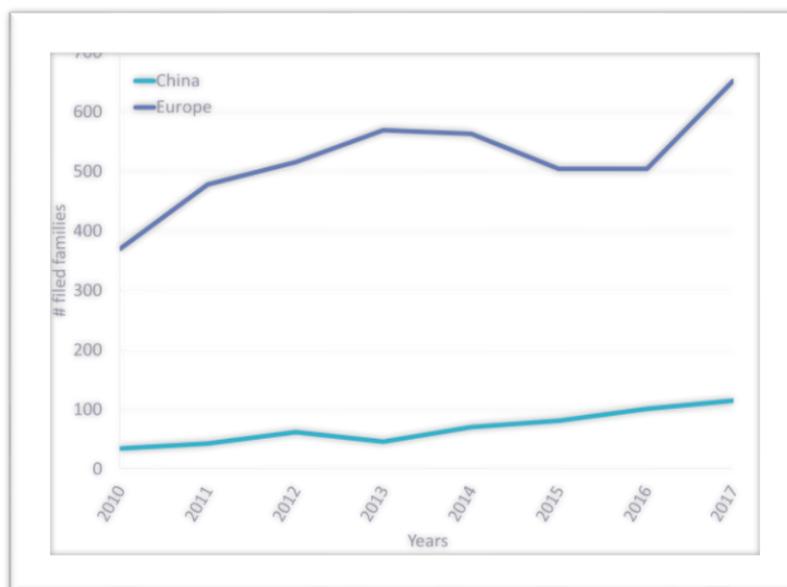


Figure 7: Patent Filing on Personalised Medicine in EU and China between 2010 and 2019 (the blind period has been removed from the figure)

By analysing the medical field of patents, both in EU and in China, we observed that Around **30-38%** of patents related to PM fall within Oncology, followed by Laboratory Medicine (**13-19%**). Similar percentages between EU and China have been observed in patents related to Medical device and In Vitro Diagnostics.

The same level of patenting activity related to IVD and Algorithms in EU and in China, combined with the strong impetus for genomic initiatives implemented both in Europe (i.e. Beyond 1+ Million Genoms Initiative) and China (David Cyranoski, "China embraces precision medicine on a massive scale," Nature 529, no. 7584 (2016): 9-10.), suggest that Massive Genome Sequencing technologies and Bioanalytical tools (which represent key IVD and Algorithms technologies for PM) may represent a favourable field of collaboration, even between public and private sector.

