STUDY ON INVESTMENT NEEDS AND OBSTACLES ALONG INDUSTRIAL VALUE CHAINS

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This paper uses data from the EC/ECB Survey on the access to finance of enterprises.

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Abstract

The European Union currently faces a need to invest in modernising its industry across all value chains in order to maintain its competitive position and economic relevance worldwide. Particularly since the start of the global financial crisis, the pace of economic recovery in the European Union has been slow, in part due to weak investment. To reverse this trend, collective and coordinated efforts at European level are needed.

Based on the current modernisation needs of the European Union industry, this study aimed to identify specific investment needs, financing gaps and obstacles to investment along a number of industrial value chains and proposed remedies to overcome those obstacles that are specific to the coordination of investments along an industrial value chain.

The study shows an integrated and coordinated approach is required to foster investment and technology adoption. Investment in technology adoption must be paired with investment in other assets, such as skills, network assets and related functional procedures.

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Executive Summary

This document is the Final Report of the "*Study on investment needs and obstacles along industrial value chains*" within the Framework Contract No. ENTR/300/PP/2013/FC-WIFO.

The overall objective of the study is to identify specific investment needs, financing gaps and obstacles to investment along a number of different industrial value chains, and to propose remedies to overcome those obstacles that are specific to the coordination of investments along an industrial value chain.

In order to achieve the study's objective, a methodology was established which consisted of the identification and analysis of five case studies representing high growth potential, and the identification of possible investment packages along these value chains to promote industry modernisation.

More precisely, the methodology consisted of the following components:

- Quantitative analysis to identify industrial value chains with high growth potential and to establish the profile of firms, including SMEs, with specific investment needs;
- Qualitative analysis of investment needs on the basis of five case studies, including the completion of interviews with relevant actors;
- Identification of specific obstacles to investment in the five value chains and illustrate a pattern observed in value chains of similar industrial sectors;
- Review of literature to identify possible remedies to overcome obstacles and develop one potential investment package per industrial value chain case study;
- Development of policy recommendations.

Identification and analysis of case studies

The quantitative analysis has revealed a large number of industrial value chains with strong backward (dependent on inter-industry supply) and forward (dependent on inter-industry demand) inter-linkages ('key industries') as well as numerous industries with strong backward linkages. The industries identified with the highest growth potential at the aggregate EU-level are:

1. Machinery & equipment;
2. Rubber and plastic products;
3. Food, beverages and tobacco products;
4. Motor vehicles, trailers and semi-trailers; and
5. Fabricated metal products.

- **The machinery and equipment value chain**: The study focused on additive manufacturing, also known as 3D printing, with a specific emphasis on the supply of high-end metal powders for metal additive manufacturing. For the full application of high-end metals, the costs of the used materials need to decrease, and therefore investments are needed to reduce the costs of the supply of high-end metal powders. Coordinated investment opportunities include further promotion of R&D, cost reductions for metal powder production and strengthening the link between the use of high-end metals, and the development of new applications. Furthermore, obstacles to such investment opportunities can refer to, for instance, lack of cooperation in the context of competition, as companies in a specific part of the value chain are less likely to collaborate when sourcing high tech components than when sourcing basic inputs such as raw materials.

- **The rubber and plastics value chain:** The study focused on tyre rubber manufacturing, and specifically the supply of natural rubber. 100% of the natural rubber used in the European tyre industry is imported. In order to reduce Europe's dependence on imported

natural rubber, it is needed to establish home production of natural rubber, develop alternatives to natural rubber for the production of tyres, and increase efficiency of the use of rubber in the production of tyres. Investment opportunities therefore include joint investment programmes for the establishment of a home production base of natural rubber, and platforms or networks for shared R&D projects to leverage internal resources of the different actors of the rubber industrial value chain (e.g. facilities). Obstacles to coordinated investments include: lack of cooperation between industry players due to the fierce competition (reluctant to share information, particularly IP); and lack of cooperation between academia and industry that may lead to slower progress concerning innovation.

- **The food, beverages and tobacco value chain:** The study focused on food manufacturing, specifically food traceability and safety where existing systems need to follow the important related technological advances. Most actors in the food value chain have low qualifications and lack the resources to bear the high costs of traceability solutions, and therefore more inexpensive technologies need to be identified. Investment opportunities include joint R&D investment programmes; tax incentives focused on the application of the traceability solutions; capacity building programmes; and initiatives focused on start-ups and SMEs. Obstacles to such coordinated investment opportunities include, but are not limited to: lack of size and resources, and higher investment priorities in relation to other company areas; low qualifications of actors in the primary and upstream segments of the value chain; complexity of the industry – thousands of food value chains; low profit margins on many food products; and low interest in investment.

- **The motor vehicles, trailers and semi-trailers value chain:** The study focused on electric vehicles (EVs) and specifically the supply of batteries for electric vehicles (BEVs). In order for EVs to reach their full potential in the consumer market through enhanced performance, cost and sustainability, high-end BEVs are needed, in particular for the application of innovative methods for performance enhancement (such as power, safety and life span). In addition, for the full application of BEVs, the costs of its materials (particularly the cell costs) need to decrease. Investments are also needed to develop new enhanced techniques for the reuse and recycling of BEVs, in particular in their use for different applications. Investment opportunities include: additional promotion of the R&D phase; and targeting cost reductions for cell production, pack assembly and recycling. Obstacles to such coordinated investment opportunities include, but are not limited to: different investment needs due to different sizes and variety of companies in specific parts of the value chain; lack of cooperation between academia and industry; and a lack of cooperation from the big players in the industry, which may lead to slower innovation progress.

- **The fabricated metal products value chain:** The study focused on metal manufacturing and sustainability. The identified investment need is related to the challenges regarding sustainable production, including the need for increasing material efficiency and the valorisation of by-products and waste. Investment is particularly required for: support for collaboration with complementarities for co-engineering; shared physical structures and R&D for co-engineering; logistics facilities for the reuse and recycling of powder coatings; and R&D for finding applications for the recycling of powder coatings. Proposed policy interventions include: shared R&D facilities that are funded publicly or through a

collaborative investment of several partners; and a third (external) party that is able to collect and valorise waste from different companies. Obstacles to such coordinated investment opportunities include, but are not limited to: transportation costs due to a lack of coordination; a lack of network for potential co-engineering partners; a lack of awareness of co-engineering possibilities; and reluctance towards setting up a recycling platform due to competition.

Policy recommendations

1. Need to identify and better analyse investment patterns and trends across industries and countries;
2. Need to identify in a more precise and systematic way industrial value chains across EU countries on the basis of firm-level data;
3. Need to better understand the drivers and constraints, especially for SMEs, for joining (global) industrial value chains;
4. Need to improve cooperation on coordinated investments along value chains;
5. Need to promote technology transfer and technology uptake along value chains;
6. Need to promote business cooperation along value chains by strengthening IPRs;
7. Need to facilitate the development of investment platforms under EFSI along value chains; and
8. Need to raise awareness, especially for SMEs working along value chains, about specific funding opportunities.

1. Introduction

After more than seven years since the onset of the global financial crisis, the pace of economic recovery in the European Union (EU) has been slow. Weak investment has been one of the main reasons for the slow recovery. Although there is considerable disparity between Member States and between industrial value chains, the EU investment activity in 2013 was 15% below the pre-crisis peak in real terms, with the shortfall ranging from 25% to over 60% in the hardest-hit Member States.

Decisive action is needed to create a stable economic, financial and regulatory environment in order to increase investment in Europe. The current subdued level of investment activity jeopardises Europe's long-term growth potential due to the erosion of the existing productive capital stock. Europe is not making the productive investment in human and physical capital that is needed for future competitiveness, growth and employment, and is thus falling behind other leading economies worldwide.

To reverse this downward trend and put Europe on the path of economic recovery, collective and coordinated efforts at the European level are needed. Adequate levels of resources are available and need to be mobilised across the EU in support of investment. There is no single, simple answer, no growth button that can be pushed, and no one-size-fits-all solution.

To address this issue and restore investment levels, the EU is implementing an Investment Plan for Europe, known as the "Juncker Plan". The Plan will unlock investment over three years and deliver a powerful and targeted boost to economic sectors that create jobs and raise growth.

To achieve these goals, the Plan is based on three mutually reinforcing strands. First, the mobilisation of at least €315 billion in additional investment over three years, maximising the impact of public resources and unlocking private investment. Second, the targeting of initiatives to make sure this additional investment meets the needs of the real economy. And third, the implementation of measures to provide greater regulatory predictability and to remove barriers to investment, and thereby multiplying the impact of the Plan. In particular, these three pillars consist of the following policy measures:

1. <u>Mobilising investments of at least €315 billion in three years</u>

   The Investment Plan is driven by the European Fund for Strategic Investments (EFSI). The EFSI's challenge is to break the vicious circle of under-confidence and under-investment, and to make use of liquidity held by financial institutions, corporations and individuals at a time when public resources are scarce. The EFSI is the main channel to mobilise at least €315 billion in additional investment in the real economy over the Investment Plan's three years. It aims to finance projects with a higher risk profile, thereby maximising the impact of public spending and unlocking private investments. The Fund is established within the European Investment Bank (EIB), with which the Commission acts as a strategic partner.

2. <u>Supporting investment in the real economy</u>

   This pillar specifically aims to support strategic investments, such as in broadband and energy networks, as well as smaller companies with fewer than 3,000 employees. Funding is channelled to viable projects that have a real added value for the European social market economy. The Investment Plan will create an EU portal that lists projects that can bring real added value to Europe's economy, as well as an Investment Advisory Hub that will be a gateway to investment support for European projects.

3. Creating an investment friendly environment

   To improve the business environment, the Plan is focusing on increasing capital to SMEs and long term projects through new financial sector measures. The Commission's 2015 Work Programme set out those priority initiatives that can help remove existing single market barriers.

In this context, a need has been detected to analyse value-chain specific investment gaps and the barriers that may be hampering investment in industry modernisation. In particular, the Commission wants to identify general investment needs along given industrial value chains that could potentially be addressed by the Investment Plan.

The overall objective of this Study is to identify specific investment needs, financing gaps and obstacles to investment along a number of different industrial value chains. It also aims to propose remedies to overcome the obstacles that are specific to the coordination of investments along an industrial value chain. The focus of the Study has been on activities and investments along critical parts of the value chain, to examine what investments would have to be coordinated in order to qualitatively upgrade efficiency and innovation capacity in the value chain. In addition, the Study focuses on trans-regional (including cross-border) value chains to address and contribute with useful evidence to the transnational dimension of the Investment Plan. Local or intra-regional value chains are not specifically examined in this study.

The overall objective of the Study has been achieved through the following tasks:

1. Provide a literature review of academic publications relating to the topic;
2. Carry out quantitative and qualitative analyses of investment needs, financing gaps and barriers to investment of industrial value chains;
3. Assess factors impacting the modernisation of selected industrial value chains;
4. Develop useful recommendations to overcome the obstacles towards modernisation and assessment of their impact on selected industrial value chains.

The subsequent chapter provides an overview of the applied methodology in order to place the results obtained and recommendations made in proper context. The results are presented based on the applied approach, through qualitative or quantitative analysis, and based on additional desk research, thus justifying the recommendations and conclusions. In order to limit the length of the Study, further key findings are provided in Annex.

2. Methodology

The methodology applied by the Study was divided into two tasks:

- Task 1 - Identification and analysis of case studies; and
- Task 2 - Rationale for policy intervention.

Each Task consisted of a series of subtasks designed to achieve results that would lead to and/or support the Study's recommendations, as shown by the below figure.

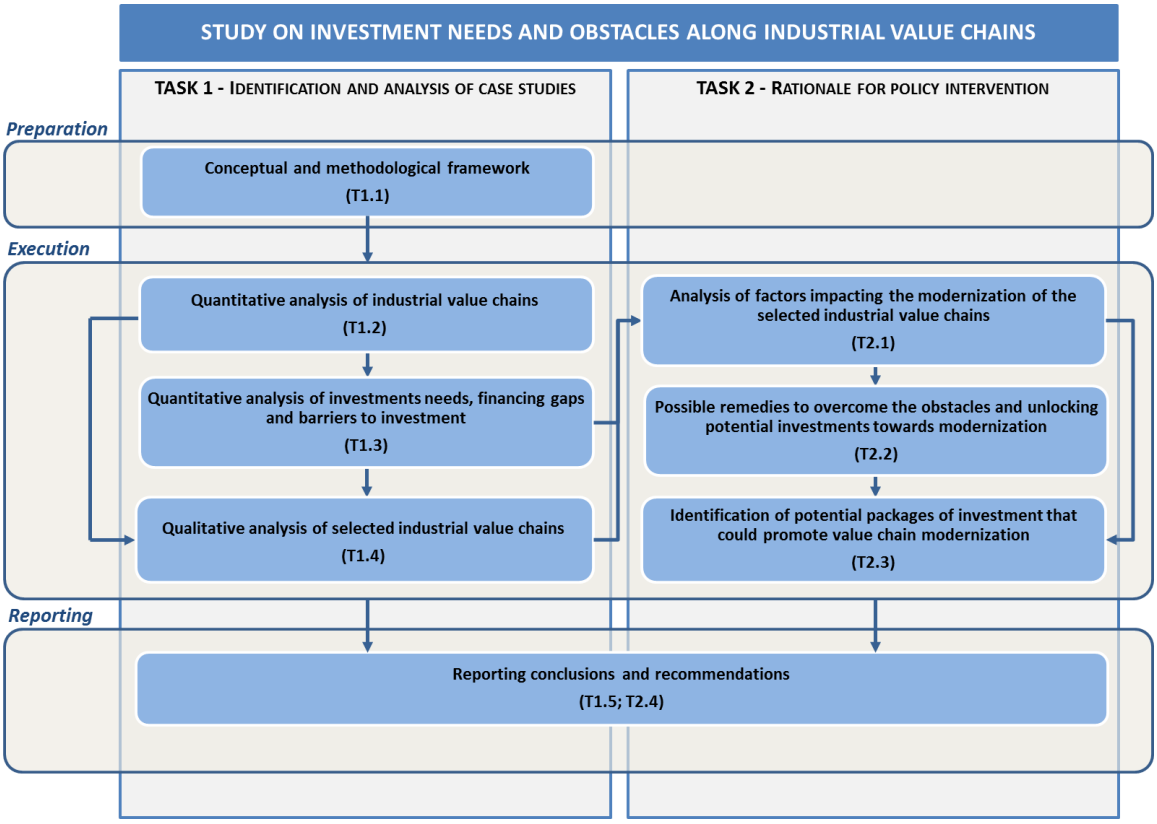

Figure 1. Framework of the Study

Conceptual Framework

It is important to note that the definition of value chain can vary accordingly with different disciplines and schools of thought. Moreover, value chains can be differentiated according to a number of criteria, such as the type of commodity, product and/or service, the degree of transformation, the type of actors involved and the degree of integration and coordination within the chain.1 For the purpose of this study, the following definitions were considered:

- Value Chain: set of activities that a firm operating in a specific industry performs in order to deliver a valuable product or service for the market.

[1] United Nations Industrial Development Organization (2009). Value Chain Diagnostics for Industrial Development - Building blocks for a holistic and rapid analytical tool.

- Industrial Value Chain: A value chain that engages in value addition by means of processing and transformation of goods, especially via manufacturing. In industrial value chains a considerable share of actors engage in the processing and transformation of primary products into consumable goods generating value added.

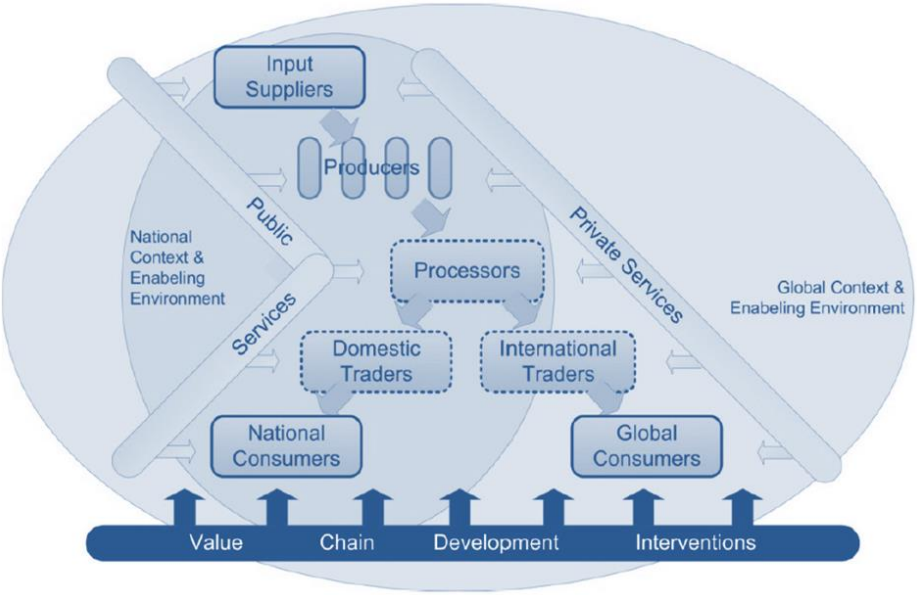

Figure 2. Map of a generic value chain

As shown in Figure 2, four main types of stakeholders can be found in a generic value chain:2

- Value chain actors: Refers to the actors who deal directly with the products, engaging directly in production, processing, and trading. Typically, actors own the product and/or take market positions.
- Public and private providers of services: These entities support the functioning of the chain including transportation, packing and handling, certification, financial support, etc. (as long as it is not carried out by the value chain actors themselves).
- Value chain promoting agents: Includes government bodies, aid agencies and international organisations that undertake support activities and interventions to foster value chain development. As an example, the actions can include capacity strengthening, provision of market information, advice on business planning or the initiation of partnering arrangements.
- Framework conditions: These include the regulatory framework, policies, trade regimes, market interventions, infrastructures, etc. at the local, national and international levels and determine if there are national and global value chain supporting environments. These conditions influence the development of value chains.

The following is a description of the tasks implemented by the Study and respective limitations. Further details on the methodology and data used are presented in Chapters 3 and 4. Recommendations for future studies are presented in Chapter 7 – Policy recommendations.

[2] United Nations Industrial Development Organization (2009). Value Chain Diagnostics for Industrial Development - Building blocks for a holistic and rapid analytical tool.

Task 1 – Identification and analysis of case studies

The objective of Task 1 was to identify and analyse five industrial value chains with a high growth potential across industrial value chains and EU Member States. Quantitative and qualitative analyses have been combined to uncover investment needs, financing gaps and obstacles to investment in each of these industrial value chains. The output of this Task provided a detailed description of the main investment needs, financing gaps and obstacles identified.

Taking into consideration the definition of an industrial value chain, the focus on technology and process based investment needs, the range of possible obstacles to investment and financing gaps, the scope of Task 1 centred on the following:

1. The identification of industrial value chains with high growth potential within and across EU countries (Task 1.2);
2. The identification of the profile of firms, including SMEs, with high growth potential, large investment needs as well the obstacles to investment they face across EU countries and groups of EU countries (Task 1.3);
3. An in-depth qualitative analysis of investment needs linked to coordination failures for selected industrial value chains (Task 1.4).

In order to achieve the scope of Task 1, the study methodology combined quantitative and qualitative analyses. Given limitations of available datasets, the quantitative analysis was followed and complemented by a qualitative in-depth case study analysis.

The first quantitative analysis task, Task 1.2, focused on identifying industrial value chains with high growth potential at the EU and member state level. The leading industrial value chains based on high growth potential were compared with industrial value chains at the member state level to determine if there were correlations. The main goal of Task 1.2 was to rank industrial value chains by growth potential at the EU level in order to select the highest growth potential industrial value chains for further qualitative analysis in Task 1.4. The quantitative analysis used industry data (World Input Output Data base – WIOD) and input-output analysis.

Limitations: It is important to note certain limitations of this quantitative analysis. First, through using input-output data the sectoral aggregation was rather broad (2-digit level) as there was no data available for input-output linkages at a more detailed level. However, coverage of industries in the course of the project could be expanded when the updated WIOD became available. While the previous version of WIOD was based on the NACE rev. 1 classification system, the updated WIOD adopted the NACE rev. 2 classification system. Shifting to the new classification meant an expansion of total industries from 35 to 64 industries, of which 19 were manufacturing industries (instead of 14, as previously). In addition, the updated WIOD provided a set of data for more recent years (2005 to 2014). In order to have more detailed information on sub-industries the Study utilised data from the Structural Business Statistics on the 3-digit and 4-digit level.

A second limitation when using input-output data and analysis is that these indicators do not provide insights of investment needs and gaps along the value chains as these are based on intermediary flows and do not assess capital requirements.

The second quantitative analysis task, Task 1.3, complemented the first quantitative analysis in Task 1.2. Task 1.3 focuses on a quantitative analysis of firms' investment needs and barriers to investment at the EU and member state level. It consisted of an econometric analysis of representative firm-level data across EU-28 countries (the EC/ECB Survey of Access to Finance of Enterprises – SAFE). Task 1.3 identified the profile of firms with high growth potential, their investment needs and obstacles to investment. The analysis across EU-28 countries was complemented with a similar analysis of groups of countries with similar economic and location characteristics. The evidence provided by this firm level analysis have guided the qualitative analysis in Task 1.4 in terms of investment needs and obstacles faced by high growth firms as well as the design of investment packages in Task 2.3.
Limitations: While the SAFE data set provides relevant information on financing growth of firms across sectors and EU countries, it does not contain information on industries within sectors to identify specific industrial value chains. This data limitation has been overcome by the analysis of industrial value chains using an input-output empirical approach based on industry data which complements the analysis of firms' investment needs, financing gaps and obstacles to investment. This empirical approach has been also chosen given the available resources for the quantitative analysis of firm-level data. An alternative analytical approach to identify European and domestic industrial value chains on the basis of firm-level data is described in section 7.1. This evidence is useful for designing investment platforms and packages involving SMEs which are connected through production linkages along the industrial value chain.

The qualitative analysis task, Task 1.4, used results and evidence from the previous tasks. The results of the firm level analysis were used as input into the interview guide developed under this task. This interview guide allowed the project team to specifically focus on the identified investment needs and obstacles in each industrial value chain. For example, the study identified two types of obstacles associated with the lack of coordination and synchronisation of investments, and with internal reasons such as a lack of necessary skills. These obstacles are presented and reflected in the interview guideline, which was adjusted accordingly.
Task 1.4 undertook a qualitative analysis of five selected high-growth industrial value chains in order to determine further details on investment needs and obstacles to investment through an interview approach. In particular, the interviewees selected under Task 1.4 were guided by the findings from Task 1.3 in relation to the firms with high growth potential within each of the 5 selected industrial value chains detailed under Task 1.2. I
In this sense, Task 1.4 combines, coordinates and expands on the results of Tasks 1.2 and 1.3 to provide relevant results on potential investment needs, obstacles to investment and suggestions for investment solutions.
Limitations: This analysis was not an exhaustive approach. Given the sheer size of information (both tacit and public) and the time and budget limitations of the project, one can only focus on the major investment needs and obstacles. In addition, the approach relied to a large extent on desk research and interviews. An extended project time span would have allowed for more details to be provided in the case studies. Caution should be used when extrapolating findings to future cases, given the specificities of the analysed industrial value chains.

The figure below illustrates the interlinkages between each subtask of Task 1. Red indicates results and blue indicates a subtask or activity within the task.

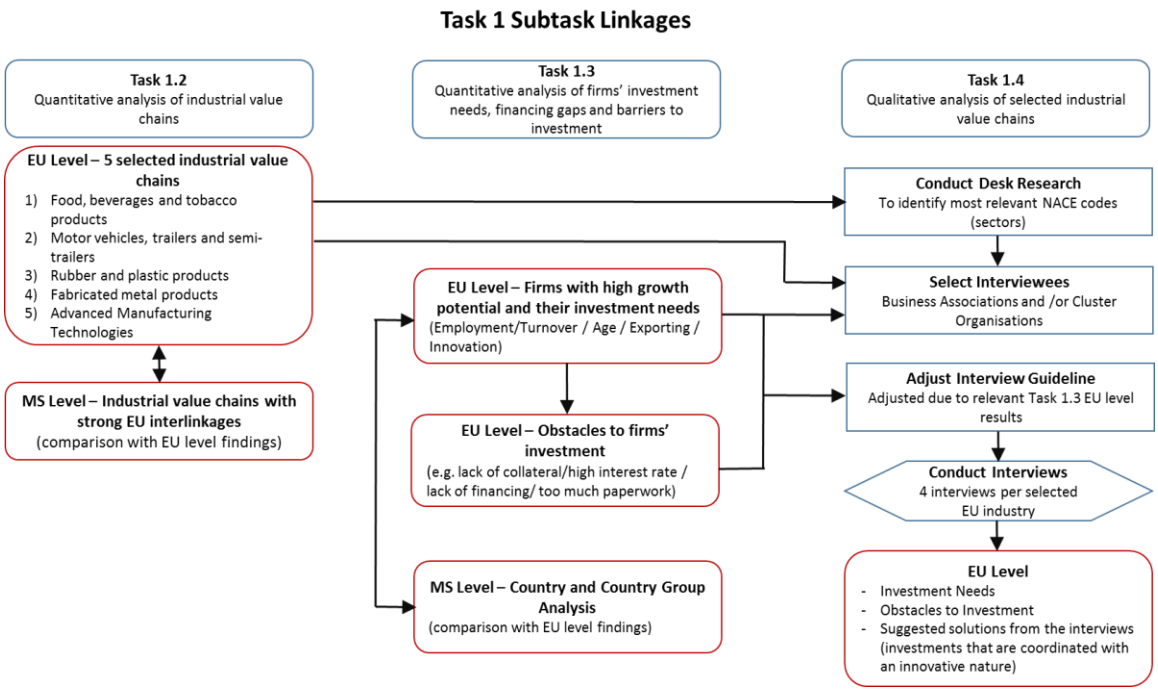

Figure 3. Subtask linkages in Task 1

Task 2 – Rationale for policy intervention

Task 2 of the Study identified possible packages of investments that could promote industry modernisation in the five industrial value chains analysed in Task 1. It established the rationale for remedies to address the obstacles identified in the quantitative and qualitative analysis conducted in Task 1 and proposes recommendations and concrete steps on how to unlock potential investments in each case. This Task applies the knowledge developed under Task 1 towards determining possible investment solutions. These investment solutions are presented in the form of investment packages that can promote modernisation in certain industrial value chains.

Task 2.1 – Analysis of factors impacting the modernisation of the selected industrial value chains, analysed the results from Task 1 (particularly from Task 1.3 and Task 1.4) in order to provide a greater understanding of which obstacles identified by Task 1 are idiosyncratic to the specific value chains studied or illustrate a pattern observed in value chains of similar industrial sectors. The results influence the possible remedies from a policy perspective that may overcome the obstacles, identified under Task 2.2. For this purpose, the results of the quantitative and qualitative analysis have been mapped in order to identify commonalities of investment needs and obstacles across the five industrial value chains.

Moreover, the obstacles were differentiated between idiosyncratic and those that illustrate a pattern which can be observed in other value chains with similar sectors. Further desk research was conducted to complement the findings of Tasks 1.3 and 1.4; and two value chains with similar industrial sectors were selected for each of the five value chains studied in Task 1. Relevant studies and documentation were identified through desk research and allowed to determine potential obstacles to investment faced by these 10 value chains, similar to the obstacles identified in Task 1. A distinction between idiosyncratic and archetypical (illustrating a pattern) obstacles was provided, taking into consideration the commonalities between the initial value chains and the two value chains with similar industrial sectors.

Limitations: The analysis of the obstacles to investment in the value chains with similar industrial sectors was conducted based on desk research only. Additional interviews to substantiate the findings would have been beneficial, as it was done in the qualitative analysis in Task 1. In addition, the findings do not preclude the existence of further obstacles to investment.

Task 2.2 – Possible remedies to overcome the obstacles and unlock potential investments towards modernisation, discusses possible remedies from a policy perspective to overcome the obstacles towards the industrial modernisation of the selected industrial value chains. The possible remedies are assessed for their potential for increasing benefits from investment; thus, improving the opportunity for modernisation of the 5 selected industrial value chains. Extensive desk research was conducted to accomplish this Task, which also benefited from the knowledge and experience of the project partners. The desk research allowed to identify, per obstacle to investment, documented successful policy interventions regarding similar obstacles; and relevant studies that propose or justify potential interventions/remedies. A list of potential remedies is provided.

Limitations: This analysis has been conducted based solely on a qualitative analysis involving the desk research results. The short time span of the Study and the need to obtain the Task 1 results prior to initiating this subtask limited the extent to which this subtask could be conducted. In addition, the methodology consisted in the identification of remedies focusing on existing documented policy interventions and relevant studies only. Moreover, the remedies identified are limited to the European scope.

Task 2.3 – Identification of potential packages of investment that could promote value chain modernisation, identifies and elaborates on one potential investment package per industrial value chain case study, taking into consideration the results of Task 1 and the obstacles and remedies identified in Tasks 2.1 and 2.2. The investment packages were designed in a coherent structure to propose concrete actions that contribute to modernise the industrial value chains and contribute to the recovery of the slow European business investment.

Limitations: This task considered the findings of the previous tasks to elaborate investment packages that are specific to the value chains selected. It is limited due to its focus on a set of specific value chains, which does not justify extrapolation to other non-related value chains.

The methodology comprised as well the interpretation of results and the derivation of conclusions, feeding into the deliverables of the project. Therefore, Tasks 1.5 and 2.4 were defined with the purpose of:

(i) Developing a report comprising the quantitative analysis results and the qualitative analysis conducted in general and specific to the 5 industrial value chains, with descriptions of the main investment needs, obstacles and the coordination gap of investments identified based on the information gathered in Tasks 1.1-1.4 and conclusions of the study (Task 1.5);

(ii) Developing a report comprising a detailed description of the types of obstacles identified and a solid justification of remedies and their potential impact on each of the 5 industrial value chains based on the information gathered by Tasks 2.1-2.3 and the main conclusions of the study (Task 2.4).

As illustrated in Task 1, the figure below shows the interlinkages between each subtask of Task 2, for which red indicates results and blue indicates a subtask or activity within the task.

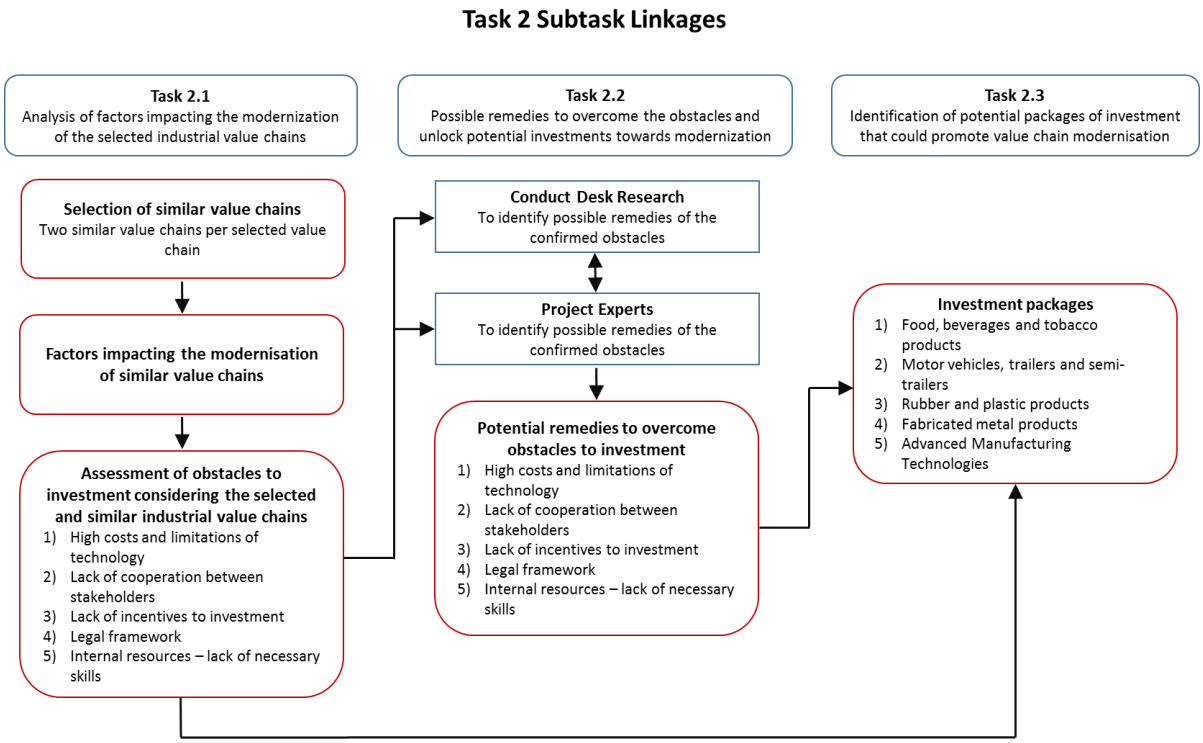

Figure 4. Subtask linkages in Task 2

This report summarises the key results of the analysis from both Task 1 and Task 2 of the Study, including the main conclusions and recommendations. After the Introduction and Methodology chapters, the report is structured into the following chapters:

- Chapter 3 focuses on the key findings of the quantitative analysis conducted in Task 1;
- Chapter 4 discusses the findings of the qualitative analysis, where five case studies were developed;
- Chapter 5 enumerates the investments needed across the five industrial value chains;
- Chapter 6 analyses the obstacles to investments, recommendations to overcome the obstacles, and the proposed investment packages for the modernisation of the analysed industrial value chains;
- Chapter 7 presents the policy recommendations of the Study, namely suggestions for future studies, potential remedies to the general obstacles to investment, and policy recommendations to foster investment irrespective of the industrial value chain.
- Finally, Chapter 8 provides the main conclusions of the study.

3. The quantitative analyses

Chapter 3 presents the main findings of the quantitative analyses conducted in the first part of the Study. The first section relates to Task 1.2, which allowed for the identification of industrial value chains with high growth potential within and across the EU countries. Further details on the analysis can be found in the Annex.

The second section presents the quantitative analysis of Task 1.3, which resulted in the identification of the profile of firms, including SMEs, with high growth potential, large investment needs and obstacles to investment. This integrated empirical approach was complemented by a qualitative analysis, presented in Chapter 4.

3.1. Quantitative analysis of industrial value chains

This section identifies European value chains across different industries and countries to highlight sectoral and cross-country interdependencies and linkages as well as to identify industries with certain characteristics for a more in-depth investigation with respect to investment gaps and needs presented in section 3.3. To this purpose, recent representative industry data and Input-Output techniques are used. Based on the results of this analysis, industrial value chains with significant growth impact at the EU level are identified and compared to industrial value chains at the member state level. The main findings of this analysis are presented below.

- The sector analysis focusing on inter-sectoral dependencies has revealed a large number of sectors with strong backward and forward interlinkages ('key industries') as well as numerous industries with strong backward linkages. Overall, nine industries were classified as key industries and eight as being dependent on interindustry supply showing large backward linkages. Otherwise only one industry was dependent on interindustry demand, showing strong forward linkages (coke); while only one independent industry – with neither strong forward nor backward linkages – was identified (pharmaceuticals).
- The growth potential of an industrial value chain, reflected by the value added multiplier, ranges between 0.8 and 0.9 for EU28 manufacturing industries (except for coke, chemicals and basic metals which is smaller). It was generally higher in 2014 compared to 2005, but declined in between these two years due to the crisis. Manufacturing industries with the highest transnational linkages within the EU are motor vehicles, basic metals, paper and the chemicals industries.
- In order to identify the European value chains with the highest growth potential, a number of indicators have been compiled in addition to input-output indicators, characterizing the size of industries, growth factors as well as aspects such as the intensity of small and medium-sized enterprises. 15 such criteria have been selected and ranked. A simple average over the rankings has been computed to select industries for a more in-depth investigation with respect to investment gaps and needs done in Chapter 4.
- The industries identified with the highest growth potential at the aggregate EU-level are: (i) machinery & equipment; (ii) rubber and plastic products; (iii) food, beverages and tobacco products; (iv) motor vehicles, trailers and semi-trailers; and (v) fabricated metal products. Two of them are key industries (fabricated metal products, rubber) and the other three are dependent on interindustry supply.
- Within the EU industrial value chains, the domestic value added component is highest for fabricated metal products and the food industry; while the industries with the

largest cross-country value added effects in the EU are motor vehicles and the rubber industry. For machinery & equipment, both components range in the middle field.