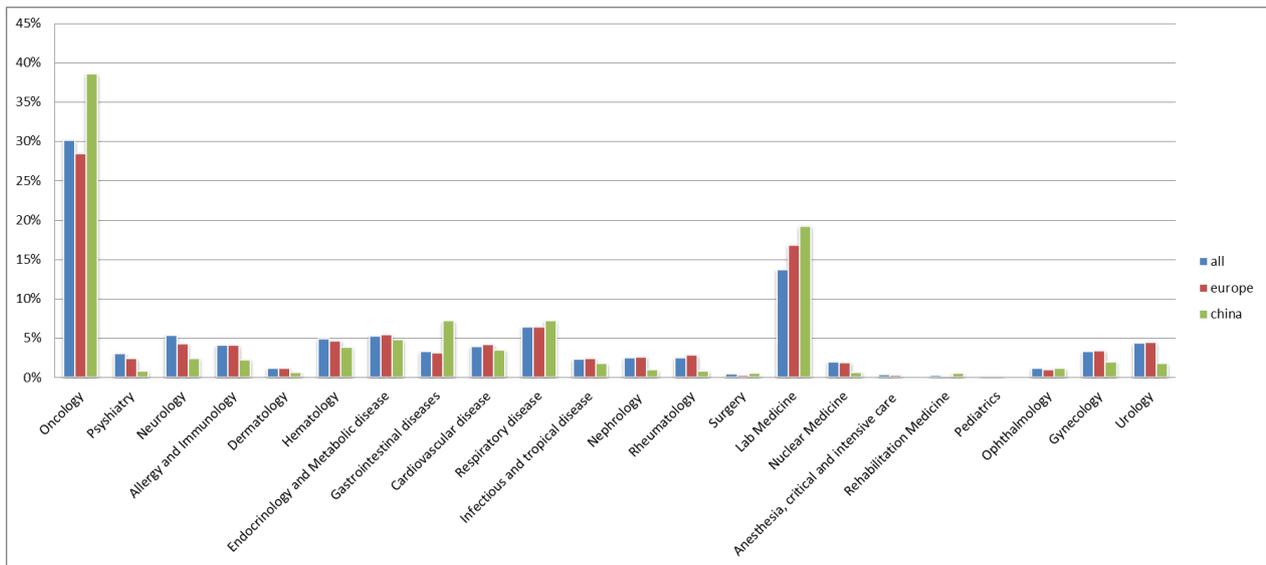


Figure 8: percentage of patent applications clustered by medical field

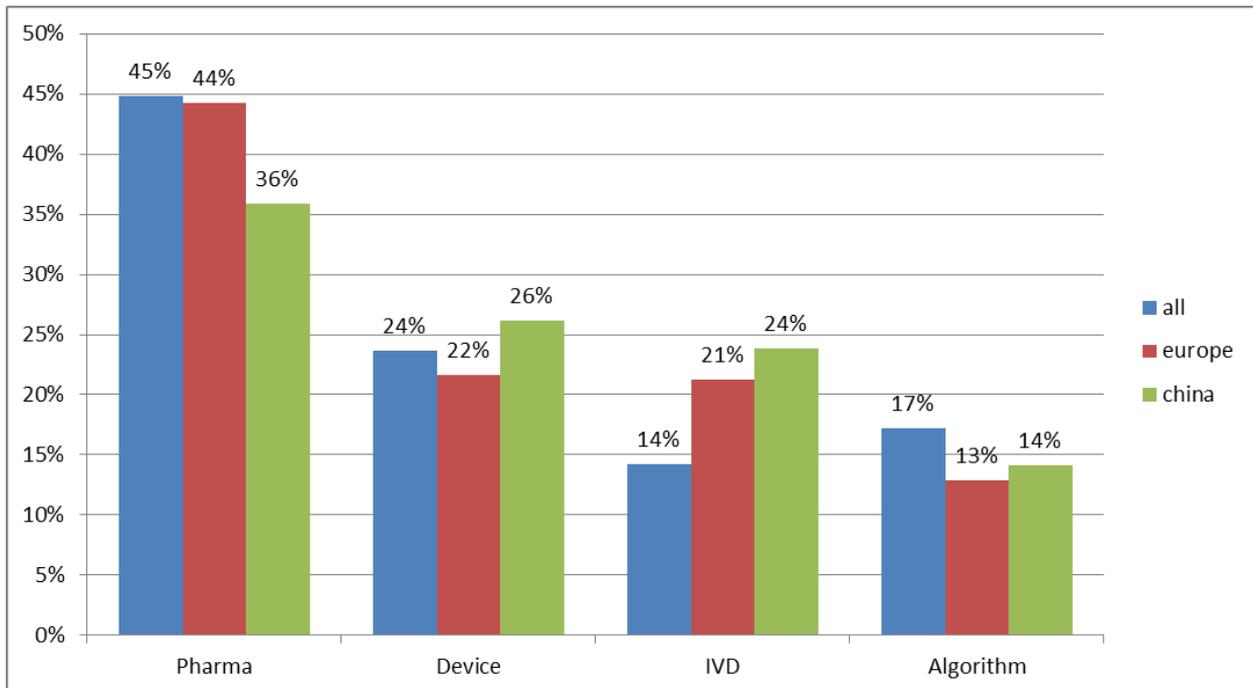


Figure 9: Patent applications clustered by Object of Patent

For what concerns **Funding Programmes**, From the analysis we have performed it has emerged that Europe has invested on Personalised Medicine in a constant manner over the last years (2011-2018). In the past decade it has, in fact, allocated more than 3 billion Euros to funding programs, for over 3.000 projects.

In this regard, joint funding frameworks are being active not only between European Countries, but they are solid with extra-EU Countries as well, like Canada, Israel and Turkey (which have been part of our mapping). This tells us that the EU already welcomes and fosters international collaboration.

China, on the other side, has launched the Precision Medicine Initiative in 2016 - a 15-year programme with funding of worth \$9.2bn - radically changing the healthcare regime in the Country and aims to build up the country's credentials in precision medicine (David Cyranoski, "China embraces precision medicine on a massive scale," Nature 529, no. 7584 (2016): 9-10

With big data in health and medicine being treated as a national priority, China is building national and regional health and big data centres in cities such as Fuzhou, Xiamen, Nanjiang, and Changzhoi. The growing interest of the Chinese in Precision Medicine is also confirmed by the observation that Chinese companies have invested \$312 million in molecular diagnostics and precision medicine in the US in 2000-2017. This is the fourth largest segment among all Chinese biotech investments. Most of the investments in this sector are involved in diagnostic testing services (US Role in China's Biotechnology Development , Gryphon Scientific 2019).

Weaknesses

One way to think of weakness is the absence of strength. Therefore, the items of the WP2 we did not identify as strengths are the first place to look for weaknesses. The idea is that we need to turn these weaknesses into strengths. Doing so, however, requires an honest assessment of where our project/work package needs to improve.

The **Communication** has proven to be difficult, both with the Chinese stakeholders and within the Consortium members. This might indeed be caused by the digital communication tools that we are using to hold our meetings, for which in general people from China have restrictions and are therefore not easy to access or use. Vice versa, using Chinese software tools in Europe are is challenging as well, due to many restrictions that apply at governmental or organisation level.

The lack of communication has certainly been exasperated by the Covid-19 outbreak and the travel restrictions that have been applied globally, which didn't allow trust to be built with face to face meetings.

All these difficulties might endanger the overall engagement strategy of the Chinese stakeholders.

The number of **collaboration papers** is higher than the one of patents, but if we compare it to the global paper set, the number remains small. In addition we need to consider that collaboration in scientific papers does not necessarily mean a complete engagement of the scientist/researcher (as the contribution can be very little within the development of scientific papers).

Another weakness is represented by the way data collection and processing is handled in the two Regions: China (where health-related data are treated as a national priority) and EU (where health-related data belong to the single person) are moving forward at a different pace/level with regard to the Data Protection Policies. This could hamper the collaboration among EU and Chinese researchers.

An analysis on Funding Programs in Europe has been carried out to understand how much the EU is investing on Personalised Medicine and how the budget is distributed.

When we tried to engage Chinese stakeholders to collect important information **on funding programs** in PM the response rate to our surveys has been very low, despite the questionnaire was provided in Chinese and English language. The difficulty of finding a suitable contact person in China has a lot to do with the hierarchy within the organizations (we tackle these cultural features more extensively in the conclusion paragraph). Tasks that do not belong to one's field of responsibility or that are not specified by the supervisor, are usually not processed.

For China, an analysis of the 2016 and 2017 annual tender cycles has underlined that international participation is still very limited:

- only 0.9% of the NKPs assigned were led by international entities
- only 2 out of 2288 National Key R&D Programmes assigned were led by a foreign Principal Investigator
- very few foreign experts sat in evaluation committees
- no evidence of foreign experts among the expert committees drafting tender guidelines

No figures on international participation in wider project consortiums are available, but it is expected that these should be higher.

The collaborations identified by the **patent mapping** (**26** EU-CN co-assigned and **140** EU-CN collaboration patents) are few and have been reduced in recent years.

In most cases they are collaborations between EU and CN subsidiaries of the same firm. Only two collaborations between EU and CN have been carried out by public institutions, in particular INSERM (France) and Shanghai Jiao Tong University and University of Singapore.

That said, it must be considered that a patent gives an “exclusive right” to exclude others from exploiting the patented technology, and according to cost-benefit assessment patent owners draw strategies to maximise the commercial value of patents: therefore the EU-CN collaboration might go well beyond the level that is traceable by our mapping. An up-to-date assessment of the rules and regulations in both Europe and China is fundamental to foster collaboration.

To date, we observed that around **3,7%** of EU-owned patents are filed in China and around **9,8%** of Chinese-owned patents are filed in an EU country, suggesting that cultural barriers and different standards and regulation may represent a weakness for technological collaboration.