Industrial Value Chains for EU-28

The main concept in this study is that of the 'industrial value chain', which is defined – as indicated before – as all value added created across interlinked sectors and countries to deliver a product to the final user (which can be household consumption, gross fixed capital formation or government consumption). Using input-output data and techniques, various indicators allow one to identify the relevance of each value chain in the economy and its growth impact as well as inter-industry and inter-country linkages (for a detailed description of data and methodology see Annex 1).

Considering European value chains, Figure 5 presents the results of the key sector analysis for the aggregate EU-28 (2014). Due to strong interlinkages within the EU and strong trade ties, inter-industry linkages are generally strong and pronounced. Overall, the 2014 nine key industries, with large backward and large forward linkages (upper right hand quadrant), are predominantly industries that source raw materials and produce intermediate goods, which are sold for further processing such as paper industry, basic metals, wood, rubber, chemicals, fabricated metal products, other non-metallic mineral products or the repair industry.

In addition, there are eight industries that are *dependent on interindustry supply*, showing large backward linkages but small forward linkages (upper left hand quadrant). These are industries that use a lot of supplies but mostly sell their products to final customers (which is household demand, investment demand or government demand). These industries include motor vehicles, food industry, machinery, electrical equipment, textiles, other transport equipment, furniture, and the computer industry. There is only one industry dependent on interindustry demand, which has small backward but large forward linkages (lower right hand quadrant), that is the coke industry. And, there is only one *independent industry*, showing small backward and forward linkages, which is the pharmaceuticals industry.

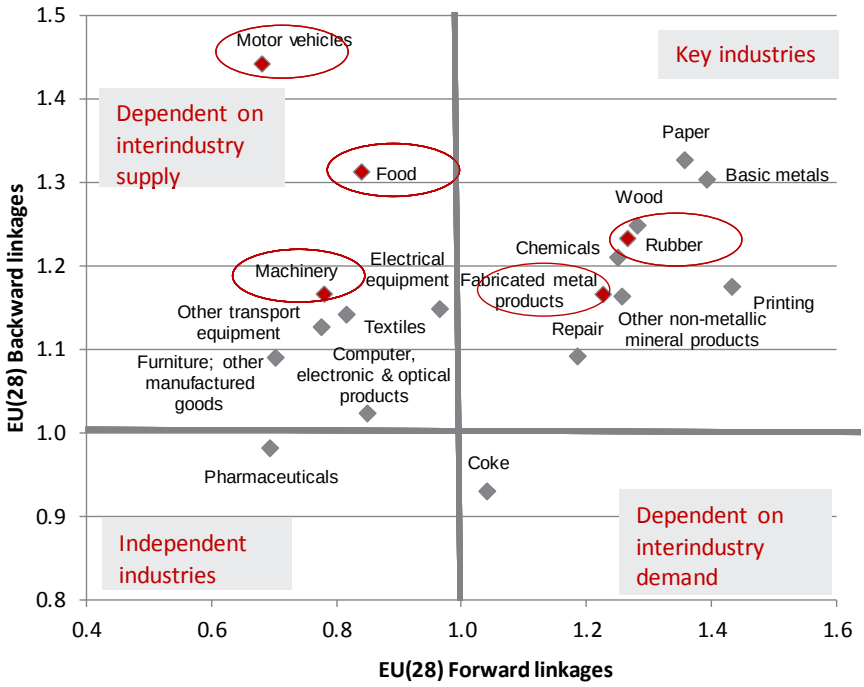

Figure 5. EU28 Key sector analysis, 2014[3]

[3] Source: Eurostat EU28 Domestic Input-Output Table.

In regard to the growth impact of different value chains, the Study used the value added multiplier at the EU-28 level. It shows how much valued added is generated within the European Union, when demand for an industry's specific final output increases by €1 million. For example, an increase of demand for food by €1 million generates value added of about €877,000 in 2014, with the rest being generated outside the EU (€123,000) due to extra-EU sourcing of intermediates. These value added multipliers are generally large for most industries, ranking between 0.8 and 0.9. Only for coke, chemicals and basic metals the multiplier is smaller, due to raw materials imported from outside the EU.

The updated and revised World Input-Output Database allows separating these value added multipliers into their domestic and intra-EU components. The intra-EU value added component for all manufacturing industries for the EU28 ranges from 23% at the top to 13% at the bottom. The motor vehicles industry is the most integrated industry within Europe, followed by basic metals, paper and chemicals industries. On the other end, pharmaceuticals, other non-metallic minerals products and the coke industry are the least integrated sectors.

A next step comprised the identification of industries characterised by a high growth potential, investment intensity, degree of interlinkages and SME characteristics needed for further investigation in the qualitative analysis (section 3.3). Thus, in order to identify the European value chains with the highest growth potential a number of indicators have been compiled, reflecting the size of industries, the growth aspects, as well as additional aspects such as the intensity of small and medium-sized enterprises within a value chain. High growth potential is thus either provided by size, dynamics or both.

The indicators (reported in the Annex) have been ranked according to size (e.g. a ranking of 19 indicates the highest performing industry and a ranking of 1 indicates the lowest performing industry). Then a simple average of these 15 criteria has been calculated (implicitly giving each indicator the same weight), which provided an overall ranking of the manufacturing industries according to these criteria. Based on this ranking of the industries, the following industrial value chains have been selected:

- Machinery and equipment n.e.c.;
- Rubber and plastic products;
- Food, beverages and tobacco products;
- Motor vehicles, trailers and semi-trailers;
- Fabricated metal products.

Analysing each of these selected industrial value chains in more detail one can find the following characteristics:

- ***Machinery and equipment n.e.c.:*** The machinery industry is dependent on interindustry supply. Its backward linkages range is large (e.g. sourcing among others from basic metals and fabricated metal products), its forward linkages are one of the smallest as it sells directly to final demand. The value added multiplier is large and situated in the middle-field of manufacturing industries. Interestingly, both the intra-EU value added component as well as the domestic component range in the middle field across the manufacturing industries. The machinery industrial value chain is one of the largest industrial value chains in terms of production, value added and employment and its changes. SME intensity is in the middle-field (41% of turnover generated by SMEs).

- ***Rubber and plastic products*:** The rubber and plastic products industry is a key industry, with large backward and forward linkages. Its inputs mainly come from the chemical industry. It sells its inputs to practically all other manufacturing industries. The value added

multiplier is also large and ranges in the middle field. Of this, the intra-EU value added component is more pronounced. The rubber industry is a medium-sized sector in terms of production, value added and employment, also in terms of changes of these indicators and in SME-intensity (56% of turnover generated by SMEs). However, it showed the largest change in the value added multiplier between 2011 and 2014.

- ***Food, beverages and tobacco products*:** The food industry is dependent on interindustry supply. It has one of the largest backward linkages (e.g. to agriculture, chemicals, rubber or fabricated metal products); while forward linkages are small, as it basically sells its products to final demand, i.e. households (in the input-output framework, food products are directly sold to final demand and do not appear in the wholesale and retail sector). The value added multiplier is the third largest within the manufacturing industries. Of this, the domestic value added component is pronounced, while the intra-EU component is smaller. The food industry is also the largest sector in the European Union in terms of production, value added and employment. It showed the largest gross investment in tangible goods in 2014. Changes in production and value added shares ranked highest between 2011 and 2013. SME intensity is in the medium field (48% of turnover generated by SMEs, manufacturing average lies at 38%).

- ***Motor vehicles, trailers and semi-trailers*:** The motor vehicles industry is also dependent on interindustry supply (sourcing from the rubber industry, basic metals, fabricated metal products or machinery). It has the largest backward linkages within manufacturing, but also the smallest forward linkages as its output goes to final demand, either to households or investment demand. The value added multiplier is large and ranges in the middle field of all manufacturing industries. Of this, the intra-EU component is very much pronounced, as the motor vehicle industry is the most integrated sector within Europe. The motor vehicle industrial value chain is the second largest industrial value chain in terms of production and ranks also high in terms of value added and employment. It shows the second highest values for gross investment and the investment rate. It scores worst in terms of value added multiplier change but high in terms of changes of production, value added and employment shares. Its SME intensity is the lowest within manufacturing (only 8% of turnover generated by SMEs).

- ***Fabricated metal products*:** The fabricated metals products industry is a key industry, with large backward and forward linkages. Main inputs are sourced from the basic metals industry, for instance. It sells its products to a range of other industries from the motor vehicles industry, other transport equipment, machinery or electrical equipment to the repair industrial value chain. The value added multiplier is large and ranges in the middle field. It has a pronounced domestic value added component. The fabricated metals products industrial value chain is a medium-sized industry in terms of production, but a large industry in terms of value added and employment. It scores in the middle field for changes, but has the second highest SME-intensity (74% of turnover generated by SMEs).

Thus, this selection of industrial value chains encompasses an interesting mix of industries, with different characteristics reflecting various degrees of inter-linkages, growth potential and SME intensity. Also with regard to value added components, the selection provides an interesting mix of industries with pronounced domestic linkages (food and fabricated metal products),

with strong intra-EU linkages (motor vehicles and rubber industry), or with both (machinery). Selected industrial value chains are circled in Figure 5 for additional reference.

3.2. Quantitative analysis of investment needs, financing gaps and barriers to investment

This analysis identified investment needs and obstacles to investment for firms with significant growth potential, including SMEs in the industry sector across EU Member States. These results based on firm level data complement the quantitative analysis of industrial value chains discussed in section 3.1 and have guided the design and development of the qualitative analysis based on interviews, reported in section 3.3. Finally, this analysis provided useful evidence for designing the investment packages discussed in Chapter 7. The main findings are summarised below.

- Firms with high-growth potential (expected turnover growth of over 20% per year over 2015-2017) and large investment needs (external financing from €250,000 to over €1 million) to realise their growth ambitions tend to be medium-sized (50-249 employees); middle aged (2-10 years); simultaneous innovators and exporters.
- Firms that prefer equity capital over bank loans are more likely to be both high growth-potential firms and firms with large-investment needs. The effect is strongest for firms reporting the highest investment needs (over €1 million).
- Firms reporting obstacles to financing (insufficient collateral or guarantee; interest rates or price too high; reduced control over the enterprise; too much paperwork involved; financing not available at all; or other obstacles) are more likely to report investment needs over €1 million.
- Smaller firms are more likely to face obstacles to financing than larger firms. Firms in the 5-10 years age category are more likely to report any type of obstacle relative to older firms; in contrast, simultaneous exporters-innovators are less likely to do so, relative to firms which neither export nor innovate.
- Overall, the general profile of firms with high-growth potential and high-investment needs described above is similar across various EU groups of countries. The smallest economies and Eastern EU countries tend to report larger shares of high-growth potential firms in comparison to Central and Western EU countries. However, Western EU countries tend to report larger shares of firms with high investment needs while Eastern EU countries tend to report lower shares of these types of firms.
- In addition to complementing the quantitative analysis in Task 1.2 and guiding the qualitative analysis in Task 1.4, the results of the firm level analysis are useful for the design of the investment packages to be discussed in Task 2.

Data and measures

This empirical analysis was based on a representative firm level data in EU Member States related to access to finance and innovation activities, the Survey of the Access to Finance of Enterprises (SAFE). The SAFE questionnaire, conducted by the European Central Bank and the European Commission, provides a rich source of information on firms' financing conditions in the Member States. The survey covers micro, small, medium-sized and large firms and provides evidence on the financing conditions faced by SMEs compared with those of large firms over six month periods over 2009-2015. This analysis was based on the April to September 2015 survey data, the most recent available for the purpose of identifying firms' investment needs, financing gaps and obstacles to investment.

The analysed sample includes 3,806 firms in the industry sector across EU 28 countries. Firms with significant growth potential are defined as those firms with expected turnover growth of over 20% per year over 2015-2017. The SAFE survey also provides direct information on firms'

assessment of investment needs (external financing) to realise growth ambitions over the three years ahead.

Empirical approach

The empirical approach is based on econometric analysis that links the high-growth potential firms with their characteristics, investment needs, and obstacles to investment.

The econometric analysis proceeded as follows:

- Profiling firms with significant growth potential (the target group) in EU 28 and its distribution across Member States;
- Identifying investment needs for the target group and preferred financing mode; and
- Profiling firms facing obstacles to investment in the target group.

The profile of *high growth-potential* firms has been identified by estimating the following probability (probit) model:

$$hgp_i = \beta_0 + \beta_1 size_i + \beta_2 turn_i + \beta_3 age_i + \beta_4 gr_i + \beta_5 exp_i + \beta_6 inn_i + \varepsilon_i \qquad (1)$$

where hpg denotes a binary variable taking value 1 if the firm expects turnover growth greater than 20% over the following three years and 0 otherwise; size, turn and age denote categorical variables identifying the number of employees, firms' turnover and age, respectively; gr denotes a binary variable taking value 1 if the firm is an affiliate or a branch of a business group; exp and inn denote, respectively, binary variables taking value 1 if the firm reports that part of its revenue is obtained from exporting and that it has introduced a product, process, marketing or organisational innovation in the past twelve months. The relevance of exporting and innovation activities has also been tested by introducing a categorical variable indicating the intensity of export turnover4 (exp_int) and a categorical variable identifying whether a firm belongs to one of the following mutually exclusive categories5 (ex_in): neither exporting nor innovation, exporting but no innovation, innovation but no exporting, both exporting and innovation.

The profile of firms with high-investment needs has been identified in two alternative ways:

(1) by analysing the factors associated with the probability of being a high growth-potential firm reporting high investment needs *(financing needed larger than €250,000)*, relative to all other firms in the sample (probit analysis). To this purpose, the following model was estimated:

$$hgp\_hin_i = \beta_0 + \beta_1 size_i + \beta_2 turn_i + \beta_3 age_i + \beta_4 gr_i + \beta_5 ex\_in_i + \varepsilon_i \qquad (2)$$

where hgp_hin denotes a binary variable taking value 1 if a firm expects turnover growth greater than 20% and reports high investment needs. The explanatory variables in model (2) have the same interpretation as in model (1), except for ex_in, which denotes the four mutually exclusive categories of exporters and innovators described above.

(2) by analysing the factors associated with the probability of being in a specific investment need category (ordered probit analysis), focusing separately on the target group of *high growth-potential firms and for all firms*. For this purpose, the following model was estimated:

[4] As an alternative to engagement in exporting *(exp)*.

[5] As an alternative to engagement in exporting and innovation (*exp* and *inn)*.

$$inv\_n_i = \beta_0 + \beta_1 size_i + \beta_2 turn_i + \beta_3 age_i + \beta_4 gr_i + \beta_5 ex\_in_i + \varepsilon_i \qquad (3)$$

where inv_n denotes a categorical variable identifying the amount of financing firms report to need to realize their growth potential.

Further, to better understand the investment needs of firms with high growth potential, the Study analysed the **preferred source of financing for firms with high growth-potential and firms with high investment-needs.** This question is explored adding to the regressors in models (1)-(3) a categorical indicator representing the reported preferred source of financing among the following alternatives: bank loan, other loans, equity, other financing.

The Study examined next **obstacles to financing growth enhancing activities.** It looked at the identified relationship between firms' obstacles to financing growth and the probability of being a high growth-potential firm and a firm with high investment-needs. To this purpose, a binary variable identifying firms facing obstacles to financing (of any kind) was introduced in the models (1)-(3) discussed above. The results of the estimated augmented models reveal that these firms are less likely to expect high growth and to be firms with high-growth and high-investment needs, relative to firms facing no obstacles to financing. When exploring the association with the probability of being in a particular investment needs category, it appears that obstacles to financing are negatively related to the probability of being a firm in lower investment needs categories, but positively related to the probability of being in the higher investment needs categories.

In order to further understand **the characteristics of firms reporting obstacles to financing growth ambitions** the following models were estimated:

$$obst_i = \beta_0 + \beta_1 size_i + \beta_2 turn_i + \beta_3 age_i + \beta_4 gr_i + \beta_5 ex\_in_i + \varepsilon_i \qquad (4)$$

where *obst* denotes a binary variable taking value 1 if a firm reports any of the following obstacles: *insufficient collateral or guarantee, interest rates or price too high, reduced control over the enterprise, too much paperwork involved; financing not available at all, or other*, and 0 if the firm reports there are no obstacles to financing growth.

In order to explore in more depth the relevance of the specific obstacles faced by firms to financing their growth, an additional series of models was estimated:

$$obst\_spec_i = \beta_0 + \beta_1 size_i + \beta_2 turn_i + \beta_3 age_i + \beta_4 gr_i + \beta_5 ex\_in_i + \varepsilon_i \qquad (5)$$

where *obst_spec* denotes a binary variable taking value 1 if a firm reports a specific obstacle (e.g. insufficient collateral) and 0 if the firm reports there are no obstacles. Model (5) was therefore estimated separately for each type of obstacle.

Firms with High-Growth Potential and their Investment Needs: Quantitative Analysis by Groups of EU Countries

In order to explore whether there is variation within the EU 28 in the profile of firms with high growth potential and large investment needs, models (2) and (3) were estimated separately for groups of countries defined along geographical closeness and economic similarities. The composition of the analysed groups of EU countries are as follows:

- **Southern EU group:** Portugal, Italy, Greece and Spain;
- **Central EU group:** Germany, France, Austria, Belgium, Netherlands and Luxembourg;
- **Eastern EU group:** Croatia, Hungary, Romania, Bulgaria, Poland, Czech Republic, Slovakia, Slovenia;
- **Nordic and Baltic EU group:** Sweden, Finland, Denmark, Estonia, Latvia, Lithuania;
- **UK and Ireland EU group.**

Overall, the general pattern in regard to the profile of high growth-potential and high investment-needs firms described above is similar across the various groups of EU countries. Due to the smaller size of the analysed firms' samples, some estimates are no longer statistically significant. However, the sign of the most estimated coefficients does not change.

4. The qualitative analysis

As a result of the detailed analysis described in section 3.1, five industrial value chains have been selected as a basis for a more in-depth investigation with respect to investment gaps and needs. A qualitative analysis which included desk research and interviews with key experts resulted in five comprehensive case studies. The findings of the investment needs, obstacles to investment and solutions are presented in this chapter. The full version of the case studies is provided in the Annex.

4.1. Machinery - Additive Manufacturing

Machinery and Equipment: Europe leads in additive manufacturing with metal powders

Machinery and equipment n.e.c (NACE rev. 2, C28), short machinery, is a sector dependent on interindustry supply. Its backward linkages range are large (e.g. sourcing among others from basic metals and fabricated metal products), its forward linkages are one of the smallest as it sells directly to final demand. The value added multiplier is large and situated in the middle-field of manufacturing industries. Interestingly, both the intra-EU value added component as well as the domestic component range in the middle field across the manufacturing industries. The machinery sector is one of the largest sectors in the European Union in terms of production, value added and employment. SME intensity is in the middle-field (41% of turnover generated by SMEs).

Within the European Union, about 42% of value added is generated in Germany, followed by Italy (16%), the United Kingdom (8%), and France (7%). The countries most specialised on the sector (i.e. measured by the share of machinery in total manufacturing value added) are Denmark, Germany, Italy, Luxembourg, Hungary, the Netherlands, Austria, Finland and Sweden. The EU value added multiplier ranges around 0.8 and is smaller only for a small range of countries.

Metal powders are transformed into three-dimensional products using a 3D printer

In metal AM, metal powders are transformed into three-dimensional products using a 3D printer. The figure below illustrates the value chain of metal AM, including the metal powder. The dotted line in the figure separates the supply and demand sided within the value chain.

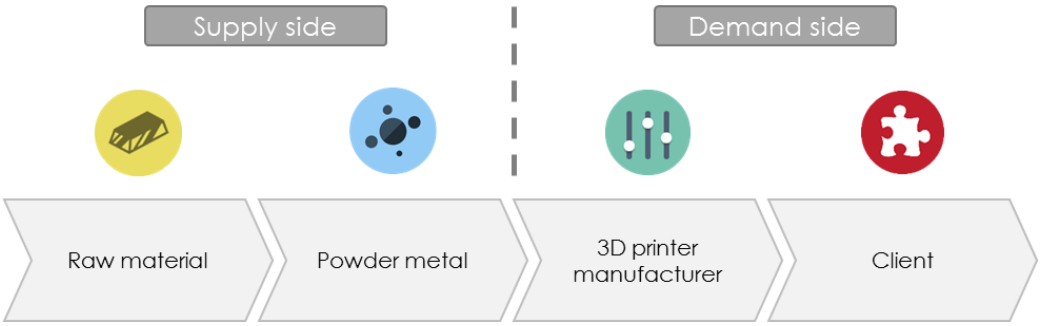

Figure 6. Value chain of AM with metal powders

At the start of the value chain, one finds the raw materials, i.e. the metals that will be transformed into powders, which are directly supplied to the powder producers. Within the production of metals powders, one can identify three major steps as identified by a powder

producer in an interview: (i) the metals are melted, (ii) metals in their melted state are atomised to a powder, (iii) the powder with varied grain sizes is sieved and tailored to the needs of the client or the 3D printer manufacturer and delivered.

It is specifically the stage of sieving the metal powders that requires the largest effort – 3D printing machines require very specific grain sizes and do not allow for a large variation in that size. In the transition to the demand side, the powders are delivered to the 3D printing machine manufacturer or to the client directly. Each 3D printing machine requires a powder tailored to it in terms of size and thus some printer manufacturers also offer powders as a service to their clients. However, it is also possible to forego the link via the 3D printer manufacturer, and for the powder producer to work directly with the client to specify which powder type they need for their machine and their product.

Investments needed on supply and demand side of value chain: better sieving techniques, wider grain size acceptance and improved exploitation of high-end metal powders

AM has witnessed major cost decrease over the past years, which has led to a boom in its adoption. In order to maintain the competitive position of the metal AM industry in Europe, it is important to strengthen the critical parts of the value chain, as well as across the value chain. The value chain consists of: (i) raw materials, (ii) powder metals on the supply side, (iii) the 3D printer manufacturer, and (iv) the client on the demand side.

Investment needs manifest on both sides of the value chain, and not only at the position of the metal powder or the 3D printing technology. At the supply side of the value chain, high-end metal powders remain very expensive, while the costs for 3D printers have seen a drop in recent years. While there are research, technology and development challenges limiting the reduction of the price, there is a need for investment in order to achieve this. Specifically, where the grain size of metal powders is concerned, there is potential for investments in the improvement of sieving techniques. This is a step which would require investment into further research and development in the atomisation process.

At the demand side of the value chain there are several potential investment needs, which are related to the 3D printer manufacturers. As with any developing technology, there is room for investment in R&D budgets in the application of high-end metals in AM. Taking into account the high price of the metal powders, there is also room for the development of 3D printers in order to accept greater grain sizes, and greater grain size distributions in order to drive down the price. Thus, this R&D research could be targeted specifically towards the technological question of the grain size in AM machines. The reasoning being, that if 3D printing machines could accept wider grain sizes then the cost of sieving and sorting, which are the most expensive parts of the powder production for AM, could be drastically reduced.

In order to improve the attractiveness of the technology, investment in the 3D printing machines could also be targeted at the speed and efficiency of the machines. These aspects also lead to high costs of products, and thus also require additional technological advancement. A third area of investment needs is the need for coordinated cooperation among the different players in the value chain with respect to the application of high-end metals. Coordinated investments require cooperation of several partners along the value chain, where investments are strongly associated to technological advancement. Specifically, where the grain size of metal powders is concerned, there is potential for investments in the improvement of sieving techniques, through coordinated, shared and confidential platforms with other powder manufacturers in order to refine the current techniques.

Investment needs are found throughout Europe

In terms of geographical scope, in the context of the value chain we differentiate between the supply side, where there are the powder manufacturers and on the demand side there is the metal additive manufacturing industry. Powder manufacturers supplying to the additive manufacturing industry includes powder manufacturers from the United Kingdom, followed by Germany, Sweden, Czech Republic, France and Finland. With respect to the subsector 'Forging, pressing, stamping and roll forming of metal; powder metallurgy', which includes the metal powder manufacturers, the highest value added was in Germany, followed by Italy, France and the United Kingdom. It seems that investment needs are concentrated in Scandinavia and Eastern Europe, or manufacturing countries in Western Europe, with the share of value added in non-financial business economy in Italy, Slovenia and Czech Republic followed by Finland. On the demand side of the value chain, the metal additive manufacturing industry, the dominant players are located in Germany.

Coordinated investments along the value chain can maintain Europe's position

In the context of the metal AM case, in order to motivate companies from different parts of the value chain to set up a coordinated investment programme, it will be necessary to identify specific topics that are (at least partly) of common interest to all companies. R&D on improved metal powder production processes may interest not only metal powder manufacturers but also companies downstream the chain, if this programme would result in better insights in material properties, which nowadays is far from optimal. The nature of the research topic (which involves fundamental physics) would require also the presence of universities/research institutes in addition to companies.

Therefore, future work could focus on identifying a very specific scope and format of a joint investment programme that would be of interest to several actors along the chain (resulting in a high investment leverage for individual participants) and would help to overcome the bottleneck of high material costs in the metal additive manufacturing value chain. Such programme could then be funded partly through EU innovation funds and programmes, such as Horizon 2020 or EFSI. These funds can bring leverage in investments and are suitable instruments for strategic areas such as additive manufacturing. Horizon 2020 is specifically applicable due to its strong focus on developing European industrial capabilities in Key Enabling Technologies (KETs), an area of which is AMT and thus also additive manufacturing. The EFSI will be also be particularly applicable due to its focus on sectors with key importance and a capacity to deliver a positive impact on areas such as resource efficiency and innovation.

Obstacles concerning coordinated investment are often related to the limited cooperation between competitors

Concerning coordinated investment options, the obstacles are often related to the (limited) cooperation between competitors. Experience in the machine tool sector has shown that, even when confronted with a common shortage of a specific component, it is difficult to get all parties to work together to alleviate that common need. Individual companies may, for example, in case of shortage try to obtain a preferred treatment from key suppliers rather than looking for joint solutions with other companies in the sector. Thus, as indicated in the interviews, coordinated efforts will be hampered, when competition is still in play.

In addition, companies in a certain part of the value chain are more likely to collaborate with each other when it comes to sourcing basic inputs such as raw materials rather than to

sourcing high tech components, because for the latter category strategic information regarding the functionalities of the clients' product needs to be shared. In regard to cooperation in the form of shared infrastructure or facilities, interviews have indicated that there is a need for an objective entity to provide a legal framework, since especially smaller companies do not have the means or human resource capacity to compose them.

In addition, coordinated investments face risk-sharing issues. Interviews have indicated that the costs associated with the high-tech facilities involved with AM (powder producing facilities, 3D printers, etc.) are very high resulting in high-risky investment decisions. Due to the high-risks, investment decisions are easily postponed.

4.2. Rubber and plastics – Tyre rubber manufacturing

Europe is 100% dependent on imported natural rubber for the production of tyres

Rubber and plastic products (NACE rev. 2, C22), short rubber sector, is a key industry, with large backward and forward linkages. Its inputs mainly come from the chemical industry. It sells its inputs to practically all other manufacturing industries. The value added multiplier is also large and ranges in the middle field. Of this, the intra-EU value added component is more pronounced. The rubber industry is a medium-sized sector in the European Union in terms of production, value added and employment, also in terms of changes of these indicators and in SME-intensity (56% of turnover generated by SMEs). However, it showed the largest change in the value added multiplier between 2011 and 2014.

Within the European Union, about 29% of value added is generated in Germany, followed by Italy, France and the United Kingdom (all about 12 %), and Spain (6%). The countries most specialised on the sector (i.e. measured by the share of machinery in total manufacturing value added) are the Czech Republic, Hungary, Poland, Portugal, Romania, Slovenia and Slovakia. The EU value added multiplier ranges around 0.8 but is smaller for a small range of countries.

Rubber is produced from natural rubber or petroleum products is processed, transformed and delivered to factories

Rubber can be produced either by the natural rubber or from the petroleum products. In the first case, rubber trees are tapped, then the latex is collected in cups and the coagulated cup lumps formed into slaps. Rubber slabs are sent to factories where they are passed through shredding, washing and creping processes. The final products are then dried, transformed into palletised rubber blocks and distributed worldwide6. In the second case, the hydrocarbon feed stocks needs to pass through several chemical reactions (polymerisation) to be transformed into synthetic rubber. The rubber is then processed and delivered to factories7,8. In both cases, different steps are required for the transformation of both natural and synthetic the rubber into the finished consumer products. Figure 34 indicates the value of rubber machines' segments in the EU in 2015.

[6] http://www.halcyonagri.com/what-we-do/

[7] http://www.cefic.org/Policy-Centre/

[8] http://www.slideshare.net/trivedi88/gujarat-chem-tech-presentation-23-feb-2011

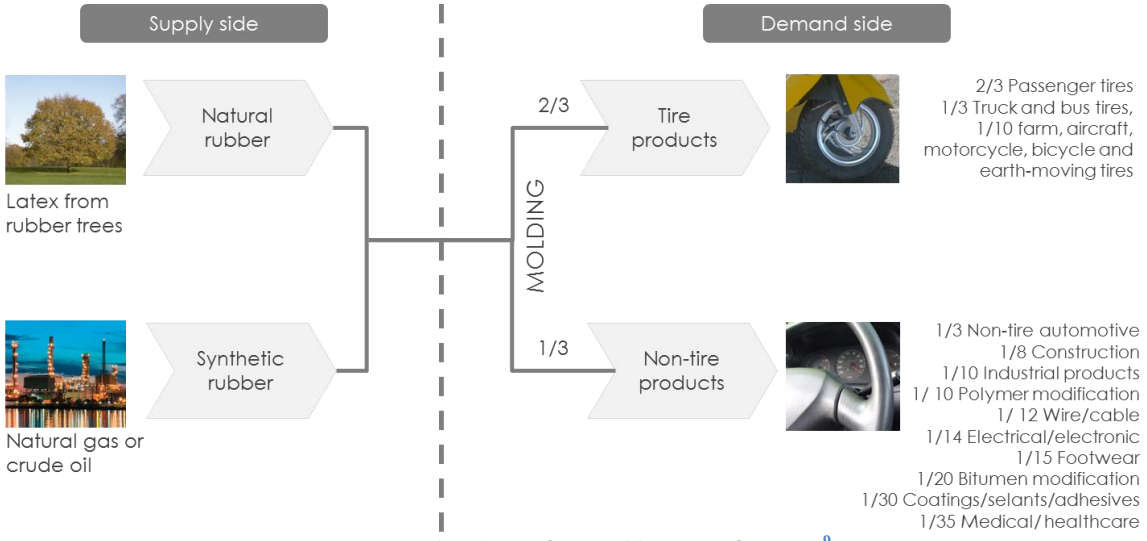

Figure 7. Value chain of tyre rubber manufacturing[9]

Investments needed on supply and demand sides of value chain: producing in Europe natural rubber, finding alternatives to natural rubber and reducing the wastage of natural rubber during tyre manufacturing

Within this industry, a major investment need has been identified in the automotive tyre sub-sector. This corresponds to the current complete dependence of the EU tyre industry on natural rubber imported from Asia. Although Europe is the second world's largest consumer of natural rubber (followed by China) and responsible for one fifth of the world tyre manufacturing, 100% of the natural rubber used in the European tyre industry is imported, mostly from South East Asia. Currently, the EU type industry is therefore dependent on the high price volatility of natural rubber coming from South East Asia which poses serious risks to competitiveness within the whole industrial value chain. At the supply side of the value chain, investment in required to find home alternatives. These could consist either in the use of other raw materials, including synthetic rubber or in the home production of natural rubber.

At the demand side of the value chain, the investment needs are linked with the need of developing machines, which could more efficiently transform natural rubber or recycled rubber into tyres. Since the market for waste tyres is tightly connected with the production of new tyre (as eventually all the produced tyres need to be reclaimed), improving the efficiency of existing rubber recycling methods or developing new methods to recycle rubber more efficiently is an important industry need. This is not only because using less rubber to produce tyres result in lower costs and a decrease in the EU dependency on imported rubber, but because the recycling process leads to a reduction of CO2 emissions. A third area of investment needs consist in the need for coordinated cooperation among the different players in the value chain with respect to the decrease in the dependence on rubber coming from Asia due to the high price volatility of natural rubber coming from South East Asia.

[9] http://www.etrma.org/uploads/Modules/Documentsmanager/20101109-etrma_statistics_final.pdf

http://www.etrma.org/uploads/Modules/Documentsmanager/etrma-annual-report-2012_8_def.pdf

Investment is particularly required in Eastern and Southern Europe

In terms of geographical scope, investment is required in South European countries for production of NR from guayule (e.g. Spain and Italy) and in Northern and Eastern countries for NR production from the Russian dandelion (e.g. Finland). Due to the high cost associated with the establishment of facilities and production techniques of NR in Europe, investment in Eastern European countries (e.g. Poland, Slovakia, and Slovenia) should be prioritised. In regards to the improvement of the quality of synthetic rubber for the production of tyres, investment should be dedicated to programmes in the Northern countries, particularly in Norway, due to the fuel resources existent for the production of synthetic rubber. Finally, the need of investment in the development of techniques which reduce wastage of natural rubber during the tyre manufacturing should be allocated to programmes in countries where the companies (world´s largest tyre manufacturers) are based: Germany, Italy, France and UK.

Coordinated investments along the value chain can enhance Europe´s competitive position in the tyre manufacturing value chain

Although the growth of the tyre manufacturing industry necessarily rely on the development of alternatives to natural rubber or methods to use more efficiently natural rubber in the future, coordinated investment actions could accelerate the process. On the supply side, these related to the home production of natural rubber, the development of alternatives to natural rubber or techniques to reduce the wastage of natural rubber during tyre manufacturing. On the demand side, the investment need consist in the required development of tyre or rubber recycling process, which could decrease costs and the current dependence of the EU on imported natural rubber.

In both sides of the value chain, there are several obstacles to the investment needs. These are primarily associated with the current lack of cooperation between academia & industry and among industry players. By analysing the investment needs and obstacles, several coordinated investment solutions have been proposed. These solutions relate to both demand and supply sides of the industrial value chain. These consist in the coordinated investment for the development of alternatives to natural rubber or methods to produce natural rubber in Europe and in the cooperation on the development of tyre or rubber recycling processes. In all cases, besides sharing costs, industry players could also share resources, such as facilities, or knowledge. Sharing knowledge is however much less common and difficult, as companies do not have any interest in educating their competitors.

In the context of the rubber tyre manufacturing case, it is required to design investment programmes on topics of common interest in order to motivate companies from the different sides of the industrial value chain. This is the case of the proposed joint investment programmes for establishing methods to produce natural rubber in Europe. Companies in the downstream side of the value chain could share their facilities and knowledge, whereas companies in the upstream side could share their transport resources and distribution channels. Besides the internal industry players, these programmes should involve research institutions so that knowledge can be easily transferred from academia to industry. In this case, it needs to establish an agreement to protect intellectual property from both parties. Overall, investment programmes need to ensure that all parties have benefits (commercial, in the case of companies) and decrease costs.

The major obstacle to coordinated investment packages is associated with the lack of cooperation between competitors

As in other industrial sectors, the major obstacle to coordinated investment packages is associated with the lack of cooperation between competitors. This is because tyre manufacturing companies are reluctant to share knowledge on technology and innovation, and in some cases, even intellectual property. According to the interviewees, the industry has been open to cooperation in the downstream services of the industrial value chain, such as commercial and distribution agreements. Nevertheless, cooperation among the industry

players has been weak and often relies on complementary capabilities rather than on the development of innovative products or techniques.