Opportunities

Here is where we identify the opportunities for better collaboration with Chinese stakeholders. What opportunities are there for us? The key with opportunities is that they must be acted on. Remember, if we don't act, others will.

As we see above, to date there are **448** SINO-EU joint **papers** in which 6543 European and 1141 Chinese research teams have already worked together, and this has to be leveraged to strengthen collaboration in PM.

Moreover we observed that some research published within the umbrella of Traditional Chinese Medicine (TCM), refers to Personalised Medicine. Therefore TCM, could be also leveraged to increase the collaboration between the two Regions on Personalised Medicine.

TCM falls within the MeSH term "Complementary Medicine" (also indicated as CM) of PubMed database (MeSH Unique ID = D000529); using this ID on lens.org we found **17072** papers. Moreover, we observed that 34 publications (while there are about 206 patents see below) are, at the same time, codified as PM (MeSH Unique ID = D057285) and Complementary Medicine (MeSH Unique ID = D000529).

Using a search tool of lens.org we observed that there are **480** CM publications cited by patents, moreover **1512** patents cited at least in one publication. In other words, about **3%** of papers that are tagged as Complementary Medicine are cited as background knowledge by **1512** patent applications.

These results are useful to better understand the relation between scientific publication within TCM and patents. In light of the above, we could assume that knowledge related to TCM may be useful to develop health technologies, even if not specifically related to Precision Medicine approaches.

All this being said, we can state that TCM could be exploited to foster scientific collaboration between China and Europe.

China's precision medicine revolution is mainly oriented to genome-sequencing approaches and cloud based genomics, as well as other key areas like big data collection and analytics, IT infrastructure, computing capabilities, in-silicon informatics and mobile health (<https://www.enterprise-europe.co.uk/blog/Precision-medicine-GBIP-looks-China>).

Also for **patents** we observed that some scientific and technical innovations related to precision medicine are included under the umbrella of Traditional Chinese Medicine, in particular we found **206** patents that met PM and TCM criteria; this datum suggests that TCM, such as herbal medicine and acupuncture, present some common points with PM approaches to treat medical disorders.

Some TCM approaches could also play a key role in the integrative medicine, and integrative medicine could contribute to primary health care in Western medicine.

The identification of common areas of interest could encourage the development of European-Chinese collaborations

To date, some initiatives aiming to promote the collaboration between China and Europe at technological level are already in place. Recently, bioXclusters plus, an initiative devoted to improve the internationalization of European personalized healthcare

(<https://www.clustercollaboration.eu/news/bioxclusters-plus-paves-way-precision-medicine-companies-china-market>), signed a Gateway Agreement with Fenglin Group establishing that European companies receive a free consultancy package from Fenglin BioMedical Center to ease the European life-sciences SMEs entering the Chinese market. At the same time, the Agreement identifies entry points to Chinese companies able to support the entrance into the European Life Sciences market.

Moreover, government-promoted networks and initiatives are starting, such as:

- **China-Germany Bioscience Innovation Platform**, which was launched by China's Ministry of Science and Technology and Germany's Federal Ministry of Education and Research (BMBF) in 2002 with the goal to facilitate academic research, cooperation, and innovation projects on biomedicine, biopharmaceutics, and new biological materials (Lin Xingxiu. Science and technology cooperation between major developed countries and China: How do countries in Europe and the United States understand China's science and technology, How to cooperate with China: Center for Research and Development Strategy: Japan Science and Technology Agency, 2016),
- **UK-China Research and Innovation Partnership Fund** that supports research and cooperation in areas including stem cells, health, food security and other topics (About Partnering Countries: China," Newton Fund, <http://www.newtonfund.ac.uk/about/about-partnering-countries/China/>).
- The European Commission launched a project, **SENET**, in order to strengthen international R&I cooperation between China and the EU. SENET aims to, firstly, create a sustainable health networking and knowledge hub which facilitates favourable conditions for a constant and constructive dialogue between Chinese and EU research and innovation entities. Secondly, it intends to increase collaborative efforts addressing common health research and innovation challenges

This suggests that technological collaboration between the two Regions has begun and personalised medicine, as an emerging industry, can fuel and be fuelled by the ongoing cooperation.