4.3. Food, beverages and tobacco products – Food traceability

The food industry is the largest manufacturing industry in Europe

Food, beverages and tobacco products (NACE rev. 2, C10-C12), short food industry, is dependent on interindustry supply. It has one of the largest backward linkages (e.g. to agriculture, chemicals, rubber or fabricated metal products); while forward linkages are small, as it basically sells its products to final demand, i.e. households (in the input-output framework, food products are directly sold to final demand and do not appear in the wholesale and retail sector). The value added multiplier is the third largest within the manufacturing industries. Of this, the domestic value added component is pronounced, while the intra-EU component is smaller.

The food industry is also the largest in the European Union in terms of production, value added and employment. It showed the largest gross investment in tangible goods in 2014. Changes in production and value added shares ranked highest between 2011 and 2013. SME intensity is in the medium field (48% of turnover generated by SMEs, manufacturing average lies at 38%).

Within the European Union, about 17% of value added is generated in Germany, followed by France (16%), the United Kingdom and Italy (both 11%), and Spain (9%). The countries most specialised on the sector (i.e. measured by the share of machinery in total manufacturing value added) are Bulgaria, Greece, Spain, France, Croatia, Cyprus, Latvia, Lithuania, the Netherlands, Poland and Portugal (above 15%) The EU value added multiplier ranges around 0.8 but is smaller for a small range of countries.

Food traceability impacts the businesses in terms of costs, organisation procedures, and integration along the value chain.

Food traceability is extremely important to ensure consumer confidence and brand loyalty, which allows for companies to explore marketing opportunities. In addition, and as mentioned above, complying with food traceability regulations is also required by legislation, as a means to ensure food safety.

Food traceability is embedded in the food safety system and is a cornerstone of the EU food safety policy, being a legal obligation, which must be complied by the food value chain actors (Regulation EC 179/2002). Every food business operating in Europe and any food business bringing products into Europe need to have a traceability and recall system in place. The regulation requires that food businesses need to be capable of identifying one step back in the food value chain, and also one step forward. This means that all partners in the supply chain must be aware of food traceability requirements. Therefore, this process demands a strong synergy between all business operators, and it is of individual responsibility of each business operator (as the data is collected in the individual systems of the companies). As such, food traceability impacts the businesses in terms of costs, organisation procedures, and integration along the value chain.

Nonetheless, despite knowing their obligations in order to be in the market, food business operators are aware of the distinction between providing the origin of the product and guaranteeing its origin and responding to consumer demands. In fact, food traceability can go beyond the general obligation of informing the consumer of the origin of the product. It

can include as well factors such as time (for instance, when the product was packed) and quality. Indeed, there are optional traceability systems, which can be applied across the different segments of the value chain.

Figure 8. Value chain of meat manufacturing

Investments needed on supply and demand side of the value chain: cheaper and more efficient food traceability solutions, improved skills of personnel, and increased cooperation among actors

This case study focuses on a major investment need, which has been identified, particularly in the food value chain: food safety and, more precisely, food traceability, which are key drivers for the modernisation of the European food value chain. While there have been several advancements in the EU in terms of technology, and the EU traceability requirements rank top in the global scenery of food safety regulations10, the interviews and extensive literature review reflected the need to modernise the food value chain in this regard. Further work must be conducted to understand why existing technologies are not adopted, and to support and encourage the smaller players to implement food traceability systems, with the ultimate goal of meeting the modern consumer demands. This investment need is thus horizontal to the industrial value chain.

Food traceability comes as a response to the need of detecting potential risks, which may emerge in food and feed, and to follow the modern consumer demands, allowing for accurate information to be provided to the public. In the EU, it is seen as the method to ensure that the food products consumed by EU citizens are safe and to respond to food crisis. Therefore, it is extremely important that when risks are identified, food operators and national authorities are able to trace them back to its origin, fast isolate the problem and avoid that unsafe and contaminated foods reach the consumers. Given that food and feed products are circulated freely in the EU internal market, strong cooperation between the Member States and compliance with the existing regulations is required for traceability to be effective.[11]

[10] http://www.foodnavigator.com/Policy/EU-traceability-requirements-rank-top-in-global-table-of-food-safety-regulations

[11] European Commission, Factsheet on Food Safety, 2007

Investments needed across all Member States

In terms of geographical scope, it is important to note that EU countries reflect considerable differences in the size of their food, beverages and tobacco industries. However, while countries with a higher value added share in manufacturing would certainly benefit from improved traceability systems (Cyprus, Greece, Croatia, Lithuania and Spain), these industries rely strongly on domestic actors and domestic added value, being less internationalised as other industries. For these reasons, the investment needs described are felt regardless of the geographical area and therefore should be addressed in all Member States.

Coordinated investments along the value chains can improve Europe's food safety

The largest players in the food value chain are also the strongest investors in R&D and Innovation. These actors implement high-level food traceability processes not only to comply with the legislation, but also to respond to the life style demands of consumers, taking into consideration factors such as price or competition. In addition, larger players have higher quality standards that need to be met and stronger levels of corporate responsibility, thus they end up taking the initiative to implement these processes.

It was also observed in the study that while the largest players, especially retailers, are more inclined to improve the traceability of their products, a company's investment decision depends entirely on that of the others in the value chain, given the strong symbioses between the stakeholders. In fact, in a certain food value chain, large projects enabling coordinated or synchronised investments along the value chain could unlock the modernisation in traceability. In order to reach the optimal efficiency, the coordination of the investments would need to be very well managed.

When questioned about private investment, the interviewees were of the opinion that it is difficult for it to be the solution to modernise the industry. A comparison between the food retail industry and the energy industry can be made: while in the former, the low margins on the products make external entities unwilling to invest, in the latter, the returns on investment are very attractive to private investors. However, public private coordinated investments could form the basis for the solutions.

For these reasons, European funding can support the modernisation of the industry, encourage the adoption of innovations, improve professional skills and support the development of new concepts, solutions, prototypes, as well as the implementation of new technologies.

Large RDI projects (eg: funded by Horizon 2020) can fund pilot actions to demonstrate the benefits of food traceability, and also help to improve the existing technologies or to identify cheaper solutions. The interviews also pointed out to the lack of knowledge transfer and difficulty in bringing the existing technologies to the market. Actions to understand why the technologies are not being adopted and how companies can start using them are also necessary.

Initiatives focused on SMEs are also seen as beneficial for the industry, as a means to increase the technology based start-ups working in the agro-food sector. Innovative companies with qualified professionals are more able to work with technology and to understand the economic benefits of transparency. Grant schemes addressed at these needs could contribute to sustainable growth of the industry.

Tax incentives have been the greatest driver in facilitating investment. However, the current funding schemes would not contemplate these activities. Tax incentives going beyond R&D and focused on innovation and the implementation of innovative traceability systems can

also unlock the modernisation of the value chain. In a specific food value chain, the investment size could be framed within the €250,000 - €1 million interval. Apart from tax incentives, an SME funding programme (through a grant scheme) could support the implementation of more complex food traceability systems at SME level.

The major obstacles to coordinated investments are related with the high costs of the technology and lack of qualified personnel

The major obstacles to coordinated investments are related with the high costs of the technology and lack of qualified personnel, less willing to adopt innovative solutions, in particular in primary and upstream activities. In addition, obstacles to coordinated investments include the size and resources of the company, which influence investment priorities. Indeed, SMEs cannot be as sophisticated as big players in these processes. Furthermore, it is important to note as well the interest from technology developers in the agri-food sector, which if higher it would support the industry development, and the difficulty in fast communication across the value chain.

In fact, advanced R&D developments have been made in traceability solutions, including in sensors and communication technologies. The greatest problem in their adoption lie in their high implementation costs, unbearable and also unattractive in terms of return on investment for most players. This issue is faced by many of the thousands of food chains, where margins are very low and therefore adopting new solutions is not sustainable in terms of price.

4.4. Motor vehicles – Batteries for Electric Passenger Cars

Motor vehicles: Europe does not have the same mass production capabilities as emerging economies

Motor vehicles, trailers and semi-trailers (NACE rev-2. C29), short motor vehicles, is also a sector dependent on interindustry supply. Given the broad nature of the motor vehicles industry, for the purpose of identifying investment needs, obstacles and remedies, a further focus is needed to select a specific segment within the automotive industry where investment needs of a coordination nature occur. Therefore, it is proposed that the case study would focus on the electric vehicles (EVs) segment, more specifically in the value chain for the development of batteries for electric vehicles (BEVs), in particular for the light passenger cars segment. It is worth mentioning that BEVs are not confined within only one activity class of the NACE classification. It runs across various sectors and is as such for analytical reasons not readily observable. Nonetheless, the case of BEVs is considered to be strongly linked with the classification under NACE classification 29.3.1 Manufacture of electrical and electronic equipment for motor vehicles.

In terms of geographical dimension within the European Union, half of value added is generated in Germany, followed by the United Kingdom (10%), France (8%), Italy (6%) and Spain (5%). The countries most specialised on the sector (i.e. measured by the share of machinery in total manufacturing value added) are the Czech Republic, Germany, Hungary, Romania and Slovakia. The EU value added multiplier ranges around 0.8 but is smaller for a small range of countries.

The motor vehicles industry is the most integrated one within Europe, being a sector dependent on interindustry supply. The motor vehicle sector is the second largest sector in terms of production and ranks also high in terms of value added and employment. This case study focuses on the analysis of the light vehicles segment, and particularly in the passenger cars industry. The high operating cost of conventional vehicles, combined with its eco-friendly characteristics, is changing the consumers' mind-set regarding EVs and driving its global market to a higher standard. In particular, lithium-ion BEVs are taken into consideration for identifying specific investment needs and obstacles within the sector.

It is expected that significant resources will continue to be used for improving the performance of lithium-ion batteries, in particular its system integration, cost, performance, safety, recyclability, among others. In terms of main players in the BEVs from the demand side, it is relevant to highlight the OEM market leaders and the recycling and reuse companies, as well as universities and research centres (for the recycling activities). Concerning the supply side, the main actors are the battery cell manufacturers (Lithium ion batteries) and the pack assembly players. Universities and research centres also play an important role in terms of developing new methods for developing enhanced BEVs. These individual actors that can influence the industry innovation process.

BEV value chain consists of seven steps from the component production until its utilisation and further reuse and recycling

In the BEVs, the value chain consists of seven steps from the component production until its utilisation and further reuse and recycling. The dotted line in Figure 9 separates the supply side and the demand side within the value chain.

Figure 9. Value chain of BEVs[12]

At the beginning of the value chain of BEVs, it is possible to find the manufacture of components, which includes raw materials that will be transformed into resources used under the production of single cells. The next steps concern the configuration of the cells into a larger module that will be further integrated into a battery pack: set of modules assembled together with systems that control power, charging and temperature. These first four steps constitute the manufacture of battery packs that will be further used by OEMs. The next step concerns the integration of the battery pack into the vehicle structure, followed by the further use of the vehicle by the client. The final step is related with the reuse and recycling of the battery used in the vehicle, including deconstruction and cleaning preparations of the battery.

Investments needed on supply and demand side of value chain: enhancing the cell production, better assembly techniques and new recycling and reuse processes

Currently, the EU industry lacks the capability of mass production of BEVs in comparison with other competitors such as China. In this sense, the EU industry needs to differentiate itself from other players in several parts of the industrial value chain. At the supply side of the value chain, investment in R&D is required for the cell production of the batteries and their assembly, finding innovative alternatives for these processes. At the demand side of the value chain, the investment needs are linked with the need of developing enhanced and leaner processes for the vehicle integration and recycling and reuse of the BEVs.

[12] Batteries for Electric Vehicles, The Boston Consulting Group (BCG) (2010)

In addition, a third area of investment needs consist in the need for coordinated cooperation for having shared facilities and infrastructures for R&D, as well as enhanced synchronisation among the different players in the value chain. In order for EVs to reach their full potential in the consumer market through enhanced performance, cost and sustainability, high-end BEVs are needed, in particular for the application of innovative methods for performance enhancement (such as power, safety and life span). In addition, for the full application of BEVs, the costs of its materials (particularly the cell costs) need to decrease. Investments are also needed to develop new enhanced techniques for the reuse and recycling of BEVs, in particular in their use for different applications.

Investment needs are found in Central, North and Southern Europe

Regarding the geographical scope of the investment needs, it is relevant to analyse the distribution of the industrial players and the universities and research centres involved in the industrial value chain. Regarding the supply side of the industrial value chains, the main producers of cells for BEVs are located outside Europe (such as China). Nevertheless, France and Germany play a strong role at the European level in terms of producing cell components for electric vehicle applications, while there are a high number of research papers published and research work developed in countries such as France, Italy and Spain.

Coordinated investments along the value chain can enhance Europe's competitive position in the BEVs value chain

Several areas where investments are needed were identified, which could contribute to enhancing Europe's competitive advantage in battery production. At the supply side, there are several investment needs in particular regarding costs and performance of BEV, namely in the cell production. As previously stated, Europe is strong in producing raw electrochemical materials and in the production equipment, but lacks in the knowledge and experience on manufacturing batteries at the mass scale level. Further investment on R&D for battery cells production and battery assembly, as well as cost reduction, are needed. Regarding the demand side of the value chain there are several potential investment needs, particularly the ones related with the reuse and recycling of the batteries for EVs, which could be used for different applications, such as photovoltaic panels.

In addition, within the segment of the vehicle integration, it is expected that improvements will be made concerning the systems integration of lithium-ion batteries into the electric vehicle, as there is a big demand from several OEMs that are very active in this area, such as VW.[13] A third area of investment needs consist in the requirement for coordinated cooperation among the different players in the value chain with respect to the application of lithium-ion batteries for EVs. Coordinated investments are the quickest way to modernise and improve EU's knowledge and competitive advantage in the development of batteries for EVs and continue to improve the EVs segment in the region. In this sense, these require cooperation and synchronisation of different actors along the value chain which is somewhat challenging due to companies' reluctance in sharing knowledge and innovation. Specifically, investment in providing a common platform for R&D progress in the cell development, pack assembly and vehicle integration would be crucial for developing innovative actions in the industrial value chain.

It is essential that Europe focuses on innovation processes that are able to further develop the EVs batteries value chain. In addition, further improvements are expected in the complementary services that are related with EVs, such as the charging system. On the supply side, the main solutions are related to the development of techniques for cell

[13] A Review of Battery Technologies for Automotive Applications, EUROBAT, ILA, ACEA, JAMA and KAMA (2014)

production and assembly techniques and processes that allow enhanced performance of BEVs, as well as lower costs in the medium to long-term. On the demand side, the investment needs consist in recycling and reusing components from the batteries for EVs, as well as improving the process of battery integration into the vehicle, which could provide a competitive advantage to Europe in the assembly part (through the big OEMs) and in finding new utilisation solutions for the recycling and reuse process. In this sense, future work should focus on identifying complementary and coordinated ways of developing a joint investment programme that would involve the several segments of the automotive industry value chain, particular in the EVs segment, taking into consideration other areas such as automated driving and e-mobility software that allows the modernisation of the industry.

There are obstacles concerning the lack of investment and improvement in the connected applications

Electric vehicles are still a niche market. There are obstacles concerning the lack of investment and improvement in the connected applications that might not be sufficiently mature to the market, e.g. battery charging process, battery insurance services, and battery replacement services, among others. The industry is opened to cooperation among different areas, providing opportunities for new organisations to be part of the automotive value chain. In addition, investment obstacles might arise for SMEs that do not have the same financial capabilities compared with OEMs that have high access to capital and finance. It is also relevant to note that car manufacturing has relatively low margins compared to other manufacturing sectors.

4.5. Fabricated metal products – Co-engineering and coating reuse & recycling

Fabricated metal products: a widely interlinked SME sector with a pronounced domestic value added creation

Fabricated metal products (NACE rev. 2, C25) is a key industry, with large backward and forward linkages. Main inputs for example are sourced from the basic metals industry. It sells its products to a wide range of other industries from the motor vehicles industry, other transport equipment, machinery or electrical equipment to the repair sector. The value added multiplier is large and ranges in the middle field. It has a pronounced domestic value added component. The fabricated metals products sector is a medium-sized industry in the European Union in terms of production, but a large industry in terms of value added and employment. It has the second highest SME-intensity (74% of turnover generated by SMEs).

Investment needs with respect to intra value chain collaboration apply to all subsectors of the fabricated metal products sector. However, co-engineering might apply mostly to the "subsector manufacture of structural metal products (NACE 25.1)", since structural metal products are often further applied in other products, thus allowing for co-engineering. In the case of the reuse and recycling of coating powders, the relevant subsector of the fabricated metal products sector would be the subsector 'treatment and coating of metals and machining (NACE 25.7)'.

Within the European Union, about 30% of value added is generated in Germany, followed by Italy (15%), France (12%), the United Kingdom (10%), and Spain (6%). The countries most specialised on the sector (i.e. measured by the share of machinery in total manufacturing value added) are the Czech Republic, Estonia, Spain, Croatia, Italy, the Netherlands, Austria, Poland, Portugal, Slovenia, Slovakia and Sweden (above 10%). The EU value added multiplier ranges around 0.8 and is smaller only for a small range of countries.

Raw material and metal scrap (post-consumer and industrial) are inputs for the production of semi-fabricated metal products

Raw material and metal scrap (post-consumer and industrial) are inputs for the production of semi-fabricated metal products, preceded by basic metal processing such as mineral processing, smelting and refining. Semi-fabricated metal products include semi-finished casting products such as ingots, blooms, billets and slabs or coils, sheets, strips, pipes and tubes that need further processing before being a finished good. The fabricated metal products sector turns these semi-fabricated metal products into a wide range of products such as structural metal products, tanks, reservoirs and containers of metal, steam generators, weapons and ammunition, cutlery, tools and general hardware. These products are then delivered as end products or semi-finished products for clients, which can be consumers or other industries, depending on the type of product and the business model of companies. A generic depiction of the value chain is displayed in Figure 10.

When zooming into the fabricated metal products segment, one can identify different steps that lead to the manufacturing of fabricated metal products. The first element of this value chain is the design of products, processes and infrastructure. The manufacturing or assembly of the products is conducted in many different ways, including forging, pressing, stamping and roll-forming of metal and powder metallurgy. The products are then treated and coated in order to improve the hardness of products, prevent corrosion or decorate the products. Finally, the waste generated in the manufacturing processes is processed.

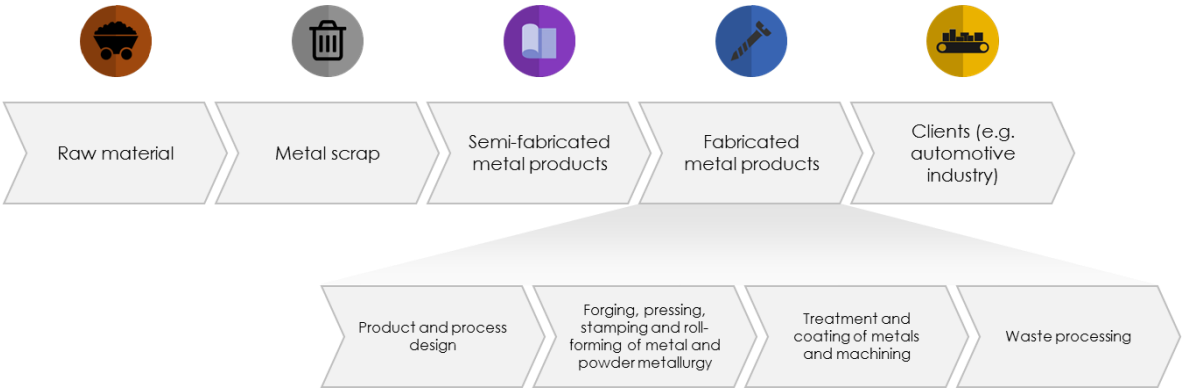

Figure 10. Generic value chain

Co-engineering and use of Best Environmental Management Practices are important areas for investment across and between value chains

The sector is characterised by several challenges regarding sustainable production and the use of Best Environmental Management Practices (BEMPs), including the need for increasing material efficiency and the valorisation of by-products and waste. An important channel through which these challenges can be met is promoting cross-value chain collaboration. In the context of the fabricated metals case, both co-engineering and waste reuse and recycling as BEMPs were identified to be in need of investment, where these investments were identified to be of a coordinated nature both intra and inter value chain, respectively.

In order to facilitate the process of co-engineering, investments that support collaboration amongst partners are needed. This investment need arises from the necessity to collaborate with complementary partners, and benefits the process of bringing a product to market, and a process to fruition that would otherwise be hampered without cooperation. In addition, co-engineering to streamline production and reduce waste requires shared infrastructure especially for SMEs. Thus, investments are needed to facilitate cooperation through shared facilities, i.e. R&D facilities. Finally, a lack of awareness of Best Environmental Management

Practices and the consideration of environmental impacts in design and the role that co-engineering can play shows the investment need in research and development.

Another very specific example is the reuse and recycling of waste from the powder coating process. The economic viability of the reuse and recycling of powder coatings waste depends on quality of the waste and the type of collaboration. The problem however is that the waste streams need to be large enough for the collection and transport to become economically interesting. It is difficult to achieve industrial cooperation on the collection of the waste. Investment needs therefore lie in promoting reuse and recycling systems for powder coatings from the fabricated metal products sector in order to apply this BEMP.

Investment needs are well distributed across Europe

When analysing the geographical dimension of the investment needs, it is necessary to zoom into the relevant subsectors of the fabricated metal products sector. Detailed information can be obtained using data from the Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E). The first investment need, on intra value chain co-engineering, cannot be specified towards a specific subsector, since this is an industry-wide opportunity. One could state however that investment needs are located in regions where there is a high concentration of SME's working in the fabricated metal products sector. A straightforward measure is the number of enterprises. In 2014, the number of enterprises were specifically high in Germany (21445), Poland (17470), Italy (14891), the United Kingdom (13319), Slovakia (12942) and Czech Republic (12075).

The second investment need, on inter value chain reuse and recycling and more specifically the reuse and recycling of coating powders, can be analysed using data on the subsector 'treatment and coating of metals and machining'. The largest share of this sector in terms of value added in manufacturing total in 2014 is noted in Slovakia (4.6%), followed by Switzerland (3.8%), Finland (3.7%), Slovenia (3.6%) and the United Kingdom (3.6%). One could state that there might be an opportunity for investment in the new Member States, given the relative importance of the subsector in this region, and the fact that a recycling network for coating powders is in its infancy and only to a limited extent established in Western Europe.

With respect to the nature of the investment needs it has been noted that the fabricated metal products sector has a pronounced domestic component. This implies that these companies are embedded in a network of suppliers and clients that is mainly of a regional or national focus. This in turn stresses the importance of regional solutions and cross-border solutions for neighbouring regions. This is reinforced by the fact that transport costs put a limit to the distance that it is economically beneficial to collect the coating powder.

Coordinated solutions allow for greater reach and reduced environmental impacts

In order for firms to co-operate in a co-engineering process, a clear advantage needs to be shared by the firms in their network, which is not always guaranteed. Network facilitation can be through shared platforms managing co-engineering practices in order to organise and manage open innovation with regards to fabricated metal products. A network should also ensure that complementarities of companies need to come together. Facilitation of asset exchange is indeed another point for improvement in open innovation. Until now co-engineering and open innovation is mostly done at the firm level, based on close personal relationships or shared visions. Through network management and facilitation, SMEs can share in the same vision and overcome some of their personal hurdles.

SMEs face a challenge in co-engineering related to a lack of infrastructure. This can be solved through shared physical structures funded through public-private financing in infrastructure for shared innovation. The Open Manufacturing Campus presents such an example where open innovation occurs. Such facilities are able to support SMEs who do not

have the necessary facilities to develop a shared product. Finally, in order to deal with the investment need towards BEMPs and specifically co-engineering, research and development funding would be a solution to tackle with the lack of awareness and available information. Indeed consideration of the environment remains a challenge and thus joint investment in pre-competitive research could be a solution to improve environmental impact considerations.

In the field of reuse and recycling of powder coatings, the solutions to the investment needs aim to support better valorisation of the powders. One such solution includes more R&D funding dedicated to the development of new applications for recycled coatings. Such R&D projects should involve intermediaries processing coating powder caste, as well as well as research partners from across the EU and potential customers (i.e. 'value chain R&D projects' including several partners from across the value chain). In addition, a networking tool can facilitate cooperation and promote exchanges between different actors in the value chain. Lastly, the number of plants where high value added recycling takes place is at this moment limited. Yet, for large scale deployment of coating powder recycling more plants spread around the EU would be needed. When a batch of powder coating waste is generated far away from such a recycling plant but close to an incinerator (which are much more widespread), transport costs will steer the choice in favour of incinerating.

Joint investment programmes powered by the EU investment promotion instruments

In order to integrate these investments into the Juncker Plan, and thus ensure that the need for improved BEMPs in the fabricated metal products sector are met, different actions could be foreseen. In the case of co-engineering, support for collaboration in co-engineering could make use of the European Investment Project Portal (EIPP) and the European Investment Advisory Hub (EIAH) in order to assist different companies in working together through a joint investment programme. With regards to shared physical structures for co-engineering, public funds could be made use of in order to mobilise additional private investment and give credit protection to the financing provided by the EIB and EIF. In order integrate the third coordinated investment option on research and development of co-engineering, the use of complementary actions such as Horizon 2020, EFSI and the ESI could be envisaged. Developing an appropriate funding mix between grants and financial instruments would be ideal.

With respect to the integration of the suggestions on waste reuse and recycling under the Juncker Plan, actions regarding research and development on coating powder valorisation could include the use of Horizon 2020, EFSI and ESI as well as national and regional support and a funding mix between grants and financial instruments as well as EIAH. For the investment need on the network on coating powder valorisation the EIPP and the EIAH could be used for integration of a joint investment programme under the Juncker Plan in order to better facilitate exchanges amongst waste producer and potential users. Finally, improving the geographical coverage of recycling plants for the improved waste reuse and recycling in the fabricated metal products sector could benefit from the use of public funds in connection with the EIB and EIF as well as private funds and the EIAH and its advisory services. Facilities are especially necessary in order to facilitate recycling and lower transport costs.

The main obstacles are finding high value added applications and stemming the competition from incineration

The main obstacle is finding high value added applications for the recycled coating powder. Finding these applications involves investing in R&D and finding/convincing potential customers from a broad range of sectors to open up for recycled materials (from which the properties but not always the exact content is 100% known) as input to their business processes.

Another obstacle is the competition stemming from incineration, which is a cost-effective way to get rid of powder coatings, and draw a significant amount of waste powder from the market. In addition, also transport costs can hinder the business case of valorising coating powder. Especially when waste powder is produced much closer to an incinerator than to a recycling plant, incineration will be preferred by the waste producer. Furthermore, the quality of waste powders suppliers to the recycling intermediaries is not always good, also depending on the country where it is produced.

4.6. Commonalities

In a quantitative analysis, five industries were identified that have high growth potential at the EU aggregate level. They are (i) machinery & equipment; (ii) rubber and plastic products; (iii) food, beverages and tobacco products; (iv) motor vehicles, trailers and semi-trailers; and (v) fabricated metal products.

The two key industries are fabricated metal products and rubber. The other three are dependent on interindustry supply. As for their EU vs. domestic component, the domestic value added component is highest for the fabricated metal products and food industries. The largest cross-country value added effects in the EU are found within the motor vehicles and rubber industries, whereas machinery & equipment lies in the mid-range.

In order to obtain an overview of all case studies, a summary of the findings on the five industries and their corresponding case studies is found in Table 1. The five industries are compared with regards to their underlying reason for the investment need, the nature of the identified investment need, the associated risks, and obstacles to those investments and the resulting policy suggestions. From this, the Study draws commonalities across the case studies, in order to provide a holistic picture.

1) **Underlying reasons for the investment need:**
    a. Environmental concern
    b. Technical challenges
    c. Perceived market potential
    d. Public health (not common)
2) **Nature of investment need:**
    a. Increase in knowledge and know-how
    b. Bringing partners/companies together
3) **Obstacles to investment:**
    a. High costs and limitations of technology
    b. Lack of cooperation between stakeholders
    c. Low incentives to investment
    d. Legal framework
    e. Internal resources – lack of necessary skills
4) **Policy suggestions:**
    a. R&D support and support for demonstration and pilot projects
    b. Support cooperation
    c. Joint investment programmes
    d. Tax incentives

Table 1. Overview of case studies with regards to their scope, investment needs, risks, obstacles and policy suggestions

Feature	Case 1: Machinery (high end metal prod.)	Case 2: Rubber (tyres)	Case 3: Food traceability	Case 4: Motor vehicles (Lithium-ion BEVs)	Case 5: Fabricated metal products
Underlying reason for the investment need	• Market potential in specialty manufacturing using a wider set of 3DP metal powders. • Technical challenges for 3DP applications in certain powders (explosion, …)	• Reducing input price volatility natural rubber: home production, increased efficiency in use of recyclables • Reduction of environmental footprint	• Detection of potential risks • Food safety and past negative experiences • Catering to changing consumer demands requiring better and more adequate information	• Reducing environmental impact: air pollution • Changing consumers' mind-set due to high costs, conventional cars and desire for eco-friendly cars • Large EU and global market potential • Reducing relatively high cost of BEVs	• Challenges regarding sustainable production, including the need for increasing material efficiency and the valorisation of by-products and waste
Nature of the investment need	• R&D into metal power production process • High-end metal production facilities • R&D in metal powder granularity acceptance of 3D printers • Coordinated efforts • Coordinated shared infrastructure / facilities	• EU grown plants from which natural rubber can be produced • Improved machine/production technologies leading to increased efficiency • Coordinated cooperation	• Food traceability requirements across the value chain • Integration of data and information across the value chain • Traceability solutions across value chain	• R&D for more efficient cells • Assembly techniques / process integration • R&D in re-use and recycling • R&D for improving vehicle integration of Li-ion batteries • Alternatives for Li-ion battery; coordinated investment	• Collaboration with complementarities for co-engineering • Shared physical structures and R&D for co-engineering • Logistics facilities for the reuse and recycling of coatings • R&D for applications for the recycling of powder coatings
Risks	• Conventional mass	• Natural to synthetic rubber implies	• Lowering the ROI of the total food	• Impact of investment on acceleration of	• Despite potential measures, companies

Feature	Case 1: Machinery (high end metal prod.)	Case 2: Rubber (tyres)	Case 3: Food traceability	Case 4: Motor vehicles (Lithium-ion BEVs)	Case 5: Fabricated metal products
	production methods remain overarching	switching price volatility from natural rubber to oil & gas • Development risks for technologies related to alternatives for natural rubber • Environmental concerns (synthetic rubber)	production (higher costs, lower profit, uncertain reaction of demand)	processes needed to make technology more ready • Environmental damage through a lack of regulation	remain unwilling to cooperate • Preference for less environmentally friendly practices due to a lack of regulation despite measures
Obstacles	• Technological know-how and challenges (feasibility) • Company secrecy and patenting	• High upfront investment costs • Protection of intellectual property rights and knowledge in a competitive setting, resulting in unwillingness to cooperate • Lack of cooperation between academia and industry tyres)	• Relatively high costs, especially in upstream segments • Relatively low interest in investing in traceability systems • Legal requirements not always well understood • Lack of skills/resources to implement traceability across the value chain	• Relatively high cost of developing alternative EV power • Related to SMEs and finance capabilities • CO2 regulation framework and the role of EVs in lowering it are still unclear • Niche market, market readiness not	• Transportation costs due to a lack of coordination • A lack of network for potential co-engineering partners • A lack of awareness of co-engineering possibilities • Reluctance towards setting up a recycling platform due to competition
Policy suggestions	• Joint investment programme via platform for powder selection	• Reducing input price volatility natural rubber: home production, increased	• Support uptake of traceability solutions, particularly for SMEs • Funding of	• Joint investment programmes; • R&D support for complementary	• Shared R&D facilities that are funded publicly or through a collaborative

Feature	Case 1: Machinery (high end metal prod.)	Case 2: Rubber (tyres)	Case 3: Food traceability	Case 4: Motor vehicles (Lithium-ion BEVs)	Case 5: Fabricated metal products
	• Joint investment programme; R&D support for coordinated efforts with powder producer, 3D printer manufacturer • Joint RTD investment / RTD support on the atomisation process, sieving of metal powders as well as granularity acceptance of 3D printing machines	efficiency in use of recyclables • Reduction of environmental footprint	demonstration and pilot projects (e.g. through Horizon 2020 • Tax incentives	services; techniques for cell production and assembly battery integration into vehicle • Improvement of links academia-industry • Improved regulatory framework environmental areas • Sharing investment facilities	investment of several partners • A third (external) party that is able to collect and valorise waste from different companies

5. Types of investment needed across the five analysed industrial value chains

Chapter 5 looks into the investment needs of industrial value chains. The chapter is divided in two parts. The first section presents the main findings of the literature review which focused on common technological developments that represent modernisation opportunities and, at the same time, can be considered as obstacles for growth if left unaddressed (Task 2.3). These findings strengthen the understanding of the investment needs. The second section builds on the results of the qualitative analysis (presented in chapter 4) and presents the findings of the investment needs identified in each of the five case studies (Task 1). The investment needs are presented in a structured manner, for a better visualisation and assessment of the results.

5.1. Major technological trends having an impact on industrial value chain actors' investment needs

Digitalisation of manufacturing, digital enhancement of products and digital transformation of business

One of the effective responses of manufacturing companies to the increasing speed of change in the business environment (e.g. shorter delivery time, accelerating technological change, shortening product lifecycles, and greater emphasis on sustainability) was the adoption of digital, cyber-physical solutions that improve the responsiveness and adaptation capacity, namely the overall re-configurability14. The initial parallel development of computer science, information technology and factory automation has gradually converged into cyber-physical production systems15, which, besides manufacturing, has been fundamentally reshaping practically all business functions and transforming the traditional business models16. The new technological paradigm, as usual17, has blurred or

[14] Váncza, J., Monostori, L., Lutters, D., Kumara, S. R., Tseng, M., Valckenaers, P., & Van Brussel, H. (2011). Cooperative and responsive manufacturing enterprises. *CIRP Annals-Manufacturing Technology*, *60*(2), 797-820.

[15] Monostori, L., Kadar, B., Bauernhansl, T., Kondoh, S., Kumara, S., Reinhart, G., Sauer, O., Schuh, G., Sihn, W., & Ueda, K. (2016). Cyber-physical systems in manufacturing. *CIRP Annals-Manufacturing Technology*, *65*(2), 621-641.

[16] Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. V. (2013). Digital business strategy: toward a next generation of insights. *Mis Quarterly*, *37*(2), 471-482.;

Teece, D. J. (2010). Business models, business strategy and innovation. *Long Range Planning*, *43*(2), 172-194.

[17] Malerba, F., Nelson, R., Orsenigo, L., & Winter, S. (1999). 'History-friendly'models of industry evolution: the computer industry. *Industrial and Corporate Change*, *8*(1), 3-40.

redefined industry boundaries18, enhanced innovation opportunities and transformed the determinants of competitiveness also in the so-called low-tech industries19.

Competitiveness is increasingly dependent on embedding smart systems into the products. This requires collaboration with actors that were previously considered as unrelated to the given value chain. At the same time, this requires value chain actors' multidisciplinary competence accumulation in a number of newly related fields and the development of their system integration capabilities20.

However, these developments have further increased the speed of change industry actors have to adapt to. These developments and the accompanying cross-cutting challenges (e.g. cybersecurity and safety) provide good rationale for policy support across industrial value chains.

Robotic technology gaining prominence

Robotics can be regarded as a key enabling technology of a broad scope, i.e. with diverse applications in practically all industrial value chains. In addition to established robotics companies, firms outside this industry (operating, for example, in automotive, electronics or machinery industries) have been dedicating significant resources (e.g. in terms of R&D, strategic alliances or acquisitions) to gain the necessary related competences21.

The development and manufacturing of industrial robots22 is expected to be the major driver for the creation of 'good jobs' across industrial value chains over the next decades23. According to the latest report of the International Federation of Robotics24, the EU is currently one of the global frontrunners in terms of technology adoption, i.e. in terms of robot density.

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[18] Porter, M. E., & Heppelmann, J. E. (2014). How smart, connected products are transforming competition. *Harvard Business Review*, *92*(11), 64-88.

[19] Von Tunzelmann, N., & Acha, V. (2005). *Innovation in „Low-Tech" Industries*. In: Fagerberg, J., & Mowery, P. (Eds.) *Oxford Handbook of Innovation*. New York: Oxford University Press, pp. 407–432.

[20] Prencipe, A., Davies, A., & Hobday, M. (Eds.). (2003). *The business of systems integration*. OUP Oxford.

[21] It is long recognised that technological discontinuities have non-negligible impact on firms' alliance formation, leading to the reconfiguration of their alliance portfolios (e.g. Asgari, N., Singh, K., & Mitchell, W. (2016). Alliance Portfolio Reconfiguration Following a Technological Discontinuity. *Strategic Management Journal*, forthcoming, DOI: 10.1002/smj.2554

[22] While robots have personal and domestic applications, they are used for education and have a variety of applications in the services industries. This section is focuses exclusively on value chains related robotic solutions.

[23] See e.g. Doyle, B. (2016). Do Robots Create Jobs? The Data Says Yes!. In *ISR 2016: 47st International Symposium on Robotics; Proceedings of* (pp. 1-5). VDE VERLAG GmbH.;

Smith, A., & Anderson, J. (2014). AI, Robotics, and the Future of Jobs. *Pew Research Center*. Available at: http://www.fusbp.com/wp-content/uploads/2010/07/AI-and-Robotics-Impact-on-Future-Pew-Survey.pdf

[24] World Robotics Report, 2016, Available at: http://www.ifr.org

Robotic solutions need to be customised and integrated in existing production systems. This need to be continuously adapted and developed, which requires programming competences. The deployment of robotic solutions needs to involve a new (reconsidered) organisation of production, of companies themselves and of whole value chains.25 New skills and capabilities are necessary26 in a wide range of corporate functions and activities (this impacts blue collar workers, technicians, software programmers, engineers engaged in production planning and also managers in the executive suite).

Robotics exemplifies multidisciplinary technologies that continuously increase in complexity and are, therefore, predisposed to open innovation (innovation decentralisation and multi-party collaboration). These technological attributes provide good rationale for policy support.

Advent of additive manufacturing that transforms manufacturing value chains

Additive manufacturing is recognised as a classic disruptive, general purpose technology that may trigger radical changes in the location of production. It may prompt the reshoring of manufacturing activities from low-cost locations and, in other industries, bring a radical decentralisation of manufacturing activities. Furthermore, AM is expected to shrink supply chains; reduce the transport of (selected) final goods; enhance sustainability (reduce the footprint of existing industrial value chains); and entail changes in technology adopters' business models27. AM-based innovations can significantly upgrade product properties in a number of industries28.

Despite the current take-off stage of the technology – the range of applications is still continuously expanding, and considerable research efforts are devoted to develop: (a) the hardware; (b) the technology (e.g. developing multi-material printing, or improving system productivity and accuracy), and (c) the range and properties of the material used.

Besides policy support to facilitate technology adoption and related competence accumulation through collaboration with the largest actors in the field (e.g. Stratasys, 3D Systems), the main area of policy intervention is the investment in technology foresight research concerning the expected impacts of AM technology.

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[25] Robotic technology greatly improves throughput. In shop-floor situations it should be considered that only parts of the production lines are automated, which creates bottlenecks. Alternatively, complete lines need to be replaced which is not always beneficial from a return-on-investment perspective.

[26] See e.g. Special issue of IEEE Transactions on Education dedicated to robotics education (Volume 56, Issue 1, 2013)

[27] Garrett, B. (2014). 3D printing: new economic paradigms and strategic shifts. *Global Policy*, *5*(1), 70-75.

Petrick, I. J., & Simpson, T. W. (2013). 3D printing disrupts manufacturing: how economies of one create new rules of competition. *Research-Technology Management*, *56*(6), 12-16.

[28] A prominent example is motor vehicle industry where parts can be hollowed out to make them lighter and more fuel efficient. Furthermore, the design of parts and components manufactured with AM technology can incorporate structures (that are hard to manufacture with conventional technologies) that provide high tensile strength, durability and resistance to impact.

It is widely recognised that the integration of AM technology in companies' production systems requires considerable organisational and business model innovations. This may jeopardise the position of both incumbents and of their existing supply chain partners.

As for the industrial value chains analysed in this report, AM may jeopardise the position of incumbent actors operating in the fabricated metal products industry and in selected segments of the plastic industry. Automotive parts and components, electronics and machinery parts industries have also established themselves as strong industrial value chains for AM-based manufacturing29. Timely information and consultancy provision for adaptation is all the more important, since the position of supporting industries (e.g. industrial tool manufacturing, distribution, warehousing, repair, etc.) is also jeopardised by AM.

5.2. Investment needs

The following tables present an overview of the investment needs identified across the five analysed industrial value chains, focusing on the demand and supply side, as well as in the coordination investment actions. Each investment need is further detailed in terms of concrete needs, as well as respective target group and geographical scope.

[29] Savastano, M., Amendola, C., Fabrizio, D., & Massaroni, E. (2016). 3-D Printing in the Spare Parts Supply Chain: An Explorative Study in the Automotive Industry. In: Caporarello, L., Cesaroni, F., Giesecke, R., & Missikoff, M. (Eds.). *Digitally Supported Innovation*. A Multi-Disciplinary View on Enterprise, Public Sector and User Innovation. Springer International Publishing.

Table 2. Investment needs in machinery additive manufacturing and respective target group and geographical scope

MACHINERY ADDITIVE MANUFACTURING			
Investment Need	**Description** *(concrete needs)*	**Target group** *(e.g. SME)*	**Geographical scope** *(e.g. Northern countries)*
Supply side			
Investment in higher yields through sieving of high-end metal powders during production (using current technique)	Research and development in higher yield sieving techniques and an improved atomisation process	Metal powder manufacturers	Countries where the metal powder manufactures are located (e.g. Scandinavia, Eastern Europe and Western Europe)
	Necessary equipment and facilities		
	Promotion of the use of the higher yield techniques		
Research and development into metal power production process (atomisation)	Research and development into metal power production process (atomisation)	Metal powder manufacturers	Countries where the metal powder manufactures are located (e.g. Scandinavia, Eastern Europe and Western Europe)
	Necessary equipment and facilities		
High-end metal powder production facilities	Necessary equipment and facilities	Metal powder manufacturers	Countries where the metal powder manufactures are located (e.g. Scandinavia, Eastern Europe and Western Europe)
Demand side			
Research and development into metal powder	Research and development into metal powder granularity acceptance of 3D	Metal additive manufacturing	Countries where metal additive manufacturing companies are located (mainly Germany)

MACHINERY ADDITIVE MANUFACTURING			
Investment Need	**Description** *(concrete needs)*	**Target group** *(e.g. SME)*	**Geographical scope** *(e.g. Northern countries)*
granularity acceptance of 3D printers	printers	companies	
Coordinated			
Coordinated efforts with powder producer, 3D printer manufacturer and client in order to develop higher quality products	Regulatory or voluntary agreements on granularity acceptance of 3D printers or granularities of metal powders Promotion of coordinated efforts Awareness creation of long term value chain cost benefits	Metal powder producers; Metal additive manufacturing companies; clients; RTD's	A regional approach to regions where metal powder producers, metal additive manufacturing companies, and clients are located.
Coordinated shared infrastructure and facilities	Shared infrastructure, equipment and facilities (e.g. a 3D printer with high granularity acceptance or specific metal powder manufacturing machines)	Metal powder producers; Metal additive manufacturing companies; clients; RTD's	A regional approach to regions where metal powder producers, metal additive manufacturing companies, and clients are located.
Coordinated platform for powder selection by machine and size (from client to supplier directly)	A platform and resources to manage the platform	Metal powder producers; Metal additive manufacturing companies; clients; RTD's	A regional approach to regions where metal powder producers, metal additive manufacturing companies, and clients are located.

Table 3. Investment needs on the tyre rubber manufacturing and respective target group/geographical scope

TYRE RUBBER MANUFACTURING			
Investment Need	**Description**	**Target group**	**Geographical scope**
Supply side			
Investment in home production of natural rubber (NR)	Establishment of facilities for the production of natural latex from Mexican shrub Guayule and the Russian dandelion	World´s largest tyre manufacturing companies	- South European countries for production of NR from guayule: Spain and Italy - Northern and eastern countries for NR production from the Russian dandelion: Finland Due to the high cost, the establishment of facilities in eastern countries should be prioritised. For example, in Poland, Slovakia, Slovenia.
	Development of techniques to increase the efficiency of the natural latex production from the aforementioned sources	European SMEs	
	Training programmes for improving skills of employees (e.g. contract qualified people with experience in producing latex)	World´s largest tyre manufacturing companies	
R&D into alternatives to natural rubber	Improvement of the quality of synthetic rubber for the production of tyres	European SMEs and research institutes	Northern countries due to the required fuel resources for the production of synthetic rubber: Norway
R&D of techniques to reduce wastage of natural rubber during tyre manufacturing	Development of techniques to reduce wastage of natural rubber during the tyre manufacturing	World´s largest tyre manufacturing companies and research institutes	Countries where the companies (world´s largest tyre manufacturers) are based: Germany, Italy, France and UK

TYRE RUBBER MANUFACTURING			
Investment Need	**Description**	**Target group**	**Geographical scope**
	Promotion of the use of techniques which reduce wastage of natural rubber during the tyre manufacturing	World´s largest tyre manufacturing companies	
Demand side			
R&D into tyre or rubber recycling process	Research techniques to improve the use of natural rubber in the production of new tyres from used tyres	World's largest tyre manufacturing companies and research institutes	Countries where the companies (world´s largest tyre manufacturers) are based: Germany, Italy, France and UK
Coordinated			
Coordinated investment into developing methods to produce natural rubber in Europe	Leveraging the industrial resources from the different actors of the industrial value chain: space; facilities	World's largest tyre manufacturing companies	Countries where the companies (world´s largest tyre manufacturers) - where NR can be produced from guayule: Spain and Italy -Where NR can be produced from Russian dandelion: Finland, Romania, Poland and Czech Republic
	Leveraging the industrial resources from the different actors of the industrial value chain: techniques; human resources	World's largest tyre manufacturing companies and research institutes	
Coordinated investment into the development of alternatives for rubber in the tyre manufacturing	Improving cooperation between industry and academia by ensuring that knowledge is transferred from research institutes to the tyre manufacturing companies	European SMEs and research institutes	Northern countries due to the required fuel resources for the production of synthetic rubber: Norway

TYRE RUBBER MANUFACTURING			
Investment Need	**Description**	**Target group**	**Geographical scope**
Cooperation on development of techniques to reduce wastage of natural rubber during tyre manufacturing	Leveraging the industrial resources from the different actors of the industrial value chain, particularly: knowledge; human resources	World's largest tyre manufacturing companies and research institutes and SMEs	Countries where the companies (world´s largest tyre manufacturers) are based: Germany, Italy, France and UK

Table 4. Investment needs in Food Traceability and respective target group / geographical scope.

FOOD TRACEABILITY			
Investment Need	**Description**	**Target group**	**Geographical scope**
Supply side			
Implementation of traceability solutions	Raising awareness of the latest consumer demands as well as the benefits of food traceability	SMEs in the primary and upstream activities of the food value chains; Research institutes (for knowledge transfer)	All countries*
	Transferability of existing traceability solutions to the market (lack of knowledge of available technologies)		
Maintenance of traceability solutions	Development of cheaper and more efficient traceability solutions, due to the high costs that the existing ones represent (in particular for products with low margins, such as fruit)	Research institutes and large industry players	All countries*

FOOD TRACEABILITY			
Investment Need	**Description**	**Target group**	**Geographical scope**
	Training programmes to improve the skills of personnel to be able to handle traceability solutions with the required accuracy	Farmers and SMEs in the upstream activities (and respective low qualified staff)	
Demand side			
Improvement of communication to the consumer	Providing accurate information to the consumer, in order to meet their needs and demands; Improving consumer confidence; Faster and more efficient response to food incidents, reaching out to consumers.	Food retailers (small and large players)	All countries*
Logistics processes	Food traceability has a direct correlation with the distribution segment, as it incorporates the information systems and the necessary logistics processes	Distributors (Wholesalers and retailers); Research institutes	All countries*
Coordinated			
Digitalisation and Internet of Things for the Traceability Information Systems	Research for the improvement of traceability information systems and the development cheaper traceability solutions	Research institutes and large industry players	All countries*
	Foster the creation of more tech based companies in the agri-food sector; Increasing the interest in traceability solutions by corporate investors	Startups; Researchers; Large industry players	
Improvement of synchronisation between stakeholders	Training programmes to improve the skills of primary and upstream segments of the value chain	Farmers and SMEs in the upstream activities (and respective low qualified staff)	All countries*

FOOD TRACEABILITY			
Investment Need	**Description**	**Target group**	**Geographical scope**
and the adoption of food traceability along the entire value chain	Improving cooperation among actors to accelerate the modernisation of the food value chains	All actors in the value chain	

**According to the interviewees, the food value chains need modernisation in terms of traceability processes all across Europe.*

Table 5. Investment needs on the BEVs and respective target group and geographical scope.

BATTERIES FOR ELECTRIC VEHICLES			
Investment Need	**Description**	**Target group**	**Geographical scope**
Supply side			
Research and development into cell production for batteries for EVs	- Research and development investment actions are crucial for enhancing the EU's position at the cell production global market. It is expected that investment in new material inventions for cathodes, anodes, electrolytes, separators, as well as new battery design and systems are included in this action.	European universities and research institutes; Cell manufacturers: SMEs and large enterprises	UK and Ireland, Central EU and Southern EU - high number of academic papers; Central EU and UK and Ireland - high EVs sales.
Investment in assembly techniques and processes for integration of batteries' primary cells into packs	- Investment in enhanced assembly techniques of the different modules into the pack and in the process for integrating these modules. Furthermore, particular attention should be given to the pack design in how to handle temperature management. - Research and development in new automated processes could improve EU's competitiveness.	Pack assembly manufacturers: SMEs and large enterprises	Central EU and UK and Ireland - highest concentration of EVs sales.
Demand side			
Research and development into reuse and recycling techniques and processes	- R&D in new reuse techniques should be a priority for the segment, in particular for energy storage at solar or wind-power plants and for remanufacturing for new vehicles. - Investment in the creation of new partnerships between auto companies and battery, recycling and electronics firms, allows the development of techniques and develop the recycling market.[30]	European universities and research institutes Recycling and reuse companies.	Central EU, mainly in France and Germany that have very active research institutions in the recycling of battery components.

[30] http://www.edmunds.com/fuel-economy/what-happens-to-ev-and-hybrid-batteries.html

Research and development techniques for improving vehicle integration of BEVs	- Investment should be made on research for optimising the mechanical properties of BMS. - Investment should be made on battery housing, in particular for the pack installation space.	EU universities and research institutes R&D departments within the big players Big OEMs	Central EU due to the high concentration of OEMs and manufacturers of electric vehicles.
Coordinated			
Coordinated investment into the development of recycling and reuse alternatives for Lithium-ion batteries	- Improving cooperation between industry and academia by ensuring that knowledge is transferred from research institutes to the recycling and reuse companies. - Improving the reuse process in the cell and module production. - Leveraging the industrial resources from the different actors of the industrial value chain.	Research institutes; Recycling and reuse companies; Manufacturers that use recycled/reused materials	Central EU and UK and Ireland due to the high sales concentration in the regions, having higher recycling opportunities.
Coordinated shared infrastructure and facilities	- Improving the innovation capacity through shared infrastructures and facilities for the different stages of the supply and demand value chains.	EU universities and research institutes Manufacturers from the different segments	Central EU, UK and Ireland and Southern EU, combining the different steps of the value chain.
Cooperation on the development of techniques to increase the battery efficiency	- Improving cooperation between industry and academia by ensuring that knowledge is transferred from research institutes to the battery cell manufacturing, pack assembly techniques and vehicle integration processes. - Leveraging the industrial resources from the different actors of the industrial value chain.	European universities and research institutes Manufacturers from the different segments	Central EU and UK and Ireland for improving development techniques for the manufacturers in the different segments.

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Table 6. Investment needs for Fabricated Metal Products and respective target group / geographical scope

FABRICATED METAL PRODUCTS			
Investment Need	**Description**	**Target group**	**Geographical scope**
Coordinated: Intra value chain – Co-engineering			
Support for collaboration in co-engineering	Networking tools or a networking platform, e.g. online platform, a one-stop-shop, mailing groups, and resources (human and capital) for managing the network	SMEs in the fabricated metal products sector that have co-engineering cooperation potential	A regional approach to regions where fabricated metal product companies and client industry are located (e.g. in countries such as Germany, Poland, Italy, the United Kingdom, Slovakia and Czech Republic
	Support for SMEs in their licencing agreements in order to create more trust in engaging in partnerships		
Shared physical structures for co-engineering	Shared physical structures, i.e. R&D facilities	SMEs in the fabricated metal products sector that have co-engineering cooperation potential	
Research and development using co-engineering to reduce environmental impacts	Research and development using co-engineering to reduce environmental impacts	SMEs in the fabricated metal products sector that have co-engineering cooperation potential	
Coordinated: Inter value chain – Waste reuse			

FABRICATED METAL PRODUCTS			
Investment Need	**Description**	**Target group**	**Geographical scope**
R&D on coating powder valorisation	Research and development of new applications for recycled coatings Awareness creation on the potential application areas for recycled coatings.	Intermediaries processing coating powder caste, as well as well as research partners from across the EU and potential customers (i.e. 'value chain R&D projects').	Industrial regions with a large concentration of fabricated metal product companies and other industries that are potential users of the recycler powder coatings
Network on coating powder valorisation	Networking tools or a networking platform, e.g. online platform, a one-stop-shop, mailing groups, physical meetings (workshops, conferences) and resources (human and capital) for managing the network	SMEs in the fabricated metal products sector; SME's that could be potential users of the recycled coating powders; intermediaries active in reuse and recycling of powder coatings	
Geographical coverage of recycling plants	Greater geographical coverage of recycling plants and infrastructure	Either directed towards SMEs in the fabricated metal products sector for a coordinated investment or towards a third party established to manage the reuse and recycling logistics	Regions where the recycling infrastructure is not yet established (thus everywhere except West-Europe)

6. OBSTACLES TO INVESTMENTS AND POSSIBLE SOLUTIONS

This chapter is divided in three sections. The first section looks in detail at the obstacles to investment and possible solutions of the five selected industrial value chains. The findings were obtained from the qualitative analysis conducted in Task 1, which included extensive desk research and interviews with key experts.

The second section presents the results of Task 2.1, which complemented the Task 1 findings by assessing the obstacles to investment of two industrial value chains with similar sectors per each of the five selected industrial value chains. The Task determined relationships/trends between the obstacles and value chains analysed, and it allowed for grouping the obstacles to investment into five main categories.

The third section proposes investment packages for each of the five selected industrial value chains. This corresponds to Task 2.3 aiming at identifying potential packages of investment that could promote value chain modernisation by overcoming the obstacles to investment analysed in the second section.

6.1. Factors impacting the modernisation of the selected industrial value chains and proposed solutions

This subsection provides an overview of the obstacles to investment, their related investment needs, and the potential solutions that have been identified through the case studies in each of the five selected industrial value chains. The results are presented in the following tables. On the right side of the tables, potential investment solutions are suggested, including indications on the type of investment, the size of investment and the coordination nature of the investment.

Specifically, the solutions include investments of the sizes: very small (<€25 000), small (€25,000 to €100,000), medium (€100,000 to €250,000), large (€250,000 to €1 million), and very large (>€1 million). Concerning the coordination nature of the investment, the scale ranges from low (single company investments), to medium (investment of several companies / competitors at one part of the value chain) and to high (investment across the value chain with several partners). Both the size of the investment and the coordination nature are estimated according to insights from interviews.

In addition, the proposed solutions (investment / support) are integrated under the Investment Plan for Europe (Juncker Plan). The following abbreviations are used:

- European Agricultural Fund for Rural Development (EAFRD);
- European Fund for Strategic Investments (EFSI);
- European Investment Project Portal (EIPP);
- European Fund for Strategic Investments (EFSI).

Table 7. Investment obstacles and solutions for Machinery Addictive Manufacturing

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
Supply side					
Investment in higher yields through sieving of high-end metal powders during production (using current technique)	Lack of interest in market (by powder metallurgy industry); Lack of cooperation between competitors in a joint investment programme	- Joint R&D investment programme to facilitate cooperation between SMEs and research institutes - Loan to facilitate the establishment of facilities - Tax incentives to promote use of higher yield techniques	Medium to Large	Medium (Joint investment programme); Low (R&D support)	- Use of complementary actions: H2020, EFSI and ESI, funds programmes, as well as national / regional support, including developing an appropriate funding mix between grants & financial instruments - Use of public funds to mobilise private investment and give credit protection to financing provided by the EIB & EIF - Use of the EIAH - single access point to advisory services (project development, access to finance)
R&D into metal power production process (atomisation)	Lack of interest in market (by powder metallurgy industry); High costs risk; Lack of cooperation (facilities and researchers	- Joint R&D investment programme to facilitate cooperation between SMEs and research institutes - Loan to facilitate the establishment of facilities	Very large	Medium (Joint investment programme); Low (R&D support)	- Use of complementary actions: H2020, EFSI and ESI, funds programmes, as well as national / regional support, including developing an appropriate funding mix between grants & financial instruments - Use of public funds to mobilise private investment and give credit protection to financing provided by the EIB & EIF
High-end metal production	High costs and high risks; Lack	- Loan to facilitate the establishment of	Very	Low	- Use of public funds to mobilise private investment and give credit protection

facilities	of financing models with risk sharing	facilities	large		to financing provided by the EIB & EIF
Demand side					
R&D into metal powder granularity acceptance of 3D printers	Physical limitations of technology; Lack of cooperation (researchers and facilities)	- Joint R&D investment programme to facilitate cooperation between SMEs and research institutes	Large	Medium (Joint investment programme); Low (R&D support)	- Use of complementary actions: H2020, EFSI and ESI, funds programmes, as well as national / regional support, including developing an appropriate funding mix between grants & financial instruments
Coordinated					
Coordinated efforts (powder producer, 3D printer manuf. and client) for higher quality	Lack of cooperation along value chain; Lack of coop. with competitors	- Joint investment programme to facilitate cooperation between stakeholders - Framework condition for investment (*)	Large	High	- Use of public funds to mobilise private investment and give credit protection to financing provided by the EIB & EIF - Use of the EIPP and EIAH
Coordinated shared infrastructure and facilities	Lack of cooperation with competitors; Lack of legal framework	- Loan to facilitate the establishment of facilities	Large to Very large	High	- Use of complementary actions: H2020, EFSI and ESI, funds programmes, as well as national / regional support, including developing an appropriate funding mix between grants & financial instruments - Use of the EIAH

Coordinated platform for powder selection by machine & size (from client to supplier directly)	Lack of cooperation along value chain; Lack of coop. with competitors	- Joint investment programme to facilitate cooperation between stakeholders	Medium to Large	High	- Use of the EIPP and the EIAH

** These actions are not investments as commonly understood, but are important to create positive framework conditions for investment.*

Table 8. Investment obstacles and solutions for tyre rubber manufacturing

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
Supply side					
Investment in home production of natural rubber	High costs; Lack of cooperation between competitors in a joint investment programme	- Loan to facilitate the establishment of facilities due to the high costs - Tax incentives to facilitate the investment in innovation - Joint RTD investment programme	Very large (€20-25 million)	Medium (Joint investment programme); Low (R&D support and tax incentives)	- EIB loan, of which 30% under EFSI e.g. approved EIB loan to upgrade existing waste water treatment facilities - Tax incentives to accelerate the adoption of structural reforms and to tackle investment bottlenecks - Under the Social Impact Instrument, EFSI could play a role in financing migration-related projects, e.g. accommodation infrastructures and integration of refugees in education and training. Migrants expert in rubber

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
					collection and processing could be employed to give training to workers of European tyre manufacturing companies.
R&D into alternatives to natural rubber	Legal framework (particularly REACH); Lack of cooperation (academia and industry); Environmental concern (case of synthetic rubber)	- Joint R&D investment programme to facilitate cooperation between SMEs and research institutes - Venture capital for the Improvement of quality of synthetic rubber by SMEs	Very large (€10-15 million)	Medium (Joint investment programme); Low (R&D support and venture capital)	- Investment Platform supported by the EIF and other sources (e.g. NPBs, national, regional and local governments, EU budget funds, commercial banks and capital markets) under the SME window - Use of the EIPP - under the InnovFin Advisory - and the EIAH to attract private investors
R&D of techniques to reduce wastage of natural rubber during tyre manufacturing	Lack of cooperation between competitors; limited technology to recover rubber from used tyres	- Joint R&D investment programme to facilitate cooperation between SMEs and research institutes - Tax incentives to promote the use of techniques to reduce wastage of natural rubber	Very large (€4-5 million)	Medium (Joint investment programme); Low (R&D support and tax incentives)	- Investment Platform supported by the EIB and other sources (e.g. NPBs, national, regional and local governments, EU budget funds, commercial banks and capital markets) under the Infrastructure and Innovation window - Tax incentives to accelerate the adoption of structural reforms and to tackle investment bottlenecks

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
Demand side					
R&D into tyre or rubber recycling process	Lack of cooperation between academia and industry	- Joint R&D investment programme to facilitate cooperation between SMEs and research institutes	Very large (€2-4 million)	Medium (Joint investment programme); Low (R&D support)	- EIB loan, of which 30% under EFSI E.g. Approved EIB loan for the construction and operation of the first European facility for recycling and re-melting titanium metal and alloy scrap from the aeronautic industry
Coordinated					
Coordinated investment into the development of alternatives for rubber in the tyre manufacturing	Lack of willingness to cooperate with competitors; Legal framework; Environment concern (in the case of the synthetic rubber)	- Joint R&D investment programme to facilitate cooperation between SMEs and research institutes	Very large (€10-15 million)	High	- Investment Platform supported by the EIB and other sources (e.g. NPBs, national, regional and local governments, EU budget funds, commercial banks and capital markets) under the Infrastructure and Innovation window
Coordinated investment into developing methods to produce natural rubber in	Lack of willingness to cooperate with competitors	- Loan to facilitate the establishment of facilities due to the high costs - Joint R&D investment programme to facilitate cooperation	Very large (€20-25 million)	High	- EIB loan, of which 30% under EFSI E.g. Approved EIB loan to upgrade of existing waste water treatment facilities - Use of the EIAH to provide advisory and technical support for tyre manufacturing consortiums,

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
Europe		between SMEs and research institutes			particularly in coordinating and facilitating the contributions from all companies as well as network of National Promotional Banks and Managing Authorities.
Cooperation in development of techniques to increase the efficiency of the recycling process of natural rubber	Lack of willingness to cooperate with competitors; Legal framework	- Tax incentives to promote the use of techniques which reduce wastage of natural rubber during the tyre manufacturing	Very large (€4-5 million)	High	- Tax incentives to accelerate the adoption of structural reforms and to tackle investment bottlenecks

Table 9. Investment obstacles and solutions in Food Traceability

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
Supply side					
Implementation of traceability solutions	High costs, particularly for products with low margins (e.g. oranges); Low interest from private investors	- Joint investment programme to fund pilot actions to demonstrate the benefits of food traceability; - Tax incentives focused on the implementation of innovative systems - SME funding programme (through a grant scheme) to support at SME level the implementation of traceability systems	Large	High	The EIPP can provide higher visibility to projects in the agricultural sector. EFSI can support digital developments at farm level, especially in SMEs.
Maintenance of traceability solutions	High costs, particularly for products with low margins (e.g. oranges); Lack of qualified professionals in	- Joint R&D investment programme for the identification of innovative cheaper solutions; - Tax incentives;	Large	High	The EIAH can support the coordination of advisory services at EU level. With technical assistance, the rural projects can be better structured. This applies to Investment Platforms grouping smaller projects (e.g. agri-tech). Innovation projects in the agriculture

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
	the upstream activities (e.g. farmers)	- Joint investment programme – grant schemes focused on training and capacity building			sector are considered by the EIB. SME financing agreements approved by the EIF can also focus on agriculture.
Demand side					
Improvement of communication to the consumer	High costs, particularly in products with low margins; Low interest in investing in improving traceability	- Joint investment programmes – grant schemes, focused on communication to the consumer - Tax incentives to foster adoption of innovative traceability systems	Medium to Large	Medium	-
Logistics processes	High costs of the technology; Low levels of knowledge transfer	- Joint R&D investment programme	Medium	High	Infrastructure and Innovation projects in the agriculture sector are considered by the European Investment Bank.

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
Coordinated					
Digitalisation and Internet of Things for the Traceability Information Systems	High costs of the technology; Lack of qualified personnel; Size of company, influencing priorities; Low interest from technology developers in agri-food sector	- Joint R&D investment programme (grant scheme divided in the following categories: capital, training, R&D); - R&D support to develop new solutions; - Tax incentives to foster the adoption of innovative traceability systems	Large	Medium	The EIPP is a good instrument to foster investment projects in this area since it covers Resources & Environment, in which the Agriculture and Rural Development, Forestry and Bio-Economy sectors are included. The EIPP also considers the knowledge and digital economy, which focuses on RDI; ICT Infrastructures, including Broadband; and other Digital, including Content and Services
Improvement of synchronisation between stakeholders and the adoption of food traceability along the entire value chain	Lack of qualified professionals; Difficulty in fast communication across the value chain; High costs of available solutions; Low interest in improving traceability; Low incentives to	- Joint R&D investment programme (grant scheme divided in the following categories: capital, training, R&D); - R&D support to the development of new solutions; - Tax incentives to foster the adoption of innovative traceability systems	Medium to Large	High	Farm-level investment projects may get funded as part of Investment Platforms with a sectorial or geographical scope. Such Investment Platforms may receive an EFSI guarantee that aims at supporting individual loans taken out by farmers. Such projects can also be eligible for the EAFRD. Part of the support can consist of a grant/loan from EAFRD and EFSI covers remaining part of costs. Resources from the EAFRD can also feed into Investment Platforms. In addition, the Investment Plan also

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
	investment				encourages the digitalisation of traditional sectors.

Table 10. Investment obstacles and solutions for BEV

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
Supply side					
Research and development into cell production for batteries for EVs	High costs; Lack of batteries' autonomy, safety, life span and power; Risk of environmental damage	- Joint R&D investment programme to facilitate the cooperation between industry and research institutes. - Tax incentives to promote the use of techniques which reduce the risk of environmental damage and increase the battery's energy and power, leading to a higher usage of EVs.	Very Large	Medium (Joint investment programme); Low (R&D support and tax incentives)	EFSI by mobilising cell manufacturers, increasing their capacity for developing new materials, designs and systems. Promotion of new joint projects for easier access to investments, in coordination with universities and research institutes, particularly through the EIPP. The subsectors covered by the EIPP that focus on Urban Mobility Projects, New Technologies and Transport Greening and Vehicles and Transport Systems should be in line with this need.

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
Investment in assembly techniques and processes for the integration of batteries' primary cells into battery packs	High costs; Limitations of the batteries technology	- Joint investment programme to enhance assembly techniques and automation processes. Investment should focus on several European organisations that are responsible for the assembly process.	Very Large	Medium	EFSI through mobilising manufacturers to increase their capacity and automated processes for pack assembly, particularly through structural funds.
Demand side					

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
Research and development into cell production for batteries for EVs	High costs; Lack of batteries' autonomy, safety, life span and power; Risk of environmental damage	- Joint R&D investment programme to facilitate the cooperation between industry and research institutes. - Tax incentives to promote the use of techniques which reduce the risk of environmental damage and increase the battery's energy and power, leading to a higher usage of EVs.	Very Large	Medium (Joint investment programme); Low (R&D support and tax incentives)	EFSI by mobilising cell manufacturers, increasing their capacity for developing new materials, designs and systems. Promotion of new joint projects for easier access to investments, in coordination with universities and research institutes, particularly through the EIPP. The subsectors covered by the EIPP that focus on Urban Mobility Projects, New Technologies and Transport Greening and Vehicles and Transport Systems should be in line with this need.
Investment in assembly techniques and processes for the integration of batteries' primary cells into battery packs	High costs; Limitations of the batteries technology	- Joint investment programme to enhance assembly techniques and automation processes. Investment should focus on several European organisations that are responsible for the assembly process.	Very Large	Medium	EFSI through mobilising manufacturers to increase their capacity and automated processes for pack assembly, particularly through structural funds.

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
Coordinated					
Coordinated investment into the development of recycling and reuse alternatives for Lithium-ion batteries	Lack of cooperation along value chain; Lack of willingness to cooperate with competitors	- Joint R&D investment programme to facilitate the cooperation between industry and research institutes. - Loan packages to support specific complementary industries. - Tax incentives.	Very Large	High	Remove barriers to investment and create simpler, better and more predictable regulation in the EU. Promote recycling actions and new application of reused/recycled components in manufacturing process. Public funds to mobilise additional private investment and give credit protection to financing provided by the EIB and the EIF.
Coordinated shared infrastructure and facilities	Lack of willingness to cooperate with competitors;	- Joint R&D investment programme to promote the establishment of a facility for further innovation actions	Large to Very Large	High	Investment Platforms which can attract private sector capital targeting development of shared infrastructures and facilities.
Cooperation on the development of techniques to	Lack of cooperation along value chain; Lack	- Joint R&D investment programme to facilitate cooperation (industry	Very Large	High	Use of public funds and incentives to mobilise additional private investment and give credit protection to the

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
increase the battery efficiency	of willingness to cooperate with competitors	and research) and improve battery efficiency - New equipment and facilities that use innovative techniques for the battery development			financing provided by the EIB and the EIF.

Table 11. Investment obstacles and solutions for Fabricated Metal products

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
Coordinated: Intra value chain – Co-engineering					
Support for collaboration in co-engineering	Cooperation with partners, availability of network, lack of complementarities, Lack of awareness on environmental	- Joint investment programme to facilitate cooperation between stakeholders - Framework condition for investment (*)	Medium to large	Medium	- Use of the EIPP and the EIAH - Use of the EIAH

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
	impacts				
Shared physical structures for co-engineering	Financing, framework for sharing, Lack of awareness on environmental impacts	- Public-private financing: e.g. public investment in infrastructure/overhead combined with private funding of the innovation projects	Very large (€5-10 million)	High	- Use of public funds to mobilise private investment and give credit protection to financing provided by the EIB & EIF

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
R&D on co-engineering to reduce environmental impacts	Lack of awareness on environmental impacts	- Joint R&D investment in R&D projects, shared investment in pre-competitive research	Very large	High	- Use of complementary actions: H2020, EFSI and ESI, funds programmes, as well as national / regional support, including developing an appropriate funding mix between grants & financial instruments
Coordinated: Inter value chain – Waste reuse					
R&D on coating powder valorisation	Insufficient knowledge on potential applications for coating powders	- Joint R&D investment programmes, shared investment in pre-competitive research - Framework condition for investment (*)	Very large	Medium	- Use of complementary actions: H2020, EFSI and ESI, funds programmes, as well as national / regional support, including developing an appropriate funding mix between grants & financial instruments - Use of the EIAH
Network on coating powder valorisation	Lack of awareness along value chain (especially user side) about potential recycled materials	- Joint investment programme to facilitate cooperation between stakeholders	Large	High	- Use of the EIPP and the EIAH
Geographical coverage of	Immaturity of the	- Loan to facilitate the establishment of	Very	Medium	- Use of public funds to mobilise private investment and give credit protection

Investment obstacles		Potential investment solutions			
Related invest. need	**Investment obstacle**	**Type of investment**	**Invest. Size**	**Coordination nature of invest.**	**Integration of the suggested investment/ support type under Juncker Plan**
recycling plants	market	facilities due to the high costs	large		to financing provided by the EIB & EIF - Use of the EIAH

(*) These actions are not investments as commonly understood, but are important to create positive framework conditions for investment.