Threats

In which areas is the collaboration, and therefore the project, at risk? Threats can be defined as "possible events or forces outside of your control that your entity or project needs to plan for or decide how to mitigate." What about new regulations and political balance between China and Europe?

The difficulties to establish fruitful **communication** with Chinese stakeholders might jeopardise not only the engagement strategy, but the entire project outcomes, which strongly rely on the interaction with the Chinese stakeholders.

The Covid-19 outbreak has further weakened the relations with the latter, and immediate planning is required to overcome such threat.

The risk that derives from the travel ban dictated by the pandemic, is that the relationship with the Chinese partners and stakeholders will not fully take off. Trust needs to be built among the Consortium and outside of it, and in-person events usually contribute positively to this and are therefore indispensable.

The European scientific community perception of TCM as a not fully methodological approach, could endanger the level of cooperation with the Chinese counterparts.

Finally, even if Whole-genome sequencing and bioinformatics tools represent a common field of interest between Europe and China and the potential of "big data" for improving health is enormous, a wide range of challenges should be overcome, in particular a common legal framework for data sharing should be reached.

The strong focus on oncology represents a good starting point, but could limit a broader development of PM. Therefore collaboration, and in general investment, should be reinforced in other disease-oriented studies

Conclusion

After carrying out the mapping and the SWOT analysis, it is important to describe how the project consortium intends to use the information gathered to ease the level of engagement between Europe and China and facilitate the achievement of the project expected results. Specifically we will:

Capitalise on strengths

The current level of collaboration will be leveraged and showcased within the Sino-EU PerMed Events, IC-PerMed related events, as well as with scientific articles to be published in peer-reviewed journals. Within the Stakeholders Workshop, the agenda, session, and speakers invited will be based on the strengths highlighted by the mapping with the aim to promote and reinforce the ongoing collaborations at scientific and technological level.

In addition, the main outcomes of the mapping will be considered in the organisation of the WP3 and, specifically, Tasks 3.1, 3.2 and 3.3

Eliminate Weaknesses

Weak **communication** is due to the lack of in-person meetings related to the Covid-19 restrictions, as well as to the not fully cultural alignment between the two Regions; we believe that once the trust is built with joint events and physical proximity, the communication will improve. In the meantime we have taken into consideration the results of the Globe 2020 International Study (referenced below) to fine-tune our communication and engagement strategy.

Promote collaboration with Chinese research groups through IC-PerMed and Era-PerMed. The partnering tool could also be enriched with Chinese institutions.

A dedicated session to the role of Traditional Chinese Medicine within Precision Medicine will be organised in order to explore the relation between these two fields.

Synergies will be sought also within Era-PerMed: financing joint research between EU and China will boost academic collaboration and joint publications among them.

We should involve the already established industrial network such as ENRICH in China (<https://www.china.enrichcentres.eu/>), which offers unique services to European research, technology and business organisations, connecting them to the Chinese market. ENRICH in China is ready to trigger all the scientific and technology collaborative potential of the Chinese market for the benefit of European research organisations and technology-based companies including start-ups and SMEs.

A dialogue with the representatives of these networks should be established while planning the SINO-EU PerMed Events.

Another possibility to mitigate this weaknesses is to explore the possibility to include, within the industrial Pillar of the forthcoming European Partnership on Personalised Medicine, the cross-regional collaboration among the two Regions.

In order to reduce lack of **communication** and trigger higher levels of engagement some cultural analysis might help. In this regard we carried out some analysis through the GLOBE 2020: a large-

scale international study of cultural, leadership and organizational practices in different areas of the Globe. According to the study, the cultural values and practices of China are scored as follows:

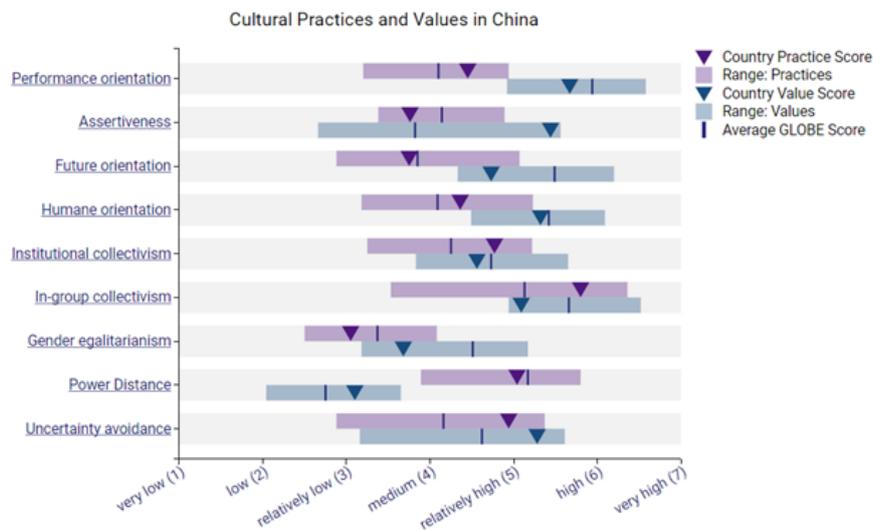


Figure 10: Cultural Visualisation of China - Globe 2020 international study (Results - China GLOBE Project)

Performance orientation: The degree to which a collective encourages and rewards group members for performance improvement and excellence

- **Assertiveness:** The degree to which individuals are assertive, confrontational and aggressive in their relationships with others.
- **Future orientation:** The extent to which individuals engage in future-oriented behaviors such as delaying gratification, planning, and investing in the future relationships with others;
- **Humane orientation:** The degree to which a collective encourages and rewards individuals for being fair, altruistic, generous, caring and kind to others
- **Institutional collectivism:** The degree to which organizational and societal institutional practices encourage and reward collective distribution of resources and collective action
- **In-group collectivism:** The degree to which individuals express pride, loyalty, and cohesiveness in their organizations or families
- **Gender egalitarianism:** The degree to which a collective minimizes gender inequality
- **Power Distance:** The extent to which the community accepts and endorses authority, power differences, and status privileges
- **Uncertainty avoidance:** The extent to which a society, organization, or group relies on social norms, rules, and procedures to alleviate unpredictability of future events

According to the study, China (which belongs to Confucian Asia cluster that comprises also Hong Kong, Singapore, Japan, South Korea, and Taiwan) is characterised by higher levels of: **Power Distance, Institutional and In-Group Collectivism**. The high Power Distance score indicates that the community accepts and endorses authority, power differentials, status privileges, and social inequality, and power is not expected to be distributed equally but is seen as providing social order and stability. Such a consolidated hierarchy, together with self-protective behaviour (that also are a cultural element of these population), suggests that for future communication we not only need to identify the right institution, but we need to make sure we target the right people

(with the sufficient amount of power to take decision and forward information) within these entities.

The societal culture dimensions of **Future Orientation and Uncertainty Avoidance** are rated in the middle range but slightly higher than average. This suggests that in the future engagement activities, we need to better explain the goals of the project and provide exact information about what will be happening in the next project phases.

The Humane-Oriented characteristics score for Autonomous and Self-Protective Leadership is higher than most other clusters. Self-Protective Leadership includes leader attributes such as engaging in status conscious, face saving, and self-protective behaviours. This suggest us that for the engagement process, we need to consider these aspects and build relationship where SINO-EU PerMed stakeholders feel safe and secure

Mitigate Threats

One of the key threats highlighted within the Mapping and this SWOT analysis is the relationship between TCM and PM, as TCM is considered as a not a fully methodological approach. In order to better understand the nuances of their relations as well as the experts' opinion on how TCM and PM can boost each other and foster higher levels of cooperation in Europe and China, we need to dedicate a specific conference/workshop/study tour to this topic in 2021 and before the engagement plan is finalised.

EU and China may pave the way for collaboration for both PM and TCM.

Invest in opportunities

The project activities included in WP3 and WP4, will be used not only to reinforce the strengths already highlighted but also to allow the project consortium to transform the opportunities in real benefit for the project and for the collaboration between China and EU. Research coming from SINO-EU collaboration can be showcased during the WP3 and WP4 activities.

Genomics and Health Related Data is a field of high interest in both Regions and can drive cooperation in science, technology and policy.