6.2. Analysis of obstacles to investment

The causes of the obstacles to investment (such as obstacles associated to market, systemic or policy failure that significantly hamper investments, lack of coordination and synchronisation of potential investments) were studied and relationships/trends between the obstacles and value chains were determined. For this purpose, two value chains with similar industrial sectors were selected for each value chain studied in Task 1. The key criteria for the selection were: the level of complexity of the products and processes, the size of production, the level of interindustry supply and the intensity level of SMEs. The following is a list of the five value chains studied and their similar industrial value chains:

- Machinery & equipment: electrical equipment, computer electronics;
- Rubber and plastic products: basic metals, other non-metallic mineral products;
- Food, beverages and tobacco products: textiles, furniture;
- Motor vehicles, trailers and semi-trailers: machinery, other transport equipment (rail);
- Fabricated metal products: other non-metallic mineral products, rubber.

Task 2.1 looked into the obstacles to investment of these additional industrial value chains. Obstacles were differentiated from the ones that are idiosyncratic to the specific value chains studied from those that illustrate a pattern that may be observed in other value chains concerning similar industrial value chains. These analyses allowed to group the obstacles to investment for the modernisation of industrial value chains into the following:

- Obstacle 1: High costs and limitations of technology;
- Obstacle 2: Lack of cooperation between stakeholders;
- Obstacle 3: Lack of incentives to investment;
- Obstacle 4: Legal framework;
- Obstacle 5: Internal resources – lack of necessary skills.

6.2.1. Obstacle 1: High costs and limitations of technology

Selected Industrial Value Chains

A major obstacle faced by the five industrial value chains concerns the high costs associated with the modernisation of the industry. In the value chains of motor vehicles and rubber, these high costs are mostly faced by the supply chain of raw materials. In the rubber industry, the home production of natural rubber implies high costs of the technology and the implementation of such technology. Likewise, in the motor vehicles industrial value chain, the development and implementation of new technologies represents significant cost barriers for the producers, specifically in Europe where the production capacity is lower than that of its competitors, mostly driven by the lack of raw materials.

In the food value chain, the implementation of technology is also seen as a barrier. The traceability solutions can represent high costs for the business, in cases where the margins in the products are very low (e.g. fruit). Consequently, apart from the legal obligation to comply with traceability, there is a low interest in investing in new technologies.

Similar Industrial Value Chains

Regarding the computer, electronic & optical products value chain, the industry has been witnessing an increase in production costs which lowers its position to compete with other international markets (e.g. China). Furthermore, the development and adoption of new smart technologies represents high costs for the producers. This is also the case of the textile industry, where there is a high-price sensitivity of consumers.

In the machinery industry, the main barriers are related with the competitive advantage gained by the competition: low costs established (e.g. China), and new innovative technologies presented (e.g. USA). Likewise, the EU furniture value chain has high labour costs, which fragments the industry.

6.3. Obstacle 2: Lack of cooperation between stakeholders

Selected Industrial Value Chains

For modernising the industrial value chain, strong cooperation between stakeholders is needed. It was identified that most industrial value chains face a lack of cooperation across the entire chain, jeopardising investments.

In the industrial value chains of rubber, machinery and motor vehicles, it is observed that most companies are reluctant to share knowledge on technology and innovation. This is mostly because it implies the sharing of technology and innovation knowledge among the different industry players and therefore an increased risk of the need of sharing intellectual property among competitors.

The majority of the manufacturers involved in the projects or initiatives consist of SMEs, as the large manufacturing companies are more reluctant than SMEs to share technology and innovation with their competitors.

There is also a lack of cooperation between academia and industry due to a low level of technology and knowledge transfer.

Besides the fact that in the food value chain a stronger synchronisation is needed as well, it is important to note that this industry is characterised by a strong level of cooperation across the value chain, when compared to other industries. However, there is a lack of cooperation in terms of the implementation of innovative traceability systems, associated with the lack of qualified professionals in primary and upstream activities.

In the majority of the industrial value chains, it was observed that there is a lack of cooperation, which could be addressed by risk sharing financing models. Sharing the risks associated with certain technologies, high-tech facilities and equipment would motivate most actors across the value chain to make investment decisions and engage in innovative activities, given that bearing the high costs would now become acceptable. Putting in place a financing model and/or investment agreement which would encourage stakeholders to share the risk would be a feasible solution to overcome the lack of cooperation along the value chain obstacle.

Similar Industrial Value Chains

In the selected industrial value chains, it was observed a lack of cooperation between manufactures, retailers and consumers in specific industries. In particular, in the furniture industry, there is a knowledge gap between the different actors of the value chain, which leads to slower modernisation levels of the industry and in specific product features.

6.3.1. Obstacle 3: Lack of incentives to investment

Selected Industrial Value Chains

Despite the existence of incentives into certain industrial value chains, quite often these are misaligned with the priorities and needs of the industrial value chain. From another perspective, the existing tax incentives are usually focused on the development of R&D activities, rather than encouraging as well the implementation of innovations, which could help modernising the industry.

Similar Industrial Value Chains

The lack of incentives to invest is also considered to be an obstacle in regard to the similar industrial value chains. It is expected that further synchronisation along the value chain exists in order to align the priorities among the different actors from the value chain.

In particular for the furniture value chain, the obstacles are related with the difficulty of SMEs to access financial incentives. In terms of the textile industry, there is a need to reinforce the EU position in the international mass market through higher investment in production processes and in some cases through reallocation. Concerning the machinery value chain, there is a need to provide enhanced after-sales services, as well as investment in new technology, such as automation. In terms of the rail industry, there is a need to invest in new reliability services to modernise the industry and increase its competitiveness. Regarding the basic metals industry, more investment is needed in order to enhance the capacity towards the achievement of an optimal utilisation of internal resources, and further develop new technologies. In this sense, a plan from

national governments and investment incentives packages should be created in order to promote the development of SMEs and the recovery of failed businesses, as well as for technology development.

6.3.2. *Obstacle 4: Legal framework*

Selected Industrial Value Chains

One of the obstacles to investment which differs across different value chains is related to the legal framework of the industries. In the case of the food industry, for instance, the legal framework obliges the implementation of traceability solutions, and encourages the implementation of more advanced traceability systems which enable the provision of relevant and complete information to the consumer. As for the rubber industry, its legal framework is the most complex in the world (REACH). The motor vehicles industry, particularly its demand side, faces a lack of regulatory framework for the recycling of BEVs components for further applications in different products. A lack of legal framework is also faced by the machinery industrial value chain, which would need a legislation to facilitate the cooperation in the form of shared infrastructure or facilities.

Similar Industrial Value Chains

In the EU, there is a very strict legislation in regard to several industries, in comparison with other regions. In particular regarding the computer, electronic & optical products industry, these are related with the lack of efficient protection of IP and copyright in some products and processes, which should be followed by an effective enforcement of the legal framework. In addition, regulations regarding the industry's environmental and safety issues represent barriers for the industry's modernisation in comparison with its competitors.

6.3.3. *Obstacle 5: Internal resources – lack of necessary skills*

Selected Industrial Value Chains

Four of the case studies focused on industries which are typically operated by technology based companies with qualified professionals. On the contrary, in the case of the supply side of the food value chain, mostly operated by individual farmers and SMEs, a low level of qualifications regarding personnel is observed, which represents an obstacle towards the interest and ability to adopt and implement new technologies. In addition, there is a low interest level by technology developers in the agro-food value chain, which prevents further R&D advancements to be undertaken.

Similar Industrial Value Chains

The main obstacles concerning internal resources in the computer, electronic & optical products industry are related with the low level of skilled labour and personnel, specifically in advanced technologies. Likewise, the machinery industry also faces problems concerning relocation and employment of qualified staff. In addition, the textile industry has been witnessing a lack of training offering to the labour force, leading to a shortage of experience in new manufacturing processes. Concerning the furniture value chain, the industry also faces the obstacle of an ageing EU workforce, representing a barrier for modernisation.

6.4. Proposed investment packages

With a clear understanding of the factors impacting the modernisation of the selected industrial value chains (section 6.1) and the obstacles to investment (section 6.2), investment packages were developed with a focus on fostering the modernisation of the five industrial value chains. One investment package per industrial value chain case study is proposed.

It was found that an integrated and coordinated approach is required in order to foster investment and technology adoption. In addition, investment in technology adoption must be paired with investment in assets, such as skills, organisational assets, network assets and related functional procedures. As a result, investment in technology adoption on its own will not ensure the ultimate objectives of the given investment will be achieved. Likewise, the policy interventions also need to be implemented in an interrelated manner, which requires coordination of all actors involved.

The below tables present the dedicated investment package developed for each of the five analysed industrial value chains. The specific objectives of the proposed investment packages are:

1. To tackle the investment gaps pinpointed in the Study;
2. To identify ways to seize the opportunities identified by the interviewees/experts from the value chains; and
3. To tackle the obstacles summarised in the individual case studies.

Priority was given to investment packages that address:

1. Needs across two or more of the analysed industrial value chains;
2. Critical parts of the value chains by eliminating existing bottlenecks and/or by retaining significant multiplier effects and boosting efficiency across multiple stages of the value chain; and

3. Capabilities, in particular value chain actors' innovation capability – where innovation is understood in accordance with its broad conceptualisation.[31]

INVESTMENT PACKAGE Machinery and equipment (additive manufacturing) value chain	
Type of investment package	Loan guarantees or preferential loans; tax credits for innovations in processes and technologies, support for cooperation in R&D among companies in the value chain. Specifically: innovation in the production of metal powder in order to decrease its costs and in enabling 3D printers to accept a wider range of metal powder granularity.
Addressed investment need(s)	Increasing know-how and innovation in certain processes and technologies in additive manufacturing. Bringing (potential) partners together. Justification: There is a high market potential in specialty manufacturing using a wider set of 3D printing metal powders. There are technical challenges for 3D printing applications in certain powders. They justify investment in innovations and R&D concerning processes and technologies or investment in higher yields through sieving of high-end metal powders during production (using current technique). Another related R&D direction may be in metal powder granularity acceptance of 3D printers. Both R&D directions require cooperation of companies in the value chain (producers and users of metal powder).
Addressed obstacle	Lack of interest on the side of metal powder producers for process and technology developments in order to reduce the price of their products (but at the same time being able to sell much larger quantities), 3D printers accepting only metal powder with certain granularity. Lack of cooperation among companies along the value chain, high price of raw materials, low internal resources for certain companies in the value chain for process and technology developments.
Target Group	SMEs in 3D printing and large companies, which are already producing metal powders (some leading EU-based companies (in Germany, France and Sweden) and certain companies in Europe, outside the EU (Switzerland, in the future: UK)), possibly a research consortia can be set up with the participation of research institutes as well. Justification: Policymakers can build on existing knowledge and experience in producing metal powder in these companies, who are among the leading companies of production of metal powder

[31] Mytelka, L.K., & Smith, K. (2002). Policy learning and innovation theory: an interactive and co-evolving process. *Research Policy*, *31*(8), 1467–1479.

INVESTMENT PACKAGE Machinery and equipment (additive manufacturing) value chain	
	for 3D printing worldwide. On the other hand, SMEs in 3D printing as the main users/buyers of metal powder can join forces with metal powder producing large companies, cooperation between smaller-sized, more innovative and large-sized firms may be an asset as they have a more in-depth overview of different parts of the producing process. The participation of research institutes can be justified on the basis of their deeper knowledge regarding the theoretical-basic research background of the production processes.
Size of investment	Medium (from €100,000 up to €250,000) to Large (from €250,000 up to €1 million) Justification: The sophistication of technology and the very specific nature of development and innovation justifies the amounts indicated. It can go up from medium to large if the participation of specialised research institutes, research experts or universities is required.
Funding source	COSME – Loan Guarantee Facility; InnovFin; InnovFin Large Projects. Justification: COSME as it supports European enterprises' growth and research and innovation through loan guarantees provided to financial and credit institutions, through this facility, joint research and innovation activities of companies of all sizes can be supported. InnovFin can support joint R&D activities (e.g. in the Key Enabling Technologies sector), with the participation of companies producing metal powder joined occasionally by universities, research institutes and 3D printing companies. InnovFin Large Projects may be the source of loans and guarantees if large firms and research organisations team up for large R&D projects in the area. In all cases, investments should be synchronised along the value chain, as they need a close cooperation between producers and users of metal powder.
Applicability Juncker Plan	Two pillars of the Juncker Plan are relevant: Pillar 1: Mobilising investments of at least €315 billion in 3 years; Pillar 2: Supporting investment in the real economy.
Level of coordination	Investment package needs to be coordinated at a European level with optional nation-state co-financing, especially in the case of metal-powder-related developments, where there is a strong dominance of certain member countries (France, Germany and Sweden).
Similar programmes	For additive manufacturing, the research nature of this manufacturing technique is apparent through the overall 10 calls through Horizon 2020 addressing this topic. Hereby seven are already closed, two are open and one is forthcoming. Powder grain size is not directly addressed by any call, however some calls mention the need for increased collaboration or improved manufacturing techniques and some calls mention high end metals. Further programmes include: Support Action for Standardisation in Additive Manufacturing[32] (can be used as a background for standards concerning AM); Existing research projects sponsored by the EU

[32] http://cordis.europa.eu/result/rcn/149448_en.html

INVESTMENT PACKAGE Machinery and equipment (additive manufacturing) value chain	
	in relation to AM[33]; Factories of the Future PPP (including, among others, R&D on 3D printing)[34] . The package can be built on the outputs and the company networks of the aforementioned programmes.
Timeline	Mid-term, given that the investment package is aimed at process and technology development; instalments should be based on the results of technology development.
Geographical scope	Given the geographical location of the leading metal powder producer companies, it may affect more the Central (Germany, France) and Nordic (Sweden) EU Groups, while basically all EU is affected in the case of SMEs operating in 3D printing (with the highest number of such companies in Germany and Italy).
Package activities	R&D (mainly development) for new processes and technologies, and related training and advisory services. Activities related to setting up, managing and coordinating networks of producer and user companies (and possibly specialised research institutes).
Expected outcome	Improved processes resulting in lower prices for metal powder used in AM and thus a wider proliferation of the technique. Enabling 3D printers to use metal powders with different granularities and thus a wider use of 3D printing. An economic consequence may be the back shoring (back to the EU) of certain previously offshored activities by European multinationals.
Social return	Improved company performance resulting in potentially higher wages and environmental/ sustainability improvements through reducing waste and material use. The wider use of 3D printing may have economy-wide consequences in terms of higher efficiency, cost reduction and emergence of new industries. Among others, public health benefits considerably from the wider use of the technique.

[33] 88 projects in Framework Porgrammes, including 10 projects on metals. Research projects on AM in Horizon2020. See: http://www.cnrs.fr/insis/recherche/docs-evenements/workshop-INSIS_11.01.16_GEsteban.pdf

[34] https://ec.europa.eu/research/industrial_technologies/factories-of-the-future_en.html

INVESTMENT PACKAGE Rubber and plastics value chain - tyre rubber manufacturing	
Type of investment package	Grants supporting dedicated R&D programmes and collaboration between stakeholders, representing a variety of scientific disciplines combined with coordinated support of investment in the development of alternatives for rubber in the tyre manufacturing. More specifically, the development of the rubber printing system: process development to cut the costs of transformation of rubber into tyres; coordinated cooperation to develop alternatives to imported rubber value chains in the tyre industry.
Addressed investment need(s)	Coordinated investment across value chain actors related to the home production of natural rubber; and the R&D related to alternatives to natural rubber, techniques to reduce wastage of natural rubber during tyre manufacturing, and tyre or rubber recycling process.
Addressed obstacle	Stakeholders' commitment to collaboration and to open innovation is low. Collaboration between multidisciplinary research teams is challenging, commercialisation of new scientific results (especially of the results in university departments) is inefficient.
Target group	Consortia of companies of all sizes and from heterogeneous industries (including both start-ups and established companies), universities and private research providers. Justification: Due to the multidisciplinary character of tyre industry related research, and the rapidly increasing weight of digital technologies, both with respect to manufacturing processes and product-embedded solutions, collaborative research programmes need to address all kind of stakeholders that can provide specialised expertise.
Size of investment	Large (from €250,000 up to €1 million) to Very large (>€1 million) Justification: The scheme is a flexible framework agreement achieved through consortium members' specific plans envisaging different activities. This allows for flexible responses to emerging research directions and new plans. The overall annual amount of funding can be different in consecutive years, depending on the specifications of activities.
Funding source	Horizon 2020; EFSI; Innovfin. Justification: EFSI can be applied given its relation to various strategic investment goals (transport, digital, environment and resource efficiency, RDI) and because the scheme is expected to mobilise private investment. Horizon 2020 targets specific research undertakings, and can be applied initially for a couple of consortium members' RDI undertakings. EFSI will build on the results of prior undertakings and integrate pieces of scientific efforts and stakeholders into a larger network. Since Innovfin programmes offer integrated and complementary financing tools and advisory services, and cover the entire value chain of research and innovation, they are complementary to the other funding sources and target specific segments of the large-scale research financed from this policy scheme.
Applicability Juncker Plan	In particular, pillar 2 is applicable: Pillar 2: Support investment in the real economy. Given the market structure characterised by a few flagship actors, whose research-based

INVESTMENT PACKAGE Rubber and plastics value chain - tyre rubber manufacturing	
	collaboration is supported. In particular, the Infrastructure and Innovation Window deployed through the EIB is considered relevant. As EU Guarantee is expected to be directed to projects with high value added, the funding of this package qualifies for the applicability of the Juncker Plan. However, the package cannot be aligned with the requirement of (geographical) additionality, which needs to be considered when applying the Juncker Plan.
Level of coordination	The investment package needs to be coordinated at a European level with optional nation-state co-financing.
Similar programmes	Some programmes include EU funded R&D projects such as EU-PEARLS[35] and DRIVE4EU[36]. The package can be built on these programmes.
Timeline	Framework agreement for annual funding of activities carried out in a multi-year programme. The amount of a given year's funding depends on the activities foreseen in consortium members' regularly prepared plans and evaluations of past activities and achievements. The call may be repeated to set up different consortia. Justification: This programme provides a platform for research and collaboration.
Geographical scope	South European countries for the production of NR from guayule (e.g. Spain and Italy) and Northern and Eastern countries for NR production from the Russian dandelion (e.g. Finland, Poland, Slovakia, and Slovenia) Justification: The establishment of facilities and techniques to the production of NR in Europe involves high costs. For investment in research and development, no geographical prioritisation should be applied since it is important that diverse stakeholders from multiple sectors and industries provide specialised expertise. Northern countries (Norway, in particular) for research in the improvement of the quality of synthetic rubber. Justification: Norway abounds in fuel resources necessary for the production of synthetic rubber. Germany, Italy, France and UK for investment in the development of techniques which reduce wastage of natural rubber during the tyre manufacturing. The world's largest tyre manufacturers are based in these countries.

[35] http://www.wur.nl/en/Research-Results/Projects-and-programmes/eu-pearls-projects.htm

[36] http://www.drive4eu.eu/

INVESTMENT PACKAGE Rubber and plastics value chain - tyre rubber manufacturing	
Package activities	Multidisciplinary research (alternatives to natural rubber related and recycling related research). Activities related to setting up, managing and coordinating networks of stakeholders. Commercialisation, patenting, licensing, education and outreach activities.
Expected outcome	Increased technology development. Reduced dependence on imported rubber. Enhanced networking of industry related stakeholders (including those operating in related and supporting industries). Improved opportunities of commercialisation.
Social return	Creation of new value chains. Improved sustainability of the value chain.

INVESTMENT PACKAGE Food industrial value chain: Food Traceability	
Type of Investment Package	Grants and/or tax credits for R&D and innovations in processes and technologies, combined with loans and loan guarantees; support for cooperation among companies in the value chain, with the aim of reducing the costs and improving food traceability.
Addressed investment need(s)	Identification and development of less expensive and simpler to manage traceability solutions; Implementation and maintenance of traceability solutions in various companies along the value chain – bringing partners/companies together (especially SMEs). Justification: Relatively high financial and human resources required for the introduction and maintenance of food traceability solutions act as an obstacle for modernisation in the industry, especially for SMEs and companies with products with low margins. Thus, the R&D efforts for the development of cheaper and simpler traceability solutions would enable more companies to use them. Loans and loan guarantees, especially if provided through investment platform instruments, would enhance SMEs' capability and cooperation in that area.
Addressed obstacle	Lack of, and low incentives for, using traceability solutions in the value chain despite its importance from the point of view of food safety, demand of EU consumers, and the European competitiveness in the industry. Relatively high costs of the introduction and maintenance of traceability solutions. Lack of cooperation between partners/companies for introducing and maintaining traceability solutions. Lack of financial and human assets in the companies in the value chain for the introduction and maintenance of traceability solutions.
Target Group	Type of stakeholders include public and private research institutes, researchers, universities and

INVESTMENT PACKAGE Food industrial value chain: Food Traceability	
	companies with relevant R&D in the value chain; and companies in the value chain (especially small- to medium-sized or those larger sized with small margin products). Justification: Relying on their specialised expertise and already existing knowledge in traceability systems, universities, public and private research institutes and companies with relevant R&D can form research consortia in order to find lower cost solutions for food traceability systems. Companies in the value chain which lack financial and human resources for implementing and maintaining traceability systems can be addressed with loans and loan guarantees to adopt traceability solutions and to cooperate in this area.
Size of Investment	Large (from €250,000 up to €1 million) Justification: A joint R&D investment or grant programme on lower cost traceability solutions (and, on one hand, providing access to the results and, on the other hand, loans or loan guarantees and other support to companies lacking resources for the implementation and maintenance of traceability solutions) add up to a relatively large amount of investment.
Funding Source(s)	Horizon 2020; InnovFin; InnovFin SME Guarantee Facility; The SME Initiative. Justification: Horizon 2020 programmes target specific research undertakings, adequate for finding lower cost solutions for food traceability systems. InnovFin covers the entire value chain of research and innovation, thus it can support joint R&D activities of consortia formed by universities, research institutes and companies (the Agriculture and Food areas are included in InnovFin). Furthermore, not only the financing tools but also the advisory services available through InnovFin may be used in terms of providing advice and support to companies for implementing and maintaining traceability solutions. InnovFin SME Guarantee Facility for groups of SMEs can provide financial support for the introduction, implementation and maintenance of traceability solutions and enhance cooperation in that area. In countries where it is operational (Bulgaria, Finland, Malta and Spain), the SME Initiative can be applied with the same aim.
Applicability Juncker Plan	One pillar is relevant: Pillar 2: Supporting investment in the real economy. Several investments can be undertaken in the scope of the Investment Plan and taking into account the priorities of Pillar 2. In particular, SMEs in a certain food value chain could apply to investment platforms financed under the Investment Plan, thus allowing for coordinated investments to take place and modernize the industry.
Level of coordination	The investment package needs to be coordinated at a national and European level.

INVESTMENT PACKAGE Food industrial value chain: Food Traceability	
Similar programmes	Various FP projects such as TRACE[37]; national or bilateral projects[38]. The research outcomes, the fora for dissemination (operational websites) and the existing participant networks can be built on and be extended to other participants.
Timeline	Mid-term investments in the case of R&D projects, as these contain mainly "technology development" type of activities; Mid-term investments for companies, as the implementation and maintenance of traceability solutions needs a mid-term timeframe to achieve visible results (and thus their reliable evaluation is possible only then).
Geographical Scope	All EU member countries would benefit from the package. Justification: In spite of their increasing internationalisation/"EU-isation", food value chains are still overwhelmingly operating at the national level. Alternative: Countries where the value added share of food, beverages and tobacco in manufacturing is outstanding (Cyprus, Greece, Croatia, Lithuania and Spain) could be the target of the investment package. Justification: In these countries, given the high share of the targeted industries within manufacturing, the investment packages could have a higher return when compared to other EU member countries (in the case of Spain, the resources of the SME Initiative are available).
Package Activities	R&D (mainly development) for the development of new traceability processes and technologies (in order to reduce the costs of the use of solutions); Improved access to R&D results by companies (free or at a reduced cost, e.g. through a web platform); Advisory services, training services, and loans or loan guarantees for companies for the introduction, implementation and maintenance of traceability solutions.
Expected Outcome	Improved and more widespread traceability EU-wide and along the value chains in the industry, resulting in a higher level of food safety and in an improved or at least maintained competitiveness of EU products in the industry.
Social Return	Environmental, public health and sustainability improvements due to increased traceability of food products; Higher level of food safety and quicker response to food recalls.

[37] See e.g. TRACE: http://www.foodtraceability.eu/page/whoweare; Pathogen Combar: http://www.foodscience.ugent.be/LFMFP/Research?ProjectID=79; FoodIntegrity: https://secure.fera.defra.gov.uk/foodintegrity/index.cfm

[38] See e.g. in Finland: http://www.metropolia.fi/en/research-and-development/projects/food-traceability-and-safety-technology-center/ or Inno-Crop-Food involving Hungarian and Croatian regions: http://innocropfood.hu/hirek/-/&l=eng

INVESTMENT PACKAGE Motor vehicles, trailers and semi-trailers value chain: batteries for electric vehicles	
Type of investment package	Medium/large-sized project grants supporting research, innovation, collaboration and commercialisation. More specifically, research in battery technologies improvement.
Addressed investment need(s)	Strengthening critical parts of the value chain concerning R&D for battery technology improvement and enhanced process techniques – cell production, pack assembly and vehicle integration, and R&D for recycling technology.
Addressed obstacle	Limitations in technology (cost, performance e.g. driving range, charging speed and new recycling solutions).
Target group	Types of stakeholders: consortia of flagship actors in industry – OEM market leaders, battery cell manufacturers and universities (in the case of recycling programmes: consortia need to include also recycling companies). Individual actors that can influence the industry innovation process. Justification: Currently, market leader (i.e. the key technology companies) have accumulated substantial stock of knowledge about battery technologies and have been investing in the improvement of these technologies. The situation is similar in the case of some university departments, specialised in BEV research. Support measures need to target collaborative undertakings. Additional actors to be considered for inclusion: power charging companies.
Size of investment	Very large (>€1 million) Justification: Very large research programmes need to target specific research undertakings which need the co-financing of private sector stakeholders. Very large programmes target the establishment of dedicated research centres and development of new innovative processes.
Funding source	National governments; Horizon 2020; EFSI Justification: EU-level support needs to capitalise on existing achievements of national-level programmes and promote international collaborative undertakings. Another option is to open up EU-level funding opportunities for stakeholders in countries that are not target by national-level support programmes.
Applicability Juncker Plan	All pillars are applicable: Pillar 1: Mobilising investments of at least €315 billion in three years.

INVESTMENT PACKAGE Motor vehicles, trailers and semi-trailers value chain: batteries for electric vehicles	
	Pillar 2: Supporting investment in the real economy. Pillar 3: Creating an investment friendly environment.
Level of coordination	Multi-level coordination is recommended: EU-level programmes should build on and complement national programmes and focus on the research undertakings
Similar programmes	Several projects, such as: GREENLION; eCAIMAN, BATTERIES2020, FIVEVB; MARS-EV[39] The proposed package needs to build on these projects and extend them, to elevate their achievements to a higher level of technological readiness, and to facilitate the collaboration of individual project teams and the transfer of technology.
Timeline	Annually but with mid-term programmes. Justification: Annual (or even bi-annual) announcement of tenders (in that case tenders of a smaller-scale support) is necessary since technology is rapidly changing, new directions and developments come up frequently. Funding provision, however, needs to be multi-annual with a necessary sequencing of support (new rounds of support are function of evaluation results). In addition, continuous investment support to the main industrial players (such as tax incentives for recycling organisations) should be addressed.
Geographical scope	Southern EU group: Italy; Central EU group: Germany, France; Nordic and Baltic EU group: Sweden; UK. Justification: Support needs to target countries where the key OEMs engaged in BEV-technology related research are located. At the same time, intra- and extra-EU international collaboration undertakings also need to be considered. The above-mentioned target countries also represent the highest share of EVs sales in Europe.
Package activities	Fostering R&D actions for new technologies. Promoting technology transfer between research centres, universities and industry players. Establishing dedicated research centres, outreach activities, and investment actions throughout the value chain to allow increased European capacity to increase the use of EVs and develop new innovative solutions to its long-term sustainability process.
Expected outcome	Value creation for enhancing production capacity and reducing costs, eliminate or reduce bottlenecks in the value chain. Development of new efficient methods for the manufacturing and assembly process.

[39] Details about the listed and other similar individual projects are found at: http://www.egvi.eu/projects/research-projects?mact=Projectslist%2Cm7803b%2Cdefault%2C0&m7803breturnid=37&m7803borderby=title+ASC&m7803bframework=&m7803bcallidentifier=&m7803btype=&m7803bstatus=ongoing&m7803bvehicle=&m7803bcategory=1&m7803btechnology=3&m7803bpartner=&m7803bsubmit=Search

INVESTMENT PACKAGE Motor vehicles, trailers and semi-trailers value chain: batteries for electric vehicles	
	Enhancing performance and providing a more reliable transport system.
Social return	Enhanced technology adoption. Mobilisation of private investment towards this solution. Reduced technological uncertainty and enhancement of consumer's confidence in the product. Improved sustainability: reduced footprint of transport.

INVESTMENT PACKAGE Fabricated metal products value chain	
Type of Investment Package	Provision of grant combined with loans for joint establishment, maintenance and upgrading of an open knowledge/technology platform for co-engineering and R&D collaboration
Addressed investment need(s)	Challenges regarding SMEs' capabilities in terms of participating in collaborative engineering practices and in terms of meeting customers' increased expectations of flexibility, own R&D inputs and sustainability. Justification: The fabricated metal industry is characterised by a high share of SMEs that are usually overly dependent on one or a couple of contractors. SMEs have little resources to keep pace with the evolving technologies and feature low commitment to collaborate and share information. Without collaboration (and shared R&D facilities), however, it is impossible for them to meet the increased customer requirements in terms of suppliers' R&D inputs, flexibility, and responsiveness to rapidly changing demand. Furthermore, SMEs also have to comply with increasingly strict regulations in terms of environmental best practices implementation.
Addressed obstacle	SMEs are not sufficiently capitalised to become integrated in their customers' collaborative engineering practices. They need to finance investment in R&D facilities and in expensive testing equipment and in collaborative engineering infrastructure. It is often cumbersome even for large firms to keep pace with the emergence of new advanced solutions and to master the deployed technologies and comply with increasingly strict environmental regulations.
Target Group	SMEs with strong capabilities to be engaged in R&D, co-engineering and co-design activities Justification: Support to SMEs and their enhanced competitiveness is expected to have strong multiplier and employment growth effects.
Size of Investment	Medium (from €100,000 up to €250,000) to Large (from €250,000 up to €1 million) - Initially large Justification: Initially (in the first two years) the size of investment (on an annual basis) is larger, since

INVESTMENT PACKAGE Fabricated metal products value chain	
	investment is related to the development and deployment of the open knowledge source and the establishment of the network and mechanism of information provision. Later, further investment requirements will progressively diminish, since private investment will also be mobilised.
Funding Source	ESIF; EFSI; COSME. Justification: ESIF is relevant since clustering, networking and collaboration is included in multiple regions' smart specialisation strategy, and also the sectoral objectives. EFSI (SME Window, COSME) are relevant as well, since the proposed package is related to the strategic investment goal of RDI and 'environment and resource efficiency'. COSME's guarantees to financial institutions to provide financing to SMEs are relevant. The proposed package is expected to mobilise private investment as a result of enhanced competitiveness, resulting from the collaboration of actors (SMEs and actors in related industries).
Applicability Juncker Plan	In particular, one pillar is relevant: Pillar 2: Supporting investment in the real economy. Justification: Use of public funds to mobilise additional private investment and gives credit protection to the financing provided by the EIB and the EIF. Additionally, the use of the European Investment Project Portal and the European Investment Advisory Hub are recommended.
Level of coordination	Multi-level coordination is recommended: EU-level programmes should build on and complement national and regional programmes to increase the size and scope of the agglomeration of engaged stakeholders.
Similar programmes	For fabricated metal products, only one call was found to be relating to the topic of reuse and recycling in relation to fabricated elements. However, this call did not address any of the further needs in the area of R&D. Nonetheless, there are a number of (broadly) similar programmes (e.g. NEFFICS, NiSB, SPIKE, SPRINT, eBBITs)[40] that support networking and collaborative engineering of enterprises or the establishment of knowledge platforms. This distributed character of currently existing programmes can be a good basis for a larger-scale, better communicated initiative.
Timeline	Medium to long-term programme: framework agreement, annual funding. Justification: This programme is medium to long-term with respect to information and services provision and short-term with respect to the development and deployment of the open

[40] Further information on these projects can be found in http://cordis.europa.eu/fp7/ict/enet/ei-projects_en.html

INVESTMENT PACKAGE Fabricated metal products value chain	
	knowledge/technology platform. This latter activity will turn into a continuous maintenance and upgrading of the platform (long term activity again).
Geographical Scope	All regions are eligible. Justification: The opportunity to gain information, upgrade and adopt the most recent technological solutions needs to be available for every actor in the industry. As for the geographical distribution, it needs to be considered that Germany has the highest value added in fabricated metal industry, and Italy and France rank second and third respectively. Most countries and several regions explicitly include fabricated metal industry in their smart specialisation strategies with labels including lightweight constructions and metallic materials (advanced materials) - Poland, Slovenia, Sweden are a few of the many examples. It is expected that countries with the highest relative value added share will be the main beneficiaries of investment packages (i.e. Germany, Italy and France). Nevertheless, benefits will spill over to locations where production is offshored. The value added share of this industry within total manufacturing is not only in selected new Member States (e.g. in Croatia, Czech Republic, Estonia, Poland, Slovakia and Slovenia) above 10%: Austria, Italy, Portugal and Spain also feature above-10% shares.
Package Activities	Joint investment programme, public-private co-financing. Advisory services, training, information provision and outreach activities.
Expected Outcome	SMEs' enhanced collaboration, learning and technology adoption. Accelerated new product development and reduced time to market. Enhanced competitiveness in terms of flexibility, responsiveness and capability to participate in collaborative R&D undertakings.
Social Return	Enhanced market access by European SMEs. Enhanced growth. Enhanced networking and open innovation (increase in SMEs' network capital). Diffusion of environmental best practices, reduced electricity consumption, and increased resource efficiency.

7. Policy recommendations

The quantitative and qualitative analyses resulted in clear indications of the factors impacting the modernisation of the selected industrial value chains, in particular, and industrial value chains in general. The previous four chapters of the report have summarised the results and knowledge gained through the applied methodology. The culmination of this information allows for specific recommendations to be made in the study, concerning: i) future potential approaches to similar empirical analysis challenges concerning industrial value chains; ii) policies to overcome obstacles to investment within industrial value chains; and iii) policies to foster proper and effective investments that will meet the needs and facilitate the modernisation of industrial value chains.

8. Empirical analysis of EU value chains

The objective and scope of this study presented challenges from an empirical analysis perspective. Some of the challenges were known from the beginning, and were highlighted and addressed by the project team's proposed methodology. Nevertheless, the availability of data sources and the complexity of the analysis became more challenging as the project team dove deeper into the quantitative analysis at the value chain and firm levels. The following recommendations are built on the results of this study and are designed to propose further comprehensive empirical analysis of EU value chains in order to broaden the understanding of how policies can positively impact their modernisation.

8.1.1. Recommendation 1: Investment trends across industries and countries

The input-output analysis of this study revealed important aspects concerning inter-industry linkages for production processes and how these developed over time for both the aggregate EU level as well as for individual EU Member States. In a next step of analysis one needs to analyse industry specific investment patterns as follows:

i. Analysing the patterns of industry-specific gross fixed capital formation and how these are correlated for specific industries across countries (i.e. whether there are common industry-specific investment patterns and trends within the EU);
ii. Using insights from the input-output analysis one should also investigate whether investment patterns and trends are correlated across those industries and countries which are closely linked via production networks;
iii. One can further split the industry-specific gross fixed capital formation into various asset types; in particular investment in transport equipment, ICT equipment, computer hardware and telecommunications equipment as well as software; and

iv. Analysing trends in investment intensity (investment relative to gross output or value added) or investment growth before and after the crisis to detect changes or significant breaks.

Data for a subset of countries are available from the recent update of the EU KLEMS data for a subset of EU-28 Member States. Further data might be gathered from Eurostat if available. In addition, SBS data provide information on various tangible investments by industry which might be considered as well.

8.1.2. Recommendation 2: Identify industrial value chains with high growth potential through a quantitative analysis based on firm-level data

The current study is limited in its ability to identify industrial value chains with high growth potential through firm-level data. The approach taken relied heavily on sector-level data. This was required due to the challenges of the study (resources and timeframe).

It is suggested that an empirical approach could be taken to identify high growth industrial value chains based on firm-level data. This empirical approach would use firm-level information from the Amadeus data set (provided by Bureau van Dijk)41 and input-output data from the World Input-Output Tables (from the World Input-Output Data Base – WIOD)42 to identify European industrial value chains with significant growth potential. The methodology would build on recent theoretical and empirical contributions on value chains43. The analysis would proceed as follows:

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[41] This data set provides comparable information on production and financial accounts and on the ownership structure of over 21 million companies located in Europe (43 countries are covered) for a ten year period up to 2015. Details about the data set are available from http://www.bvdinfo.com/en-gb/our-products/company-information/international-products/amadeus

[42] The World-Input Output Tables are available for 43 countries and the world for the period 2000-2014 (Release 2016). Details are available from http://www.wiod.org/new_site/data.htm.

[43] Acemoglu, D., Johnson, S. and Mitton, T. (2009). "Determinants of Vertical Integration: Financial Development and Contracting Costs". The Journal of Finance, 64: 1251–1290. Acemoglu, D., P. Aghion, R. Griffith, F. Zilibotti (2010). "Vertical integration and technology: Theory and Evidence". Journal of European Economic Association 8(5): 989-1033. Alfaro, L. and Charlton, A.(2009). "Intra-industry Foreign Direct Investment." American Economic Review, 99(5): 2096-2119. Altomonte C. and Rungi A., (2013)."Business Groups as Hierarchies of Firms: Determinants of Vertical Integration and Performance," Working Papers 2013.33, Fondazione Eni Enrico Mattei.

- Identify business groups (firms linked by ownership rights) using information on firms' ownership structure (identify parent and affiliate companies), industry activity, and location. A survey to capture supply and selling structure of firms is necessary. Within each business group two sets of activities can be identified:
    - A set of output activities – the *primary* and *secondary* activities of the parent company; and
    - A set of *intermediate activities* – the primary and secondary activities in which the affiliates are involved.
- Compute business group-specific index of industrial value chain integration –based on the input coefficients for the output activities of the parent company sourcing intermediate activities from all affiliates.
- Rank business groups by the index of industrial value chain integration.
- Identify growth potential for business-groups with the 10 highest index of industrial value chain integration – on the basis of the world demand prospects for the industry of the primary activity of the parent company.
- Rank business groups by growth potential.
- Select five business groups with the highest growth potential.

8.1.3. Recommendation 3: Engagement in European and global value chains under financing constraints

It is recommended a follow-up research which identifies the relationship between financing constraints and the engagement of enterprises in European and global value chains.

Innovative enterprises integrated in European and global production and innovation networks are likely to drive the European innovation-based growth in the next decade. Understanding the drivers and the effects of integration in European and global value chains is key to informed policies aimed at competitiveness and growth at firm, country and European levels.

Specifically, this follow-up research would address the following questions: (i) What determines the propensity of enterprises to engage in European and global production and innovation networks? (ii) Do internationalisation strategies of large enterprises differ from those of SMEs? (iii) How do financing constraints affect the European enterprises' internationalisation strategies? (iv) Is there a role for policy measures to assist enterprises to engage in European and global value chains?

The analysis would use information from the Amadeus dataset provided by Bureau Van Dijk. This data set contains comparable information on over 21 million domestic and foreign owned firms in Europe including financial variables, the sector of activity and firms' ownership and production linkages across the world.

8.2. Policy recommendations to overcome obstacles to investment

As discussed in detail in Chapter 6, this study was able to group the obstacles to investment for the modernisation of the selected industrial value chains into the following five obstacles:

- Obstacle 1: High costs and limitations of technology;
- Obstacle 2: Lack of cooperation between stakeholders;
- Obstacle 3: Lack of incentives to investment;
- Obstacle 4: Legal framework;
- Obstacle 5: Internal resources – lack of necessary skills.

Three high priority policy recommendations are foreseen to have a significant impact on the obstacles to investment mentioned above.

8.2.1. Recommendation 4: Better connect the different stakeholders of a value chain

Besides the identification of key value chains across regions and sectors, additional efforts should be performed to facilitate the cooperation of the different stakeholders along a value chain. This will help to better identify the different needs in terms of investments and to allow different partners to explore ideas for coordinated investments along a value chain. Such efforts can be conducted under the Thematic Smart Specialisation Platforms44 (currently on Industrial Modernisation, Agri-food, and Energy).

Training webinars could be conducted so that leaders of the concerned industrial value chains could present their insights, ideas and advice on how to modernise both the supply side and demand side of the value chain. Moreover, some of the webinars could be focused on providing information on IPR protection and enforcement.

Therefore, these types of activities would be able to overcome the current lack of cooperation between stakeholders along a value chain (obstacle 2) by leveraging resources from the different stakeholders (obstacle 5) and by mitigating the lack of awareness and enforcement of IPR (obstacle 4).

[44] http://s3platform.jrc.ec.europa.eu/s3-thematic-platforms

8.2.2. *Recommendation 5: Capital Allowances for technology acquisition*

To overcome obstacles, specifically on financing and technology development, it is recommended to create capital allowances for Medium Enterprises exclusively for technology acquisition. The model of the proposed allowances could be based on existing incentives for Medium Enterprises. These include the R&D Capital Allowances for SMEs in the UK45, SkatteFUNN R&D tax credit in Norway46 and the Skattekreditordningen R&D tax credit scheme in Denmark47.

The allowances could be provided through annual calls in support of specific industrial value chains. These allowances should be dedicated to Medium Enterprises which employ less than 250 employees, have a turnover of €10 million to €50 million and also have been active for between 3 and 6 years. These criteria have been determined in this study as those that will ensure the enterprises have both human and financial capital to transform the technology acquired into business value, and will have an impact on the modernisation of the concerned industrial value chains. Indicators for evaluating the business value generated could include the impact of the technology acquisition on cost reductions and revenue gains.

In this context, this initiative would address the need for more investment incentives (obstacle 3) since it consists of a measure to promote investment in technology. It would also overcome the high costs associated with the modernisation of the value chain, including the costs due to the acquisition of technology (obstacle 1).

8.2.3. *Recommendation 6: Value chain IPR initiative to foster alliances between competitors*

In order to overcome stakeholder cooperation and the legal issues that can arise with them, it is recommended to create conditions at the EU level to ensure that IPR protection is not an obstacle for the different stakeholders along value chains to cooperate. As previously indicated, industry players are often reluctant in sharing technology and innovations with their competitors. Therefore, it would be important to create the conditions to prevent commercial-scale infringements and foster collaborations between companies that traditionally compete with each other for the greater good of the value chain. The conditions should be developed with stakeholder input to ensure they will be effective in

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[45] http://www.ayming.co.uk/rd-tax-credits/rd-tax-credits/

[46] http://www.forskningsradet.no/en/Funding/SkatteFUNN/1210046495447

[47] http://www.pwc.dk/en/news/the-danish-tax-credit-scheme.html

alleviating potential concerns that exist among competitors. Undoubtedly due to the complexity of the issue, creating the proper conditions for the initiative would most likely require the involvement of policy makers and legal experts from the EC to ensure the cross-border applicability of the developed conditions.

This initiative would promote the cooperation between stakeholders (obstacle 1) through the establishment of sectorial IPR policies and law (obstacle 4).

The initiative should be aligned with existing initiatives with a similar objective, including the Action Plan on the Enforcement of IPR48, the Public Consultation on the Evaluation and Modernisation of the IPR Enforcement Framework49, and the Consultation on the Protection of Intellectual Property in Supply Chains50.

8.3. Policy recommendations to foster investments

Chapter 6 recommends investment packages that address the investment needs of the five individual industrial value chains that were a strong focus of the Study's methodology. These investment packages, as well as the obstacles to investment, as previously discussed, are the basis for focused policy recommendations that will foster investment in support of the modernisation of industrial value chains. The following two recommendations are relevant to most if not all industrial value chains, as they target investment needs across industrial value chains, while accounting for common obstacles that are not industrial value chain specific.

8.3.1. Recommendation 7: Foster coordinated investments through Investment Platforms established along value chains

[48] http://ec.europa.eu/DocsRoom/documents/10058

[49] http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8580

[50] http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8603

In order to modernise industrial value chains, the investment needs identified in this study relate to coordination along the value chain, shared infrastructure for SMEs, R&D, as well as technical solutions along the value chain. A commonality amongst these is that coordinated and collaborative efforts are needed to foster investments. Thus, a primary policy recommendation that arises as an opportunity to foster investments is the establishment and use of the tool of investment platforms that is proposed in the context of the Investment for Europe51 to specifically assist SMEs that have smaller and quite often higher risk investment projects.

Investment platforms can foster investments by providing a "one-stop-shop" through a legal and administrative framework that (i) encourages collaborative investment (also joint investment programmes), (ii) supports cross-value chain and inter-regional cooperation and facilitation amongst actors, and (iii) brings together various types of financial instruments.

Investment platforms offer the opportunity to foster investments across value chains, by overcoming obstacles such as (i) reaching critical mass, (ii) providing a finance hub and (iii) tackling information asymmetry, which were identified as key issues along the industrial value chains addressed in this study. Especially for SMEs which typically have smaller but also relatively more risky investment projects in comparison to large companies, the pooling of investments with those of other SMEs in an investment platform generates a package with a minimum critical mass that is more appealing for private investors and financers, potentially being backed by EIB funding.

Furthermore, investment platforms can serve as a financing hub and thus foster investment by targeting several financial instruments in order to reach the "appropriate" funding mix (own capital, regional subsidies, early stage funds, promotional banks, EIB and commercial investment banks) for investments, which would otherwise be unconceivable for single actors in the value chain to achieve.52

Through collaboration (information and network exchange) in investment platforms, the modernisation of the industrial value chain becomes a common goal and investment needs subsequently arise from what would otherwise be information asymmetries. The investment platform is at-the-ready to immediately aid in financing these needs.

Through the coordinated nature of investment platforms, the investment needs for shared infrastructure, R&D as well as technical solutions, and especially the need for better coordination along industrial value chains can be addressed. While the project team believes that investment platforms offer a promising opportunity to foster investments, further research is needed in order to specify the structure and guidelines that these should take on. It would be advisable that such initiatives are explored and piloted under the Thematic Smart Specialisation Platforms by the regional partnerships established so far in different Thematic Areas.

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[51] https://ec.europa.eu/commission/priorities/jobs-growth-and-investment/investment-plan_en

[52] Recent events point towards the possibility of this option of collaboration amongst the financial investment sector: Kick-off events of the Smart Specialisation Platform on Industrial Modernisation and launch of the Watify Campaign, Barcelona 16-17 November 2016 http://s3platform.jrc.ec.europa.eu/-/kick-off-event-of-the-smart-specialisation-platform-on-industrial-modernisation?inheritRedirect=true

8.3.2. Recommendation 8: Further financing sources for innovative and export-oriented SMEs

Especially SMEs face significant challenges in acquiring financing due to both the size of the investment and the risks associated with the innovative work they do. Thus, it is recommended to make appropriate financing sources available to tackle SME financing. The quantitative analysis of firms' investment needs has identified that when considering financing sources, high growth-potential firms and firms with large investment needs are more likely to prefer equity capital over bank loans. This evidence suggests that diversifying the sources of finance available to firms in a determined industrial value chain, in particular to innovative export-oriented SMEs, could foster their investment and growth. Specifically, measures that widen the mix of financing sources available to European innovative and export-oriented SMEs and improve their access to equity and debt markets could strengthen their capital structure and enhance their financing capacity, contributing to the modernisation of the value chain. This enhanced financing capacity will ensure that innovative export-oriented SMEs have the necessary financial platform on which to invest and grow.

Annexes

Annex 1: Quantitative analysis of industrial value chains

This annex describes the process of identifying European value chains across different industries and countries to highlight sectoral and cross-country interdependencies and linkages, as well as to identify industries with certain characteristics for a more in-depth investigation with respect to investment gaps and needs. To this purpose, recent representative industry data and Input-Output techniques are used. Based on the results of this analysis, industrial value chains with significant growth impact at the EU level are identified and compared to industrial value chains at the member state level.

Data and Methodology

This section uses two sets of Input-Output Data available for the European Union. First, to characterise European value chains at the aggregate EU(28) level EUROSTAT consolidated EU-28 Input-Output Tables are used. These provide information based on the NACE Rev. 2 2-digit classification system; in particular, this provides a rather detailed classification of 19 manufacturing industries. The latest year available is 2014. The second database used is the recently updated and revised World Input-Output Database (WIOD) which is used for the analysis on the country level.53 The updated WIOD is also based on the NACE Rev. 2 classification system, which again comprises 64 industries of which 19 are manufacturing industries. The database covers 43 countries (all 28 EU Member States and 15 major economies) over a time period 2005-2014.

The main concept in this study is that of the 'industrial value chain', which is defined – as indicated before – as all value added created across interlinked sectors and countries to deliver a product to the final user (which can be household consumption, gross fixed capital formation or government consumption). Using input-output data and techniques, various indicators allow one to identify the relevance of each value chain in the economy and its growth impact as well as inter-industry and inter-country linkages. Therefore, multi-country input-output tables (like the WIOD) in particular take into account international linkages, i.e. countries sourcing intermediate inputs from other countries that have become more important over the last decades due to increased production sharing and increasing importance of supply chains. This is even more the

[53] See Stehrer, R. and M. Timmer (2016), Provision of updated input-output and supply-use tables of the WIOD database, Final report, Project Nr. ECFIN 2015 019/B.

case as cross-border value chains with a focus on intra-EU value chains are investigated, which are captured by using these multi-country Input-Output tables.

Based on the data described above and input-output techniques as well as other data the following indicators are employed for the analysis, characterisation and selection of industries:

a) A first step to investigate the relevance of a specific industrial value chain in the European economy is to assess its importance with respect to its backward and forward linkages, meaning linkages to upstream suppliers and downstream customers. Backward linkages are calculated using the Leontief inverse (also called 'gross output multiplier'), forward linkages are calculated using the so-called Gosh-inverse. Both multipliers are presented in normalised form to allow for a neat comparison independent of the size of the industries. Backward and forward linkages then also allow one to differentiate industries into four categories ('Key sector analysis'): (i) key industries with large backward and forward linkages, (ii) industries dependent on interindustry supply having large backward linkages and small forward linkages, (iii) industries dependent on interindustry demand having small backward but large forward linkages, and (iv) independent industries with small backward and small forward linkages.
b) Second, the growth potential of an industrial value chain defined as above is derived as the value added multiplier indicating the increase in value added due to an increase in final demand. Relying on multi-country input-output tables, this again can be broken down into various subcomponents according to stages of production. In particular, the domestic versus international dimension is assessed first for the EU as a whole and for selected industrial value chains (here again differentiating between intra- and extra-EU dimensions). This indicator basically assesses the value added created along the value chain to deliver a final product. Based on the value added multiplier, the "EU28" value chains for the 19 manufacturing industries, e.g. the "EU28 electrical equipment VC", are assessed.
c) Using various additional indicators from the Eurostat Structural Business Statistics (SBS) the industries with highest growth potential are selected at the EU level. This provides the basis for further investigation in Chapter 4, where case studies for each of these selected industries are done.

Industrial Value Chains for EU-28

Considering European value chains, the figures below present the results of the key sector analysis for the aggregate EU-28 for the years 2005 and 2014. Due to strong interlinkages within the European Union and strong trade ties, inter-industry linkages are generally strong and

pronounced. Overall, the 2014 nine key industries, with large backward and large forward linkages (upper right hand quadrant), are predominantly industries that source raw materials and produce intermediate goods, which are then sold for further processing such as the paper industry, basic metals, wood, rubber, chemicals, fabricated metal products, other non-metallic mineral products or the repair industry.

In addition, there are eight industries that are ***dependent on interindustry supply***, showing large backward linkages but small forward linkages (upper left hand quadrant). These are industries that use a lot of supplies but mostly sell their products to final customers (which is household demand, investment demand or government demand). These industries include motor vehicles, food industry, machinery, electrical equipment, textiles, other transport equipment, furniture, and the computer industry.

There is only one industry ***dependent on interindustry demand***, which has small backward but large forward linkages (lower right hand quadrant), that is the coke industry. And, there is only one ***independent industry***, showing small backward and forward linkages, which is the pharmaceuticals industry.

Between 2005 and 2014, the picture of industries slightly changed, with industries moving slightly upwards (indicating increasing backward linkages) and left (less importance of forward linkages). Overall, backward linkages increased during this time period in almost all industries (except three industries), while the trends in forward linkages were mixed. In fact, they decreased in eleven industries and increased in eight industries. However, only one industry changed its classification: the computer, electronic & optical products industry that was an independent industry in 2005 (less dependent on supplies from within the European Union), but moved up to the quadrant of industries dependent on interindustry supply by the year 2014.

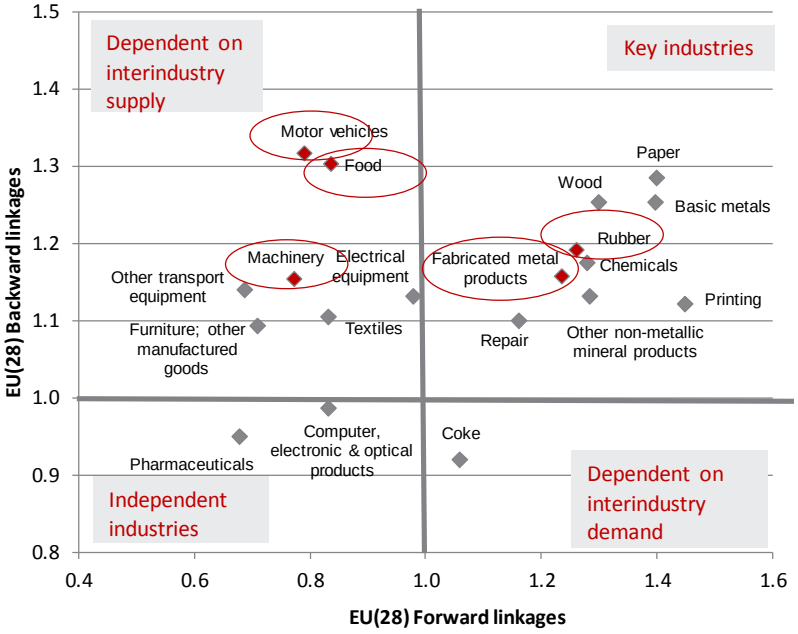


Figure 11. EU28 Key sector analysis, 2005

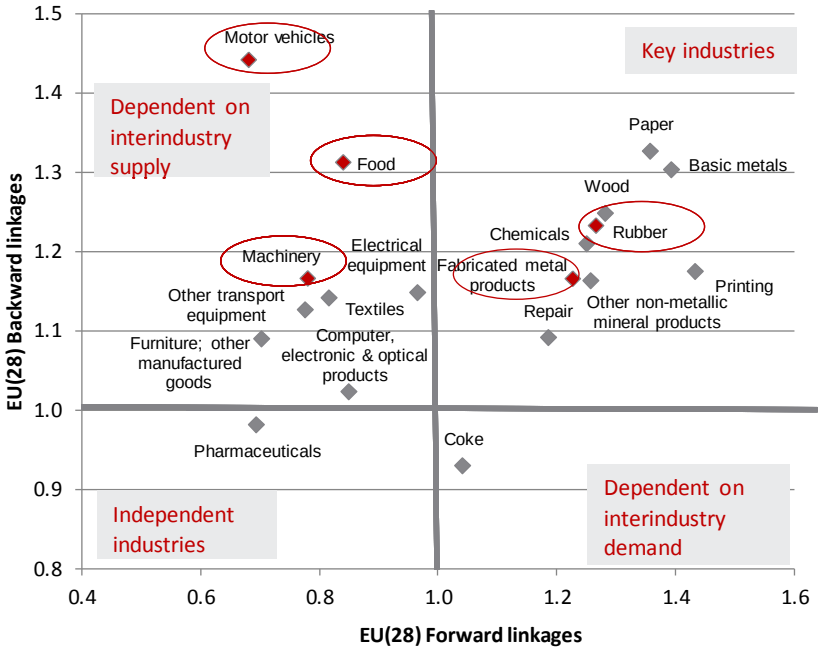


Figure 12. EU28 Key sector analysis, 2014[54]

In regard to the growth impact of different value chains, Figure 13 depicts the value added multiplier at the EU-28 level. It shows how much valued added is generated within the European Union, when demand for an industry's specific final output increases by €1 million. For example, an increase of demand for food by €1 million EUR generates value added of about €877,000 in 2014, with the rest being generated outside the EU (€123,000) due to extra-EU sourcing of intermediates. As one can see, these value added multipliers are generally large for most industries, ranking between 0.8 and 0.9. Only for coke, chemicals and basic metals the multiplier is smaller, due to raw materials imported from outside the EU.

Between 2005, 2011, and 2014 one can see quite interesting developments. While in 2011 the value added multiplier has been generally lower as compared to 2005, the multiplier grew again between 2011 and 2014, becoming even larger than in 2005 in all industries, except coke.

[54] Source: Eurostat EU28 Domestic Input-Output Table.

Though one would expect these (domestic, i.e. within European Union) multipliers to decline due to increasing internationalisation of production (also with extra-EU) it seems the crisis reverted this trend.55

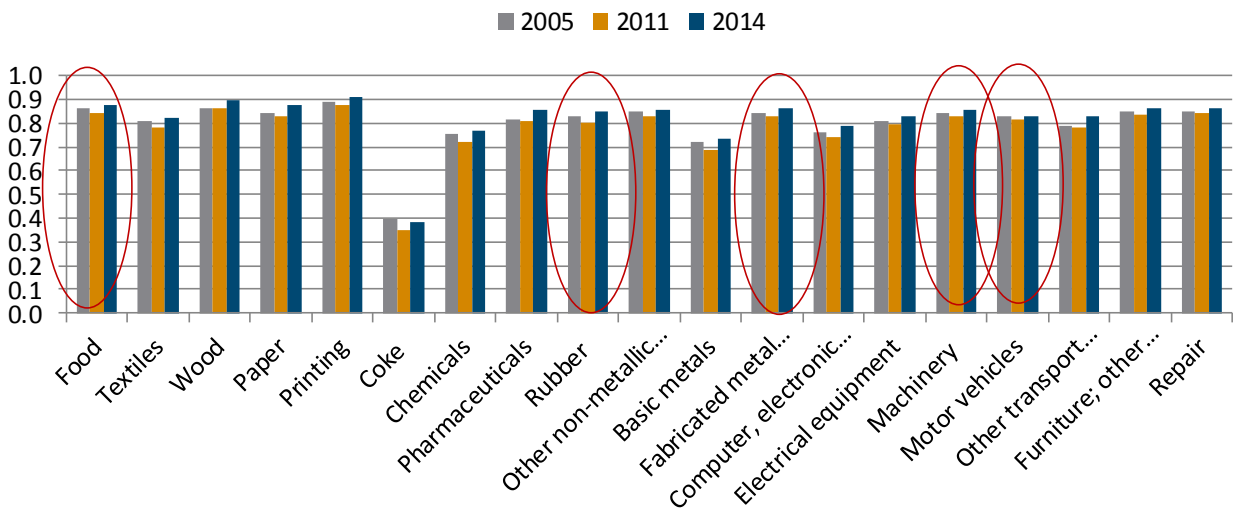


Figure 13. EU28 Value added multiplier, 2005, 2011, and 201456

The updated and revised World Input-Output Database allows separating these value added multipliers into their domestic and intra-EU components. By doing so, for each individual country it is possible to distinguish where value added is generated, either domestically or abroad. In this sense, it is possible to separate the value added multiplier into its domestic component, the value added generated within the EU itself,

[55] However, one should notice that this is based on nominal data, thus price changes might play a role.

[56] Source: Eurostat EU28 Domestic Input-Output Table.

and the value added generated outside the EU. The whole EU value chain of one industry is thus defined as the sum of domestic linkages and intra-EU linkages, which are both of high interest, as well as the extra-EU linkages.

The calculation of these components has to be done at the country level. In order to achieve an average value on the EU28 industry level, however one has to take the different country sizes into account. By doing so, the value added generated along the value chain to produce a final product has been calculated, providing information on the value added generated at each production stage which, when summed up, equals by definition the value of the final product in value terms. This allows one to determine the total value added generated domestically, and in the EU and non-EU countries. Having this information available in value terms allows one to determine the total value across all EU28 countries – thus calculating a weighted average, and calculating shares at the EU28 level for the domestic component and the intra-EU component in total value added.

Figure 14 shows the intra-EU value added component for all manufacturing industries for the EU28, which ranges from 23% at the top to 13% at the bottom. The motor vehicles industry is the most integrated industry within Europe, followed by basic metals, paper and chemicals industries. On the other end, pharmaceuticals, other non-metallic minerals products and the coke industry are the least integrated sectors.

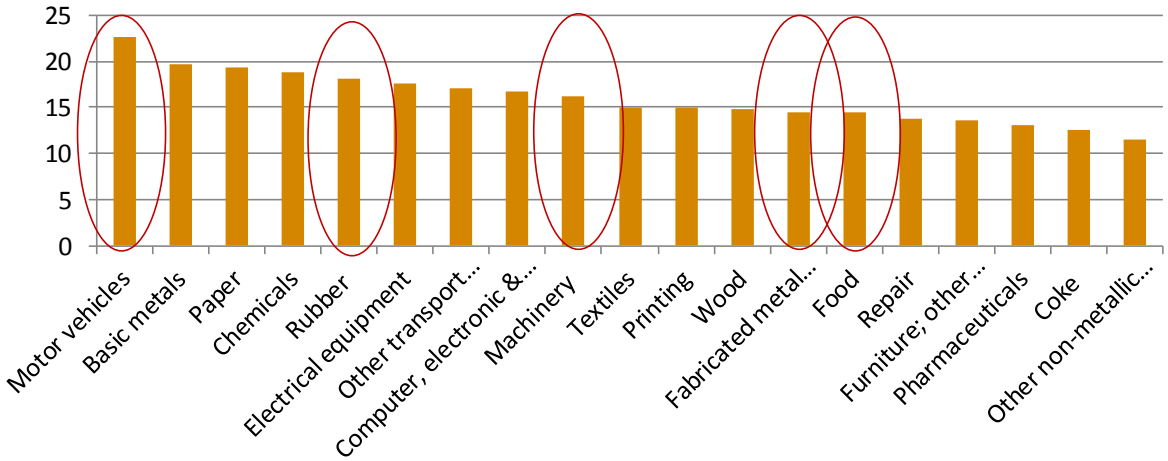


Figure 14. Intra-EU value added component, in %, 2014[57]

[57] Source: WIOD release 2016 (preliminary).

Figure 15 depicts the domestic value added component for all manufacturing industries for the EU28, which is much higher than the EU-intra component and ranges from 74% at the top to 27% at the bottom. The repair, furniture & other manufacturing, wood and printing industries represent the largest shares; while computer, electronic & optical products, basic metals and coke industries represent the smallest shares.

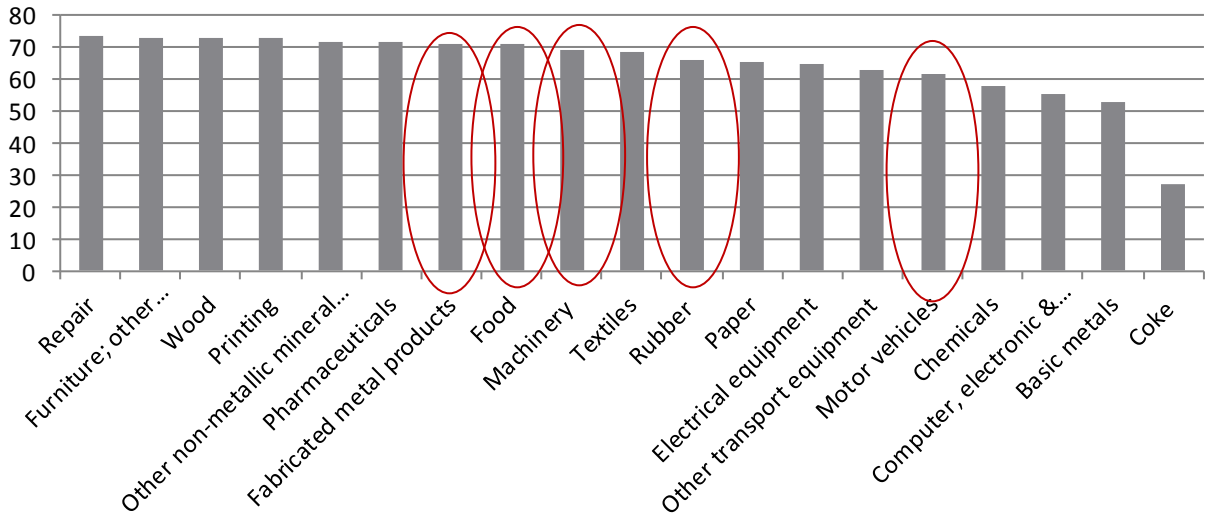


Figure 15. Domestic value added component, in %, 2014[58]

A next step comprises the identification of industries characterised by a high growth potential, investment intensity, degree of interlinkages and SME characteristics needed for further investigation in Chapter 4. Thus, in order to identify the European value chains with the highest growth

[58] Source: WIOD release 2016 (preliminary).

potential a number of indicators have been compiled, reflecting the size of industries, the growth aspects, as well as additional aspects such as the intensity of small and medium-sized enterprises within a value chain. High growth potential is thus either provided by size, dynamics or both. As such, the results of the input-output analysis were combined with additional indicators from Eurostat Structural Business Statistics (SBS). This resulted in the following 15 indicators:

- Input-output indicators: Backward linkages (2014), forward linkages (2014), value added multiplier (2014), the change of the value added multiplier (2011-2014) and the intra-EU value added component (2014);
- SBS indicators: Production share (2014), value added share (2013), shares of employees (2013), gross value added per employee (2013), gross investment in tangible goods (2013), investment rate (2013, investment/GVA);
- Change of indicators (2011-2013): change of production shares, change of value added shares, change of employees;
- Intensity of small and medium-sized enterprises: share of SMEs in turnover (2013).

The European value chains are thus captured by input-output indicators, and the growth potential is reflected either by size (value added multiplier and SBS indicators), or by the change of indicators. Additional characteristics are captured as well (productivity, investment and intensity of SMEs).

The indicators reported in Tables 2-4 below have been ranked according to size (e.g. a ranking of 19 indicates the highest performing industry and a ranking of 1 indicates the lowest performing industry). Then a simple average of these 15 criteria has been calculated (implicitly giving each indicator the same weight), which provided an overall ranking of the manufacturing industries according to these criteria. The Tables report the indicators used and the rank of the industries for each of the indicators. Based on the ranking of the industries, the following industrial value chains have been selected:

- Machinery and equipment n.e.c.;
- Rubber and plastic products;
- Food, beverages and tobacco products;
- Motor vehicles, trailers and semi-trailers;
- Fabricated metal products.

Overall, three out of the five industries are classified as industries dependent on interindustry supply (food, motor vehicles, and machinery); while two are key industries (fabricated metal products and rubber). Generally, their value added multiplier is high, above 0.8. Overall, there are two

industries, which show a high domestic value added component (food and fabricated metal products) and two industries which show a high intra-EU component (motor vehicles and the rubber industry). Machinery is placed in the medium range for both components.

Indicators for the Selection of Five Industrial Value Chains

Table 12. EU28 Input-Output indicators and ranking

Overview 1: EU28 Input-Output Indicators and ranking

		Backward linkages		Forward linkages		Industry classification1)	Value added multiplier		Value added multiplier PP. change 2011-2014		VA EU-intra component 2) in %	
		2014	Rank	2014	Rank	2014	2014	Rank		Rank	2014	Rank
C10-12	Food	1.31	17	0.84	7	Supply	0.88	17	0.033	8	14.4	6
C29	Motor vehicles	1.44	19	0.68	1	Supply	0.83	6	0.012	1	22.6	19
C22	Rubber	1.21	13	1.25	13	Key	0.85	9	0.048	19	18.1	15
C25	Fabricated metal products	1.17	10	1.23	12	Key	0.86	13	0.033	9	14.6	7
C28	Machinery	1.17	11	0.78	5	Supply	0.86	12	0.030	6	16.2	11
C13-15	Textiles	1.14	7	0.82	6	Supply	0.82	5	0.037	11	15.1	10
C16	Wood	1.25	15	1.28	16	Key	0.89	18	0.028	4	14.9	8
C17	Paper	1.33	18	1.36	17	Key	0.87	16	0.043	13	19.3	17
C18	Printing	1.18	12	1.43	19	Key	0.91	19	0.029	5	14.9	9
C19	Coke	0.93	1	1.04	10	Demand	0.39	1	0.034	10	12.6	2
C20	Chemicals	1.23	14	1.27	15	Key	0.77	3	0.045	15	18.8	16
C21	Pharmaceuticals	0.98	2	0.69	2	Indpendent	0.86	10	0.047	18	13.1	3
C23	Other non-metallic mineral products	1.16	9	1.26	14	Key	0.86	11	0.025	3	11.4	1
C24	Basic metals	1.30	16	1.39	18	Key	0.74	2	0.047	17	19.7	18
C26	Computer, electronic & optical products	1.02	3	0.85	8	Supply	0.79	4	0.046	16	16.7	12
C27	Electrical equipment	1.15	8	0.96	9	Supply	0.83	8	0.037	12	17.6	14
C30	Other transport equipment	1.13	6	0.78	4	Supply	0.83	7	0.044	14	17.1	13
C31-32	Furniture; other manufactured goods	1.09	4	0.70	3	Supply	0.86	14	0.031	7	13.5	4
C33	Repair	1.09	5	1.19	11	Key	0.86	15	0.024	2	13.8	5

Notes: 1) Industry classification: Key (= Key industry, backward and forward linkages above 1); Supply (=Industry dependent on interindustry supply, backward linkages above 1)

Demand (=Industry dependent on interindustry demand, forward linkages above 1); Independent (=Independent industry, backward and forward linkages below 1).

2) Based on WIOD Data.

Source: Eurostat EU28 Domestic Input-Output Table, WIOD-release 2016 (preliminary).

Table 13. EU28 SBS indicators 2013 and ranking

Overview 2: EU28 SBS Indicators 2013 and ranking

		Production		Value added		Employees		GVA per employee		Gross investment 2)		Investment rate	
		Shares	Rank	Shares	Rank	Shares	Rank	in ths.	Rank	mn EUR	Rank	(investment/GVA)	Rank
		2014 1)		2013		2013		2013		2014 1)		2013	
C10-12	Food	16.2	19	13.4	19	15.3	19	51	6	38,377	19	16.1	13
C29	Motor vehicles	11.7	18	9.7	16	8.2	16	69	15	35,941	18	20.7	18
C22	Rubber	4.3	12	5.0	13	5.7	13	52	8	13,180	14	14.6	11
C25	Fabricated metal products	7.1	14	9.8	17	11.7	18	49	5	20,211	16	10.8	9
C28	Machinery	9.4	17	11.7	18	10.2	17	67	13	17,491	15	8.5	2
C13-15	Textiles	3.0	7	3.3	5	6.6	15	29	1	5,616	4	8.5	3
C16	Wood	1.8	2	1.8	2	2.9	6	36	2	5,357	3	16.0	12
C17	Paper	2.6	4	2.5	4	2.2	3	66	12	7,360	7	17.5	15
C18	Printing	1.3	1	1.8	3	2.3	4	46	4	3,832	1	10.7	8
C19	Coke	7.5	16	0.8	1	0.4	1	114	18	6,836	6	43.1	19
C20	Chemicals	7.5	15	6.8	15	3.9	10	100	17	20,257	17	18.2	16
C21	Pharmaceuticals	3.5	9	4.9	12	2.0	2	143	19	8582.2	10	10.0	6
C23	Other non-metallic mineral products	3.0	5	3.6	8	4.1	11	51	7	9,620	12	16.5	14
C24	Basic metals	5.2	13	3.5	7	3.2	7	63	11	11,222	13	19.3	17
C26	Computer, electronic & optical products	3.9	10	4.6	11	3.9	8	69	14	9,525	11	11.3	10
C27	Electrical equipment	4.1	11	5.2	14	5.0	12	60	10	8,055	8	9.4	4
C30	Other transport equipment	3.0	6	3.3	6	2.5	5	76	16	6,400	5	10.7	7
C31-32	Furniture; other manufactured goods	3.0	8	4.3	10	5.7	14	43	3	8,286	9	9.8	5
C33	Repair	2.3	3	3.7	9	3.9	9	55	9	3,844	2	5.8	1
C	**Manufacturing**	**100.0**		**100.0**		**100.0**		**58**		**239,990**		**13.5**	

Notes: 1) Provisional Data.- 2) Gross investment in tangible goods.

Source: Eurostat SBS.

Table 14. EU28 change of indicators (2011-2013), SME intensity and total ranking

Overview 3: EU28 Change of indicators (2011-2013), SME intensity and total ranking

		Production		Value added		Employees		SME-intensity turnover		Final ranking	
		Shares	Rank	Shares	Rank	um. changes	Rank	Share	Rank	Value	Rank
		2014-2011		2013-2011		2013-2011		2013			
C10-12	Food	0.8	19	0.5	19	99.2	13	47.8	11	14.1	19
C29	Motor vehicles	0.4	17	0.4	17	102.8	18	8.2	2	13.4	18
C22	Rubber	0.2	15	0.1	12	98.5	12	55.8	13	12.8	17
C25	Fabricated metal products	0.1	11	0.2	15	98.0	11	73.6	18	12.3	16
C28	Machinery	0.3	16	0.1	14	100.7	15	41.4	9	12.1	15
C13-15	Textiles	0.0	8	-0.1	8	95.0	6	72.3	16	7.5	2
C16	Wood	0.0	10	-0.1	6	93.6	5	72.9	17	8.4	6
C17	Paper	0.0	7	0.0	11	97.4	10	43.5	10	10.9	13
C18	Printing	-0.2	6	-0.2	5	89.7	1	81.1	19	7.7	3
C19	Coke	-0.8	2	-0.4	1	95.1	7	3.3	1	6.4	1
C20	Chemicals	-0.4	3	0.1	13	91.7	3	35.6	8	12.0	14
C21	Pharmaceuticals	0.2	14	-0.3	4	102.7	17	15.0	3	8.7	7
C23	Other non-metallic mineral products	-0.2	5	-0.4	3	91.7	4	53.9	12	7.9	4
C24	Basic metals	-0.9	1	-0.4	2	90.4	2	28.6	5	9.9	12
C26	Computer, electronic & optical products	0.1	13	-0.1	7	99.4	14	30.7	6	9.8	11
C27	Electrical equipment	-0.2	4	0.0	9	97.2	9	31.6	7	9.3	9
C30	Other transport equipment	0.4	18	0.4	18	101.0	16	15.0	4	9.7	10
C31-32	Furniture; other manufactured goods	0.0	9	0.0	10	96.3	8	62.7	14	8.1	5
C33	Repair	0.1	12	0.4	16	102.8	19	63.8	15	8.9	8
C	**Manufacturing**					**97.7**		**37.7**			

Source: Eurostat SBS.

Industrial Value Chains at Country Level

The previous analysis focused on the aggregate EU28 level has shown differences among manufacturing industries and the five selected value chains for further investigation. However, while there are differences between industries, there are also differences between countries. As such, the selected industrial value chains are analysed at the country level, in particular on their degree of intra-country linkages within the EU. The value added multiplier for the respective industry is given for the respective country, split up in a domestic part and intra-EU part, reflecting the size of EU value chains.59

Overall, the general pattern is that small countries tend to have smaller domestic and larger intra-EU value added multipliers than large countries. Integration within the EU, i.e. the intra-EU part, is most pronounced in the motor vehicle industry as seen before. In Hungary, for example, the part of intra-EU value added creation is even larger than that of domestic value added creation, which indicates the strong European production linkages of this industry. Looking at the country level across industries, the Irish sectors show the smallest EU value added multipliers (domestic plus intra-EU part). The country data for two industries, the food industry – example of an industry with pronounced domestic linkages – and the motor vehicle industry – example of an industry with strong intra-EU linkages – are shown in Figure 16 and Figure 17.

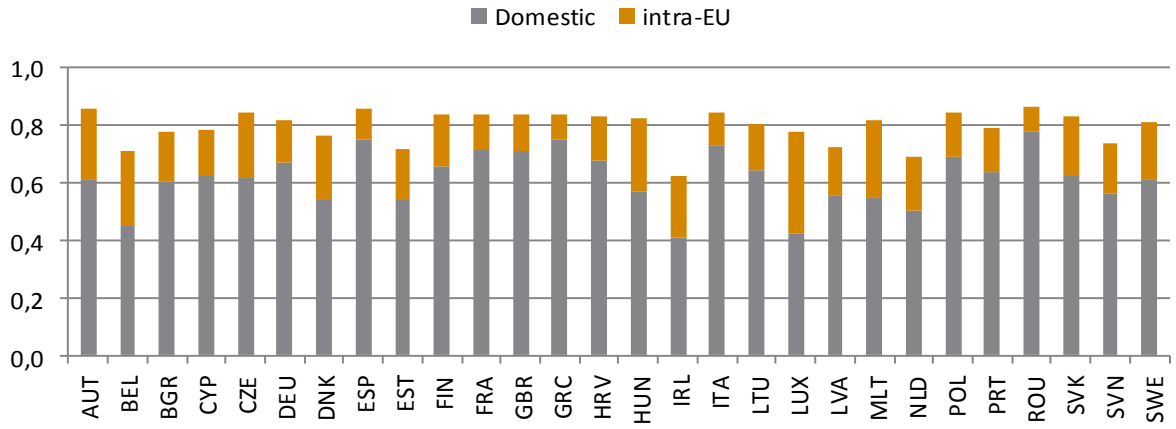


Figure 16. Food, beverages and tobacco products – Industrial value chains: value added multiplier, 2014

[59] The remaining part represents the size of extra-EU linkages.

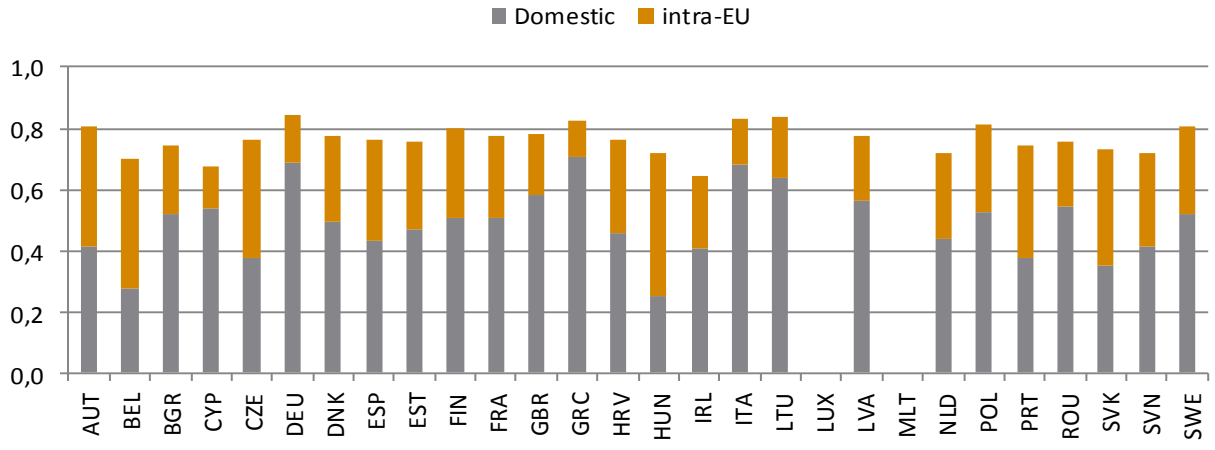


Figure 17. Motor vehicles, trailers and semi-trailers – Industrial value chains: value added multiplier, 2014[60][61]

[60] Note: Data for Luxembourg and Malta not available in certain industries.

[61] Source: WIOD-release 2016 (preliminary).

Annex 2: Case Studies

Task 1.2 identified European value chains across different industries to highlight sectoral and cross-country interdependencies and linkages as well as to identify industries with certain characteristics for a more in-depth investigation with respect to investment gaps and needs in Task 2. To this purpose, Input-Output techniques and recent representative industry data were used. Thus, in order to identify European value chains with the highest growth potential overall 15 indicators have been compiled, ranked according to size and then a simple average of these 15 criteria has been calculated. The respective indicators included Input-output indicators (backward and forward linkages, value added multiplier, change of value added multiplier, and the intra-EU value added component), size indicators and change of size indicators based on Eurostat Structural Business Statistics (production share, value added share, share of employees). Additional characteristics were captured as well (productivity, investment and intensity of SMEs).

As a result of this detailed analysis, five industrial value chains have been selected as a basis for a more in-depth investigation with respect to investment gaps and needs. They are (i) machinery & equipment; (ii) rubber and plastic products; (iii) food, beverages and tobacco products; (iv) motor vehicles, trailers and semi-trailers; and (v) fabricated metal products.

This annex presents the findings of the qualitative analysis and includes the complete version of the case studies developed.

Figure 18 complements the description of the five selected industrial value chains across the EU-28 countries in terms of the size of their SMEs sector. The share of SMEs in the total number of enterprises is the highest in Food, beverages, and tobacco products (99.8%), followed by Fabricated metal products (99.5%), Rubber and plastic products (98.6%), Machinery and equipment (97.9%), and Motor vehicles (94.0%).

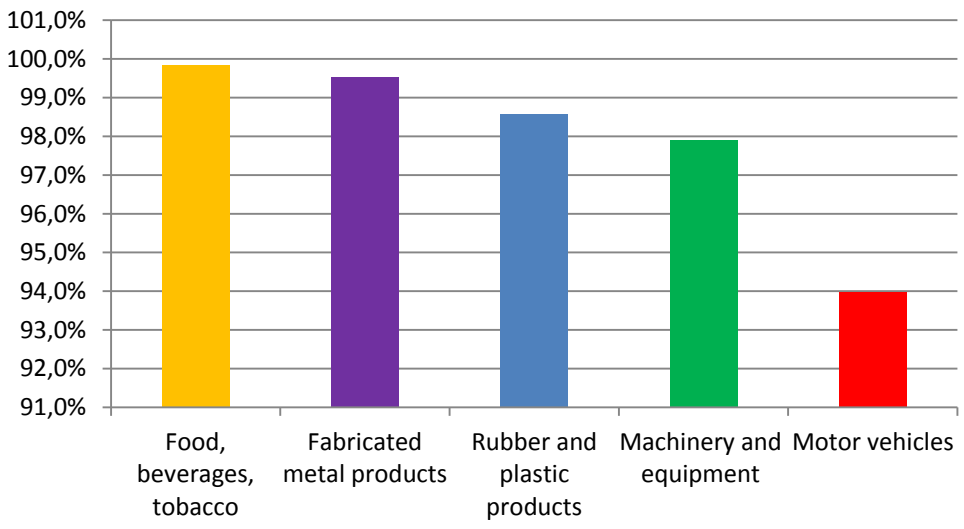


Figure 18. Selected industrial values chains: Share of SMEs in the total number of enterprises, EU-28, 2013[62]

[62] Authors' elaboration based on data from the Structural Business Statistics, Eurostat

Figures 21-25 show the share of innovative enterprises in the five selected industrial value chains by country in the EU-28.63 Among the five analysed industrial value chains, the highest shares of innovative enterprises are in Motor vehicles and Machinery and equipment.

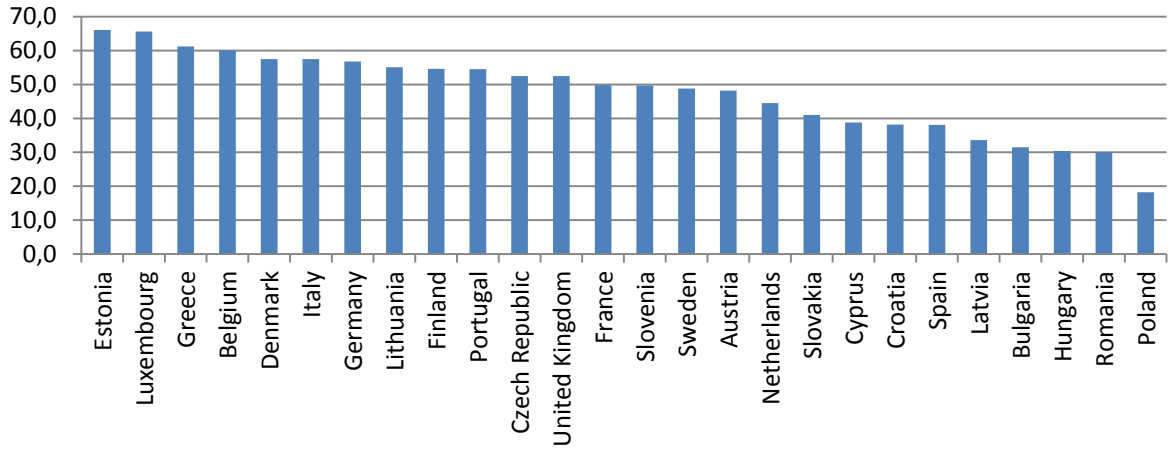


Figure 19. Food, beverages, tobacco: The share of innovative enterprises, 2012[64]

Estonia, Luxembourg, Greece, and Belgium have the highest shares of innovative enterprises in Food, beverages, and tobacco products (above 60.0% of all enterprises). At the other end of the range is Poland with less than 20% of innovative enterprises.

In Rubber and plastic products, the leading countries with over 70.0% of enterprises being innovative are Germany, Finland, Ireland, Belgium, Portugal and Italy. Poland has the lowest share of innovative enterprises (30.5%).

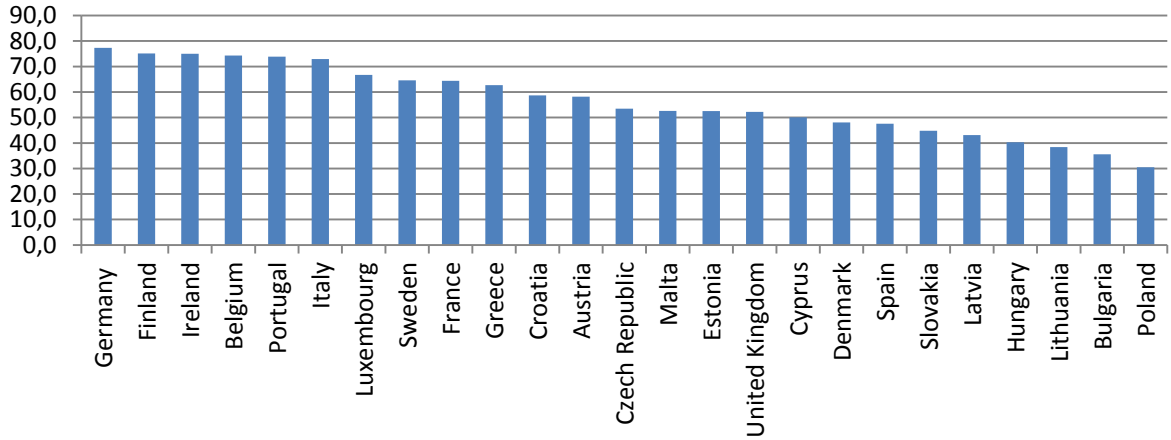


Figure 20. Rubber and plastic products: The share of innovative enterprises, 2012 [65]

[63] This analysis is based on the data for 2012, the most recent available.

[64] Authors' elaboration based on data from the Structural Business Statistics, Eurostat

The shares of innovative enterprises in Fabricated metal products are the highest in Luxembourg and Germany (over 65.0%) and the lowest in Hungary (22.2%).

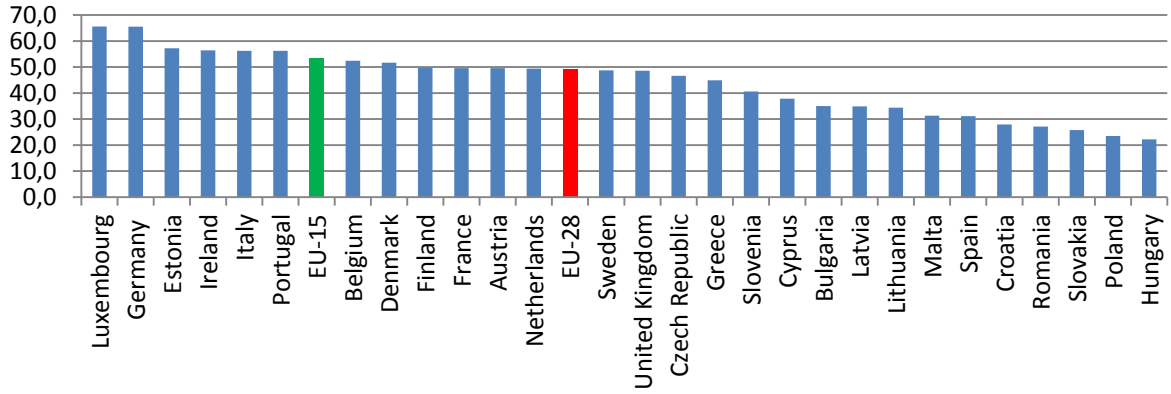


Figure 21. Fabricated metal products: The share of innovative enterprises, 2012[66]

In Machinery and equipment, the shares of innovative enterprises are the highest in Germany, Luxemburg and Austria (80.0% and more) and the lowest in Romania (32.2%).

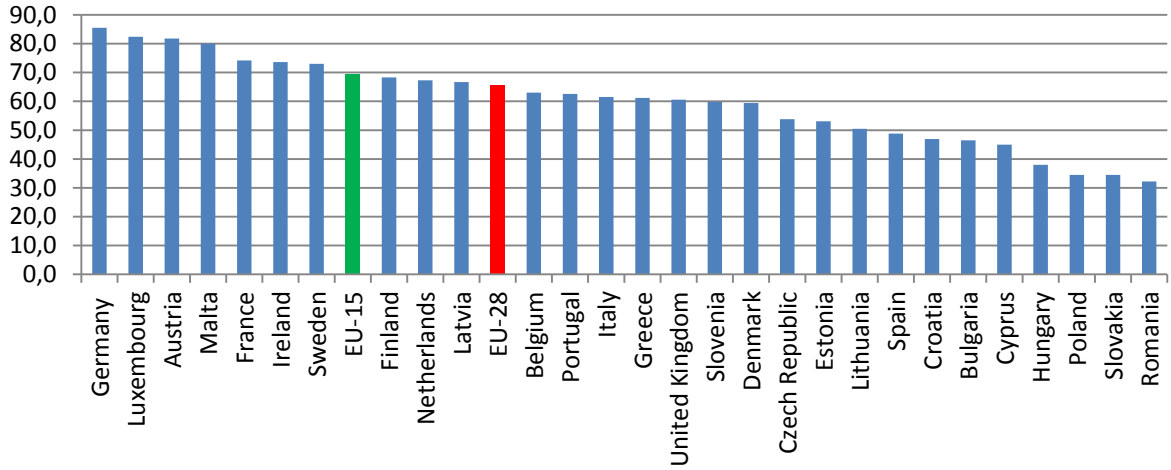


Figure 22. Machinery and equipment: The share of innovative enterprises, 2012[67]

[65] Authors' elaboration based on data from the Structural Business Statistics, Eurostat

[66] Authors' elaboration based on data from the Structural Business Statistics, Eurostat

[67] Authors' elaboration based on data from the Structural Business Statistics, Eurostat

Finally, in Motor vehicles, Germany is leading with over 85.0% of enterprises being innovative, with Latvia at the lowest end of the spectrum, with only 29.4% of innovative enterprises

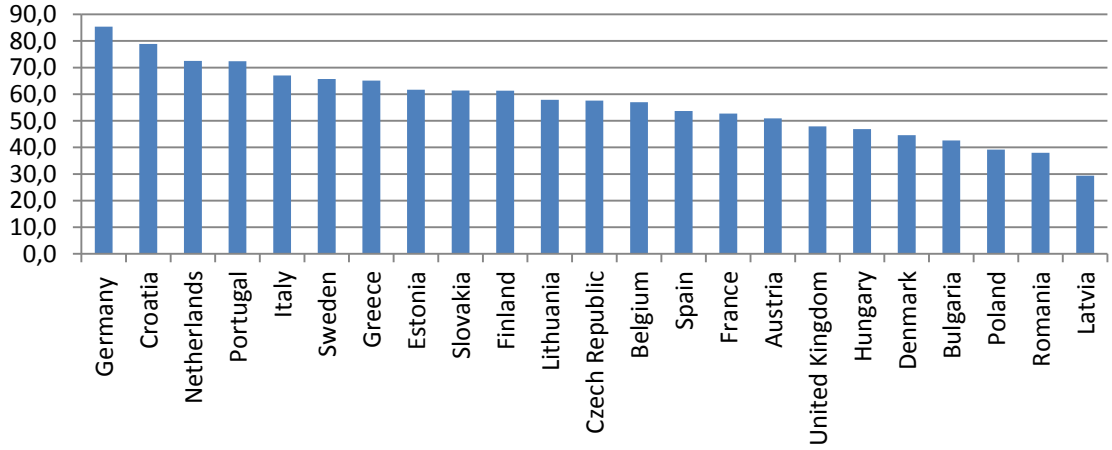


Figure 23. Motor vehicles, trailers and semi-trailers: The share of innovative enterprises, 2012[68]

Overall, this selection of industrial value chains encompasses an interesting mix of industries, with different characteristics reflecting various degrees of inter-linkages, growth potential and SME intensity. Also with regard to value added components, the selection provides an interesting mix of industries with pronounced domestic linkages (food and fabricated metal products), with strong intra-EU linkages (motor vehicles and the rubber industry), or with both (machinery).

Thus, these five industrial value chains have been selected as a basis for a more in-depth investigation with respect to investment gaps and needs in Task 2. Detailed data on the 3-digit NACE level, provided a first indication of "high growth potential sub-sectors", on which we focused, based on results of Task 1.3 for the selection of case studies. However, detailed literature review and interviews were used to select case studies for in depth investigation of investment gaps and needs. As such, the results of the five case studies are presented in the following.

The upcoming subsections present the case studies which have been developed for each of the five industrial value chains selected in Task 1.2. The case studies follow the same structure: i) Understanding of the industrial value chain; ii) Investment needs; iii) Investment obstacles; iv) Investment solutions.

In each of the five case studies, specific attention was given to the geographical dimensions of the industrial value chains under analysis. This is important due to several reasons. First, investment needs, obstacles and solutions may differ in different regions of the EU. Second, and following from these differences, an understanding of the geographical context of the case study may aid in defining the appropriate investment packages or policies. From the perspective of the EU's Cohesion Policy and Regional Policy69, it is important to explore

[68] Authors' elaboration based on data from the Structural Business Statistics, Eurostat

[69] 'Cohesion policy' is the policy behind the projects all over Europe that receive funding from the European Regional Development Fund (ERDF), the European Social Fund (ESF) and the Cohesion Fund. Regional Policy provides the necessary investment framework to meet the goals of the Europe 2020 Strategy for smart, sustainable and inclusive growth in the European Union.

where the investment needs are mainly located and to determine how the different industrial value chains could benefit from the available funds. Therefore, for each of the five case studies, there is a section describing the geographical dimension of the investment needs. This contains an analysis of the geographical coverage of the industrial value chain and an analysis of the geographical nature of the value chain (domestic, regional, European).

The desk research and expert interviews conducted in the case studies provide recommendations and possible solutions to remove the investment obstacles identified. While solutions addressing specific segments of the value chains are more easily designed, investments of a coordinated nature along the different actors of the value chain are considered more difficult to achieve. In order to provide more solid recommendations, the investment solutions are complemented with a successful example of coordinated investments, which have been undertaken in value chains reflecting investment needs of similar nature to those of the case study.

Each case study was developed based on extensive desk research and on reflections by experts in the field, who were interviewed in the scope of this Study. At least 4 interviews were conducted per case study: 2 associations with a European level activity, and 2 industry players.

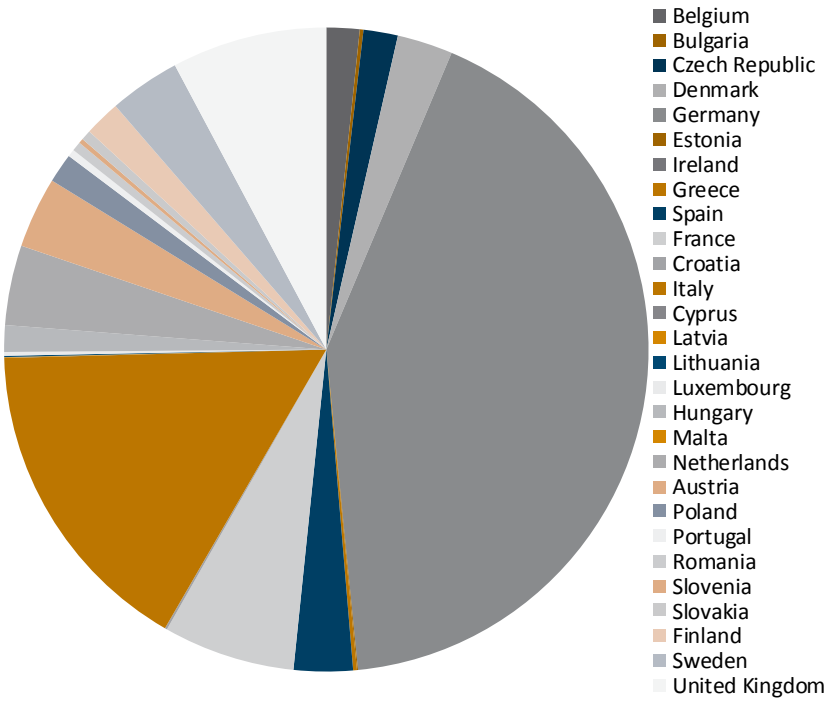
Case Study 1: Machinery - Additive Manufacturing

In Task 1.2, five key industries were selected as industrial value chains. The first explored industrial value chain is that of machinery.

Machinery and equipment n.e.c (NACE rev. 2, C28), short machinery, is a sector dependent on interindustry supply. Its backward linkages range are large (e.g. sourcing among others from basic metals and fabricated metal products), its forward linkages are one of the smallest as it sells directly to final demand. The value added multiplier is large and situated in the middle-field of manufacturing industries. Interestingly, both the intra-EU value added component as well as the domestic component range in the middle field across the manufacturing industries. The machinery sector is one of the largest sectors in the European Union in terms of production, value added and employment and its changes. SME intensity is in the middle-field (41% of turnover generated by SMEs).

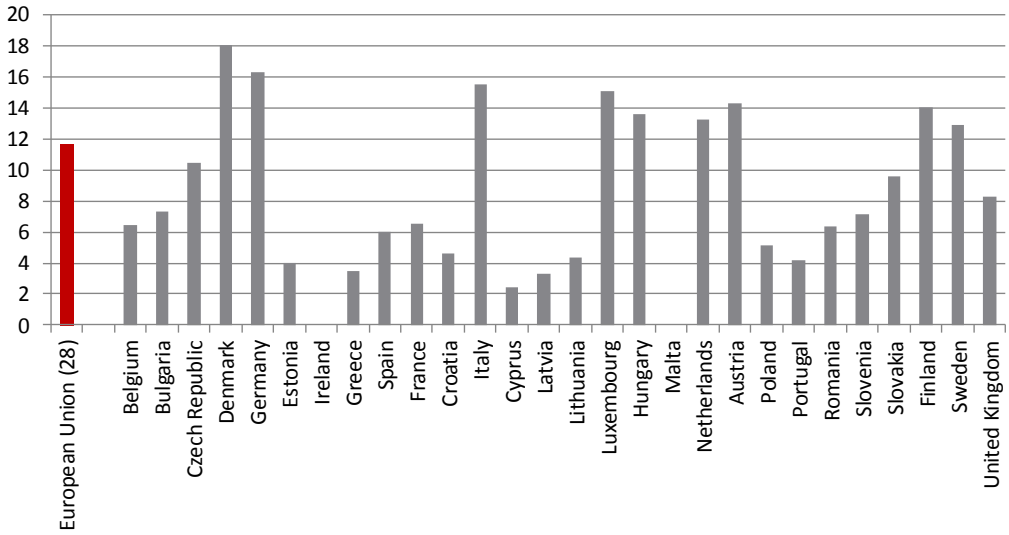
Within the European Union, about 42% of value added is generated in Germany, followed by Italy (16%), the United Kingdom (8%), and France (7%). The countries most specialised on the sector (i.e. measured by the share of machinery in total manufacturing value added) are Denmark, Germany, Italy, Luxembourg, Hungary, the Netherlands, Austria, Finland, and Sweden. The EU value added multiplier ranges around 0.8 and is smaller only for a small range of countries (see the figure below).

A. Machinery and equipment n.e.c., value added, 2013, in % of EU-28[70]



B. Machinery and equipment n.e.c., value added, 2013, in % of manufacturing

[70] Colors/countries change clock-wise starting at 12.00.



C. Machinery and equipment n.e.c., Industrial value chains: value added multiplier, 2014

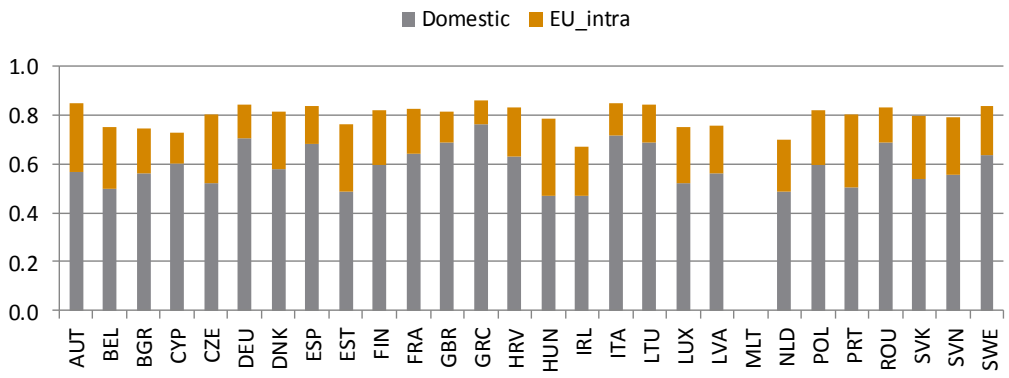


Figure 24. Country overview Machinery and equipment n.e.c., value added, 2013, in % of EU-28[71]

In order to address the investment needs in this industry, it is further specified, using the inputs on Task 1.3 that these should be high growth segments of the industrial value chain. A literature review revealed that a specific field within the machinery sector characterised by high growth rates is **advanced manufacturing technology (AMT)**. AMT can be described as different technologies to boost the competitiveness of the manufacturing sector, with interest mainly focused on new technologies which rely more and more on information, automation, software and networking. The development and adoption of AMT by companies is seen as a prerequisite for the modernisation of the European industry. To maintain its economic importance, Europe needs to invest more in advanced technologies to modernise its industry. Advanced manufacturing is thus increasingly seen as a key driver for the modernisation of the European industry in the coming years.

For the cause of this study it is worth mentioning that AMT is not confined within one or the other activity class of the NACE classification. It runs across various sectors and is as such for analytical reasons not readily observable. Nonetheless, the majority of activities are classified

[71] A and B: Eurostat SBS; C: WIOD-release 2016 (preliminary)

under sector 28.4 Manufacture of metal forming machinery and machine tools. This is a subsector of machinery, which has been identified in Task 1.4 as one of the five sectors whose value chain has a relatively high value added multiplier within the EU economy.

As indicated before, given the broad nature of the machinery industry and of the AMT sector, for the purpose of identifying the investment needs, obstacles and remedies, a further focus is necessary to identify a specific segment where investment needs of a coordination nature occur. Therefore, through additional indicators of EUROSTAT's Structural Business Statistics, a literature review as well as interviews were proposed to focus the analysis on additive manufacturing (AM), also known as 3D printing, and within the value chain of AM specifically the supply of high-end metal powders for metal AM. This is not to claim that this is the only sub-sector or segment in the manufacturing sector where investment needs of a coordination nature exist, as there might be others as well. Thus, it is an exemplary case, where the operational, technological and resource-related aspects are brought to the surface. As such, this enriches the analysis with valuable qualitative information. The next section elaborates in more detail why high-end metal powders are regarded as a critical segment in the industrial value chain of metal AM and what the investment needs and obstacles are. The case concludes with potential solutions that could remove the perceived investment obstacles of a coordination nature for upgrading efficiency and innovation capacity.

2.1.1 Understanding of the industrial value chain

AM is regarded as a high growth sector, as illustrated by market forecasts by Wohler and RBC, showing the potential of AM, with estimated CAGR's of 19% and 24% respectively (see Figure 25).72

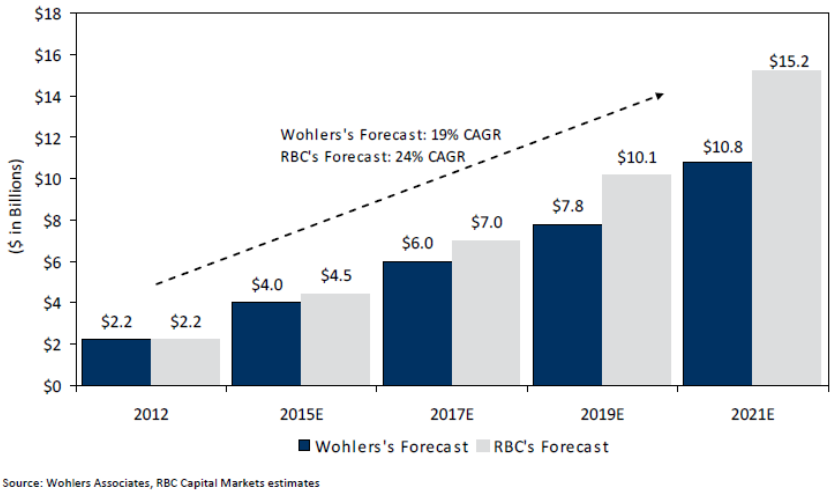


Figure 25. Forecast for long-term additive manufacturing market size and growth rates (2013-2021)

Specifically, metal printing is the fastest-growing segment of AM, with printer sales growing at 48% and material sales growing at 32%.73 In general, the USA is leading the AM market, with

[72] RBC (2014) - 3D Printing From Prototyping Evolution to Manufacturing Revolution

key players such as Stratasys and 3D Systems. In the field of metal AM, however, Europe has a leading position. According to the study made by Roland Berger, the market share of German companies alone regarding metal AM systems (e.g. EOS, Concept Laser, Trumpf, etc.) already accounts for more than 80%.74 A geographical representation of the main metal AM system manufacturers with details on revenue, technology, amount of sold systems and employees is displayed in Figure 26.

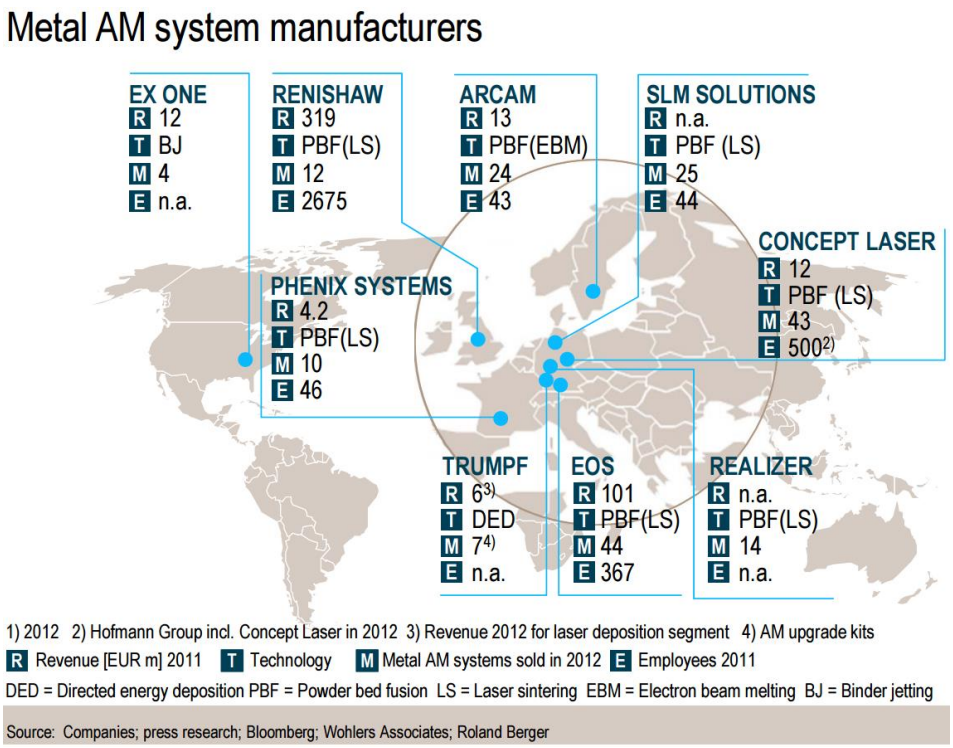


Figure 26. Main metal AM system manufacturers[75]

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[73] IDTechEx (2015). 3D Printing of Metals 2015-2025
See: http://www.idtechex.com/research/reports/3d-printing-of-metals-2015-2025-000441.asp

[74] Roland Berger (2015) - Additive manufacturing (additive manufacturing) – Opportunities in a digitalized production

http://www.rolandberger.com/media/pdf/Roland_Berger_Additive_Manufacturing_Opportunities_in_a_digitalized_production_20150714.pdf

[75] Roland Berger (2015) - additive manufacturing (additive manufacturing) – Opportunities in a digitalized production

http://www.rolandberger.com/media/pdf/Roland_Berger_Additive_Manufacturing_Opportunities_in_a_digitalized_production_20150714.pdf

A key strength of the European metal AM industry is its strong coverage among the various parts of the value chain. For example, Europe has a strong position in the field of high quality lasers and fibre lasers, the type of lasers that are being applied in AM machines, and the leading system software supplier Materialise is located in Belgium.

However, multiple sources state that the strong European position will be challenged by American and Asian players.76,77 In countries such as the USA, China, and Singapore, AM is regarded as the key enabling technology for innovation in products and the supply chain, and is receiving substantial government funding to increase the maturity level.

In order to maintain Europe's leading position in the metal AM value chain, it is seen as paramount to keep this excellent value chain coverage in place. This is especially important given the high growth prospects of this segment of the value chain, as well as the significant enabling potential of the technology.

Another research conducted by IDEA Consult, in cooperation with AIT, VTT and CECIMO commissioned by the European Commission, DG GROW and EASME78, has revealed that a particular critical segment of the metal AM value chain is the supply of high-end metals such as aluminium, titanium, and magnesium.

Improving the ability to manufacture parts using high-end metal powders will be game changing. Possible application markets for such high-end metal parts include the aerospace, automotive and medical industry – specifically those application areas that have high demand regarding the durability and strength properties of the materials used. 2015 saw the approval of the first 3D printed jet engine part by the FAA, which has the advantage of being five times more durable, 25% lighter and combines what were previously 18 parts into one, which is only the beginning79.

In metal AM, metal powders are transformed into three-dimensional products using a 3D printer. The figure below illustrates the value chain of metal AM, including the metal powder. The dotted line in the figure separates the supply side and the demand side within the value chain.

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[76] Roland Berger (2015) - additive manufacturing (additive manufacturing) – Opportunities in a digitalized production

http://www.rolandberger.com/media/pdf/Roland_Berger_Additive_Manufacturing_Opportunities_in_a_digitalized_production_20150714.pdf

[77] Fornea, D., van Laere, H. (2015) - Opinion of the European Economic and Social Committee on 'Living tomorrow. 3D printing — a tool to empower the European economy' - 2015/C 332/05

[78] IDEA Consult, AIT, VTT, CECIMO (2016) - Identifying current and future application areas, existing industrial value chains and missing competences in the EU, in the area of additive manufacturing (3D printing)

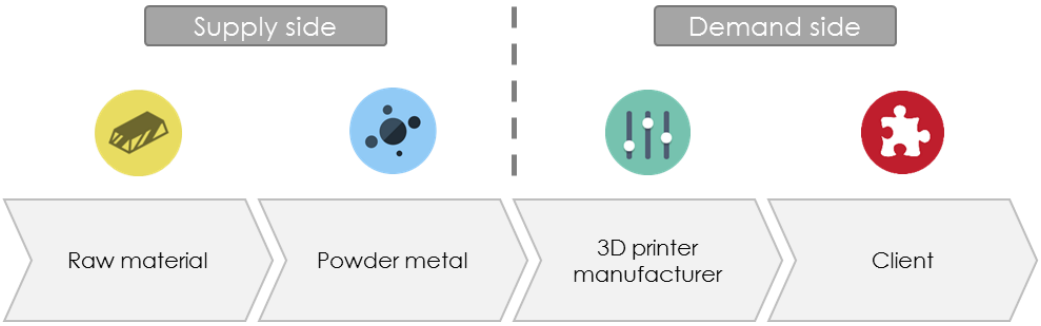

Figure 27. Value chain of AM with metal powders

At the start of the value chain, one finds the raw materials, i.e. the metals that will be transformed into powders, which are directly supplied to the powder producers. Within the production of metals powders, one can identify three major steps as identified by a powder producer in an interview: (i) the metals are melted, (ii) metals in their melted state are atomised to a powder, (iii) the powder with varied grain sizes is sieved and tailored to the needs of the client or the 3D printer manufacturer and delivered. It is specifically the stage of sieving the metal powders that requires the largest effort – 3D printing machines require very specific grain sizes and do not allow for a large variation in that size. In the transition to the demand side, the powders are delivered to the 3D printing machine manufacturer or to the client directly. Each 3D printing machine requires a powder tailored to it in terms of size and thus some printer manufacturers also offer powders as a service to their clients. However, it is also possible to forego the link via the 3D printer manufacturer, and for the powder producer to work directly with the client to specify which powder type they need for their machine and their product.

Clients using 3D printing technologies with high-end metals are interested in the production of tough, durable and strong materials, for which high-end metals such as aluminium, titanium and magnesium are ideally suited. Thus, it is the primary concern of the client, and of the value chain, to produce high quality products that are more advanced in their physical properties and printed structure, e.g. for airplane engine parts, than the traditional process could allow for. Powder manufacturers work together with clients to achieve high quality specifications for their products, resulting in high costs of tailored powders – a process which could be optimised in order to drive down costs.

Improvements that could be made in order to overcome hurdles are found all across the value chain, both on the supply and the demand side, as well as in a coordinated nature amongst the value chain. The costs of the metal powders could be reduced through returns to scale, but also through technological and process improvements. The costs for the process of producing powders could be reduced by eliminating the need of sieving, e.g. by improving the understanding of atomisation process, and targeting singular grain sizes in the process. As the grain size is so vital for 3D printing, and only such a limited range can be accepted, also the demand side of the value chain could be improved, specifically towards its acceptance of larger grain size distributions, which would also lower its costs.

Interviews further revealed that there are still some research challenges with respect to the material characteristics and properties within the metal AM process. There is still very basic research being conducted regarding the long durability of metal AM parts, for example by studying the fatigue of the materials. Research on such challenges would benefit all players in the value chain: powder producers would be able to improve the powder producing process, 3D printer manufactures would be able to improve their machines and the printing and controlling process, and clients would have a better understanding of the physical properties of their 3D printed parts. Thus, along the value chain there could be a need for

increased coordination and cooperation between the powder producers, the 3D printer manufacturers and the clients, in order to modernise the industry and ensure that the European metal AM value chain remains competitive.

2.1.2 Identification of investment needs

AM has witnessed major cost decrease over the past years, which has led to a boom in its adoption. As indicated in a roadmap study by the European Commission on metallurgy in Europe80, one of the key barriers in the application of high-end metal AM is its high costs, despite the fact that the solutions are available. In order to maintain the competitive position of the metal AM industry in Europe, it is important to strengthen the critical parts of the value chain. Through coordinated investments it might be possible to kick-start innovation on cost reduction in the area of high-end metal powders. The investment need could be justified by the fact that improving this critical part of the value chain would benefit the entire industrial value chain, from the metal powders suppliers to the 3D printer manufacturers and the clients.

Through interviews, the project team identified several areas where investments are needed, which could contribute to the increased deployment of high-end metal AM through a decrease in costs over the value chain, as well as an improvement in the technological capabilities, and maintain Europe's leading position in this industrial sector.

Building on the findings from the EC study81, interviews have revealed that investment needs manifest in both sides of the value chain, and not only at the position of the metal powder or the 3D printing technology.

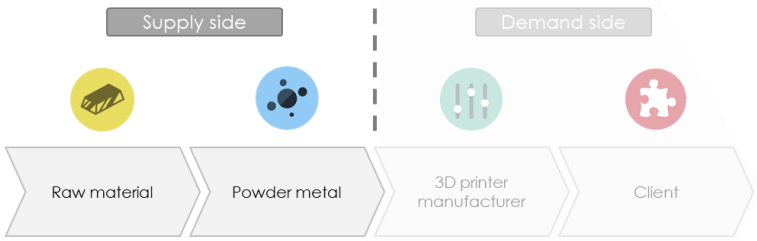

Figure 28. The supply side of the AM value chain using high-end metal powders

At the supply side of the value chain (as indicated in Figure 28), specifically with the (high-end) powder metal suppliers, there are several investment needs, especially those targeted towards the reduction of costs. High-end metal powders remain very expensive, while the costs for 3D printers have seen a drop in recent years. While there are research, technology and development challenges limiting the reduction of the price, there is a need for investment in order to achieve this. It appears to be a vicious circle: the high costs of the high-end metal powders hamper the deployment of the technology, which in turn hampers a cost reduction of this part of the value chain through scale and learning effects. It can, therefore, be described as a critical element in the industrial value chain. By kick-starting investments at this point of the supply side of the value chain, the vicious circle might be broken.

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[80] European Commission (2014) - Metallurgy made in and for Europe - The Perspective of Producers and End-Users – Roadmap – p28

[81] European Commission (2014) - Metallurgy made in and for Europe - The Perspective of Producers and End-Users – Roadmap – p28

Specifically, where the grain size of metal powders is concerned, there is potential for investments in the improvement of sieving techniques. In order to allow for an even greater potential price drop, interviews revealed that the sieving process could be removed by developing the powder production so that the initial yield no longer requires sieving and selection. This is a step which would require investment into further research and development in the atomisation process.

Some metal powders pose the need for highly technological facilities. Magnesium, for example, as a high-end metal powder is explosive when it comes into contact with oxygen – this poses a problem for production facilities. Oxidation is also a problem for all high-end metals, where titanium is most greatly affected. As titanium is very expensive, oxidation losses are also costly. Investments in expensive facilities, e.g. for magnesium powder production, with the necessary explosion protection systems and an oxygen-free environment could be envisaged for selected powder manufacturers in order to ensure production and maintain Europe's competitive position.

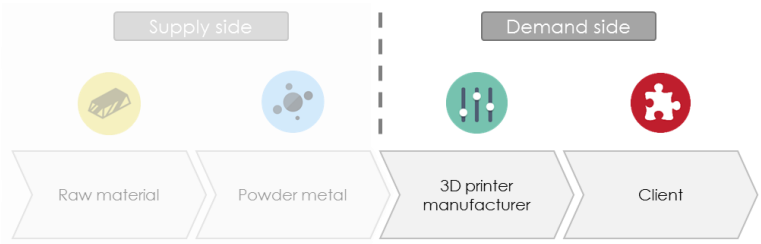

Figure 29. The demand side of the AM value chain using high-end metals

At the demand side of the value chain (illustrated in Figure 29) there are several potential investment needs, which are related to the 3D printer manufacturers. The process using high-end metals with 3D printers has made large advancements in the recent years, with a previously mentioned drop in the price of the machines. As with any developing technology, there is room for investment in R&D budgets in the application of high-end metals in AM.

Interviews have revealed that, taking into account the high price of the metal powders, there is also room for the development of 3D printers in order to accept greater grain sizes, and greater grain size distributions in order to drive down the price. Thus, this R&D research could be targeted specifically towards the technological question of the grain size in AM machines. The reasoning being, that if 3D printing machines could accept wider grain sizes then the cost of sieving and sorting, which are the most expensive parts of the powder production for AM, could be drastically reduced.

In order to improve the attractiveness of the technology, investment in the 3D printing machines could also be targeted at the speed and efficiency of the machines. These aspects also lead to high costs of products, and thus also require additional technological advancement. For the time being, interviews reveal that AM should target niche fields. AM products benefit from being able to print complex structures that traditional press and sinter or metal injection moulding processes cannot achieve. Thus, AM with high-end metals should target fields where these types of complex internal structures are needed, e.g. airplane parts.

A third area of investment needs is the need for coordinated cooperation among the different players in the value chain with respect to the application of high-end metals. There are several strategies proposed, which were supported by the interviews:

1) Coordinated investment into the development of metal powders with limited and specific granularity (albeit mostly limited amongst powder suppliers);
2) Coordinated investment into developing a metal powder with limited and specific granularity (in one of two ways: (i) sieving techniques, (ii) atomisation process);

3) Coordinated investment in developing 3D printers that accept a wider range of grain sizes, as well as greater granularity deviations in metal powders;
4) Cooperation on the development of products across the value chain in order to create a higher quality product;
5) Coordinated investments in RTD shared facility or infrastructure;
6) Coordinated platforms on powders, in order to facilitate selection and distribution for specific machines and grain sizes, to alleviate the pressure from the metal powder producer.

Coordinated investments require cooperation of several partners along the value chain, where investments are strongly associated to technological advancement. Specifically, where the grain size of metal powders is concerned, there is potential for investments in the improvement of sieving techniques, through coordinated, shared and confidential platforms with other powder manufacturers in order to refine the current techniques. Furthermore, the process of atomising the powder from the liquid metal could be improved, with the aim of producing single grain sizes as opposed to a large range. This is a step which would require investment into further research and development on the atomisation process, and completed in a coordinated nature in association with universities and research facilities through a shared test facility.

In shared platforms, not only the material requirements could be addressed, but also the targeted product and its quality. Such platforms could include powder producers, 3D printer manufacturers and clients, in order to develop high quality products in a joint venture and to advance industry developments.

With respect to investment in research or production facilities, interviewees indicated the need for investments on the supply side such as powder atomising facilities, as well as on the demand side such as 3D printers. Furthermore, one interviewees indicated that such facilities do not necessarily need to be acquired by one company, but that there are also opportunities in investing in shared infrastructure or facilities. For example, instead of buying a specific expensive metal AM facility, several companies can, possibly in cooperation with an RTD or university, buy the machine together, resulting in all having access to it. Such joint investment programmes should be accompanied by a legal framework. A legal framework should clearly specify the terms of cooperation, such as what information is and is not to be disclosed, agreements on terms of access to the shared infrastructure or facilities, as well as on the conditions for valorising the results of the joint investments. Interviewees have indicated that they foresee a role for an objective entity such as an RTD, a governmental agency or a government, to provide such a legal framework.

As a non-technical solution, powder purchasing could be completed in a centralised way. At the moment, powder manufacturers work together with 3D printer manufacturers as well as clients in order to select the powders through a very intensive process. Through a central system, the powders needed for certain 3D printer types, as well as product requirements, could be collected and shared with both powder producers as well as clients. This would allow for more centralised communication, alleviate pressure on both the side of the powder producer as well as the client and simplify the process.

Geographical dimension of the investment needs

When analysing the geographical dimension of the investment needs, it is important to analyse the geographical distribution of the companies involved in the industrial value chain as well as the nature of the industrial value chain. With respect to the companies involved in the industrial value chain, a distinction needs to be made between the supply side and the

demand side. On the supply side there are the powder manufacturers, while on the demand side there is the metal additive manufacturing industry. Information on the geographical coverage of high-end metal powder metallurgy can be found in two ways. First, using the database of the member's directory of the European Powder Metallurgy Association, which provides a list of powder manufacturers supplying to the additive manufacturing industry. The list includes 3 powder manufacturers from the United Kingdom, followed by Germany (2), Sweden (2), Czech Republic (1), France (1) and Finland (1). To triangulate this information, use can be made of data from the Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E).82 With respect to the subsector 'Forging, pressing, stamping and roll forming of metal; powder metallurgy', which includes the metal powder manufacturers, information can be found on countries with the highest value added in 2009: Germany (23.7%), Italy (22.1%), France (15.4%), and the United Kingdom (12.2%). Another potentially interesting indicator is this sector's share of value added in non-financial business economy, with Italy (2.1%), Slovenia (1.6%), Czech Republic (1.3%) and Finland (1.2%) having the largest shares. It thus seems that investment needs are concentrated in Scandinavia and Eastern Europe, or manufacturing countries in Western Europe. On the demand side of the value chain, the metal additive manufacturing industry, the dominant players are located in Germany. According to the study made by Roland Berger, the market share of German companies accounts for more than 80%.83

2.1.3 Assessment of investment obstacles

In the above section, based on the interview results, investment needs across the AM value chain with high-end metal powders have been identified. However, it is important to note that there are obstacles to each need for investment. This section aims to understand why some investments are limited in their exploration to date. Obstacles to investment are found both on the supply and demand side of the value chain, whether it be attributed to low demand towards high-end metal powders or the RTD advancement on both the supply and demand side, or specifically towards coordination gaps across the value chain.

On the supply side, a lack of investment in the development and cost reduction of high-end metal powders could possibly arise from the fact that companies are not facing a sufficient level of demand that would incentivise them to invest in research on the grain size selection in order to lower the costs. Especially from the perspective of large players in the general powder metal for metallurgy market, the market for AM remains relatively small and therefore unattractive. A 2015 article by Dawes, Bowerman and Trepleton84 on the supply chain of powder metals for the AM industry provides a good summary of the powder metal market: "Based on data from 2013 there are 855 powder manufacturers worldwide (425 located in North America, 205 in Europe and 225 in the Asia-Pacific region) capable of producing an estimated 1.12 million metric tonnes, to a value of approximately US$6.9 billion.

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[82] Eurostat (2013) - Archive: Manufacture of fabricated metal products statistics - NACE Rev. 2 - http://ec.europa.eu/eurostat/statistics-explained/index.php/Archive:Manufacture_of_fabricated_metal_products_statistics_-_NACE_Rev._2

[83] Roland Berger (2015) - additive manufacturing (additive manufacturing) – Opportunities in a digitalized production

http://www.rolandberger.com/media/pdf/Roland_Berger_Additive_Manufacturing_Opportunities_in_a_digitalized_production_20150714.pdf

[84] Dawes, J., Bowerman, R., Trepleton, R. (2015) - Introduction to the additive manufacturing Powder Metallurgy Supply Chain - *Johnson Matthey Technol. Rev.*, 2015, 59, (3), 243

When the powder metal market was evaluated, only US$32.6 million was sold for AM usage (0.0047%). This shows that despite the enormous anticipation of the impact of AM, traditional powder processes such as press and sinter and metal injection moulding (MIM) still dominate the marketplace. However, as AM processes become more established as component manufacturing routes, rather than rapid prototyping technologies, the potential for growth in the metal AM powder supply is considerable." This lack of interest in the market hampers large scale investment that could in turn lower material costs. These solutions could be investment into current sieving technology in order to fine-tune the selection of grain sizes and in turn lower the cost. In addition, more fundamental research on the atomisation process could be completed in order to avoid the sieving process altogether.

RTD is a significant part of advancing and maintaining Europe's current position in the AM metal market, and plays a role in the supply, demand and coordinated parts of the value chain. However, the obstacles to RTD are also mentioned in the roadmap study by the European Commission on metallurgy in Europe85, including a lack of effective collaborations between physics/chemistry scientists/researchers and metal processing researchers and engineers, stemming from the abandonment of metal physics in many university departments of physics. As the completion of RTD is key for the advancement of the atomisation research, the availability of researchers with the necessary know-how will also be vital. The same is true for the advancement of the 3D printing machines, in order to develop the technology towards higher quality products.

On the demand side, another obstacle to investment might be the claim that 3D printer manufacturers keep material prices high by blocking the use of other materials apart from their own on their printers. The most common procurement option for the supply of metal powders is through the AM equipment suppliers (rather than procuring powders from third party suppliers or procuring powders directly from powder atomisers). 3D printer manufacturers like to sell the powder that they receive from the powder suppliers as a kind of service to their printer clients. Indeed, these are sold as 'validated' powders: powders that have been identified as suitable for use in AM. The costs are evidently greater than purchasing directly from the powder manufacturers.

Concerning coordinated investment options, the obstacles are often related to the (limited) cooperation between competitors. Experience in the machine tool sector has shown that, even when confronted with a common shortage of a specific component, it is difficult to get all parties to work together to alleviate that common need. Individual companies may, for example, in case of shortage try to obtain a preferred treatment from key suppliers rather than looking for joint solutions with other companies in the sector. Thus, as indicated in the interviews, coordinated efforts will be hampered, when competition is still in play. In addition, companies in a certain part of the value chain are more likely to collaborate with each other when it comes to sourcing basic inputs such as raw materials rather than to sourcing high tech components, because for the latter category strategic information regarding the functionalities of the clients' product needs to be shared. In regard to cooperation in the form of shared infrastructure or facilities, interviews have indicated that there is a need for an objective entity to provide a legal framework, since especially smaller companies do not have the means or human resource capacity to compose them.

In addition, coordinated investments face risk-sharing issues. Interviews have indicated that the costs associated with the high-tech facilities involved with AM (powder producing facilities, 3D printers, etc.) are very high resulting in high-risky investment decisions. Due to the

[85] European Commission (2014) - Metallurgy made in and for Europe - The Perspective of Producers and End-Users – Roadmap – p47

high-risks, investment decisions are easily postponed. One of the interviewees mentioned that access to finance was not necessarily a problem for his company, however, the high risks were. The interviewee therefore indicated that there was a need for financing models that involve a certain degree of risk sharing or risk coverage.

Finally, some smaller companies (especially), e.g. in the machine tool sector, have limited resources for networking and the development of large joint co-investment projects, thus limiting their ability to take part in coordinated efforts.

2.1.4 Possible solutions to remove investment obstacles

It can be expected that as AM grows over time, material costs will be reduced through research, the development of the technology and returns on scale, yet the question remains whether coordinated investment action offers a possibility to speed up this development. In the previous sections several investment needs have been identified, both on the supply side and the demand side of the value chain. Examples of investment needs for the AM with high-end metal powder value chain are, on the supply side, related to the grain size, improving current sieving techniques and developing new atomisation techniques. On the demand side, they are again related to incorporating greater grain sizes distributions in 3D printing machines, which would in turn lower the cost of high-end AM metal powders. Furthermore, obstacles to these investments have been identified, such as the relatively small size of the market, the high costs and associated risks of the technologies and facilities involved and some technological challenges. Throughout the exercise of identifying investment needs and obstacles, several suggestions have been made towards the possibility of coordinated and synchronised investment opportunities.

The opportunities for coordinated investments not only address one side of the value chain, but also run across the value chain, integrating both demand and supply, and their nature makes for the most interesting investments for AM with high-end metals. Through coordinated investments developed with competitors in a pre-competitive environment, the yield of specific grain sizes could be increased through improved sieving techniques, which would result in a decrease in the price of metal powders. Even a further cost decrease could be conceived through RTD on atomisation processes together with universities in a non-competitive environment. Coordinated investments could also include shared facility development with the purpose of sharing risks, as well as machinery for product development. Similar scenarios could be envisaged across the value chain with powder producers, 3D printer manufacturers and clients coming together to work on product quality improvement in pilot studies. A pre-technological coordinated investment could consist of a common platform facilitating the exchange of powders for clients. This would include assisting the contact between the powder producer and the client, guiding powder selection for machines and product wishes. In the medium to long term, this could also contribute to a normalisation of powders, which in turn could lower the costs from the powder producers. In the next section, the potential of such a joint investment programme is further elaborated.

Example of a coordinated investment solution: joint investment programmes

The basic premise behind this study is that when a certain company makes an investment, this has usually a (positive) impact on other companies in the value chain. When several companies would make investments in a coordinated manner, this would create a virtuous cycle and accelerate the development of the value chain as a whole. In the context of the metal AM case, this could be, for example, when a metal powder producer makes an investment that reduces material costs, or when a 3D printer producer makes an investment that improves the different grain sizes that printers can use. Both investments would lower the cost of 3D printed objects and accelerate the development of 3D printing.

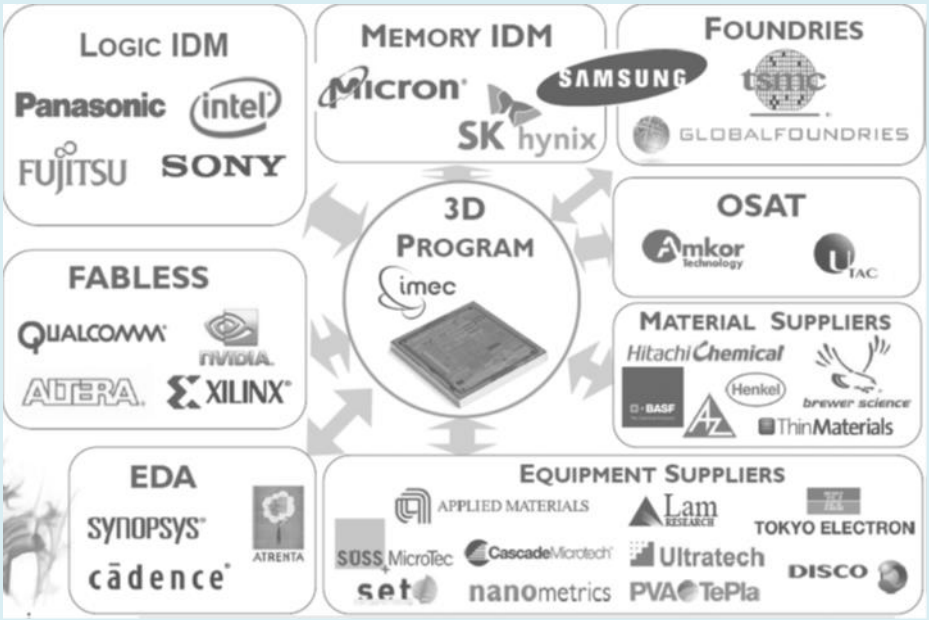
The question which arises is how coordinated investments involving multiple actors from different parts of the 3D printing value chain could be organised, in order to promote such breakthroughs. Organising such coordinated investments requires taking into consideration the benefits and costs of each party to invest in the joint project, including IP rights allocation.

In this respect, it may be worthwhile to learn from the experience of the semiconductor industry, which has observed ever growing R&D costs resulting from the increasing complexity of making chips smaller and better performing. Even for large multi-billion companies these costs have become unbearable. In order to overcome these high costs, many companies in this industry have organised themselves in joint R&D projects. A key actor organising coordinated R&D projects is imec, a leading research organisation based in Leuven, Belgium. Imec has launched the so-called 'industrial affiliation programs' (IAPs), which consist of research programmes focusing on pre-competitive research (up until TRL 6-7) conducted by imec, as well as a broad number of companies from the semiconductor value chain86. The main difference between this model and the more 'traditional' consortia based approaches is that most IP generated in the programme is shared among participants (through non-transferable, non-exclusive licenses for all companies who paid a fee to participate in the programme, even if the company did not contribute to the generation of the IP).

Because costs are split between several participants in the IAP but most resulting IP is shared, companies get a significant leverage on their invested R&D budgets (e.g. a company may invest 500.000 euro but get access to IP worth 2.000.000). This model is especially useful for technologies which are necessary building blocks for next generation processes and products, but which by themselves are not sufficient for that purpose. Once they have these building blocks, companies may close the final gap to commercialisation for their specific business on an individual or bilateral basis.

[86] Leten, B., Vanhaverbeke, W., Rojakkers, N., Van Helleputte, J. (2013). IP Models to Orchestrate Innovation Ecosystems: IMEC, a Public Research Institute in Nano-Electronics. California Management Review 55(4):51-64

The aim of the 3D systems integration IAP is to conduct collaborative research on a new technology to create electronic circuits (3D integrated chips) which can bring multiple benefits, including reduced power consumption, new design possibilities, and improved circuit security due to more complex chip designs. Today, the 3D systems integration IAP brings together 35 industrial partners in one innovation ecosystem.



Partners take different positions in the value chain of the nano-electronics industry:

1. First, there are the end-users of the 3D technology, such as the fabless companies, Integrated Device Manufacturers (IDMs), and foundries.
2. Second, the Electronic Design Automation (EDA) vendors participate in the ecosystem for the development of design software packages.
3. Next, the Original Subcontract and Test (OSAT) companies are responsible for the assembly, testing, and packaging of chips.
4. Finally, multiple Equipment Suppliers and Material Suppliers develop new types of equipment and materials for manufacturing 3D integrated chips.

Figure 30. Example of a coordinated investment solution: joint investment programmes

As indicated in Figure 30, a key feature of joint research programmes is that they involve companies from very different parts of the value chain. Each of these has their own objectives, and is interested in the parts of the programme that affect their business. For example, an equipment manufacturer will be interested in everything that affects manufacturing while an end user may be more interested in the characteristics of the novel product.

Coordinated investment solutions

In the context of the metal AM case, in order to motivate companies from different parts of the value chain to set up a coordinated investment programme, it will be necessary to identify specific topics that are (at least partly) of common interest to all companies. For example, in the investment in higher yields through sieving of high-end metal powders during production, R&D on improved metal powder production processes may interest not only metal powder manufacturers but also companies downstream the chain, if this programme would result in better insights in material properties (which nowadays is far from optimal, as indicated by several interviewees). The nature of the research topic (which involves fundamental physics) would require also the presence of universities/research institutes in addition to companies.

Therefore, future work could focus on identifying a very specific scope and format of a joint investment programme that would be of interest to several actors along the chain (resulting in a high investment leverage for individual participants) and would help to overcome the bottleneck of high material costs in the metal additive manufacturing value chain. Such programme could then be funded partly through European innovation funds and programmes, such as Horizon 2020 or EFSI. These funds can bring leverage in investments and are suitable instruments for strategic areas such as additive manufacturing. Horizon 2020 is specifically applicable due to its strong focus on developing European industrial capabilities in Key Enabling Technologies (KETs), an area of which is AMT and thus also additive manufacturing. The EFSI will be also be particularly applicable due to its focus on sectors with key importance and a capacity to deliver a positive impact on areas such as resource efficiency and innovation.

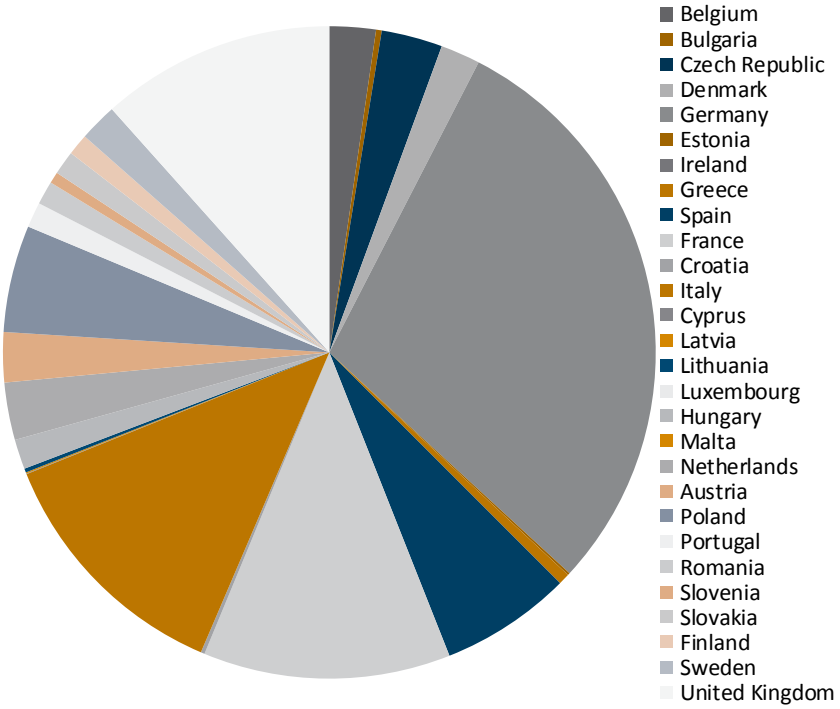
Case Study 2: Rubber and plastics – Tyre rubber manufacturing

The rubber and plastics industry has been selected in Task 1.2 as one of five key industries to be explored in case studies.

Rubber and plastic products (NACE rev. 2, C22), short rubber sector, is a key industry, with large backward and forward linkages. Its inputs mainly come from the chemical industry. It sells its inputs to practically all other manufacturing industries. The value added multiplier is also large and ranges in the middle field. Of this, the intra-EU value added component is more pronounced. The rubber industry is a medium-sized sector in the European Union in terms of production, value added and employment, also in terms of changes of these indicators and in SME-intensity (56% of turnover generated by SMEs). However, it showed the largest change in the value added multiplier between 2011 and 2014.

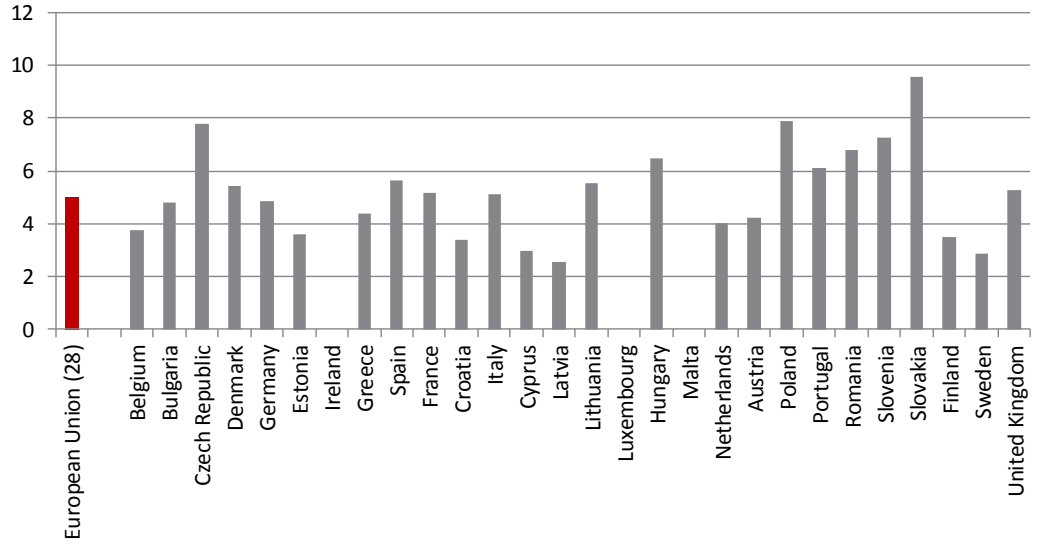
Within the European Union, about 29% of value added is generated in Germany, followed by Italy, France and the United Kingdom (about 12 % combined), and Spain (6%). The countries most specialised on the sector (i.e. measured by the share of machinery in total manufacturing value added) are the Czech Republic, Hungary, Poland, Portugal, Romania, Slovenia and Slovakia. The EU value added multiplier ranges around 0.8 but is smaller for a small range of countries (see the figure below).

A. Rubber and plastic products, value added, 2013, in % of EU (28)[87]



[87] Colors/countries change clock-wise starting at 12.00.

B. Rubber and plastics, value added, 2013, in % of manufacturing



C. Machinery and equipment, Industrial value chains: value added multiplier, 2014

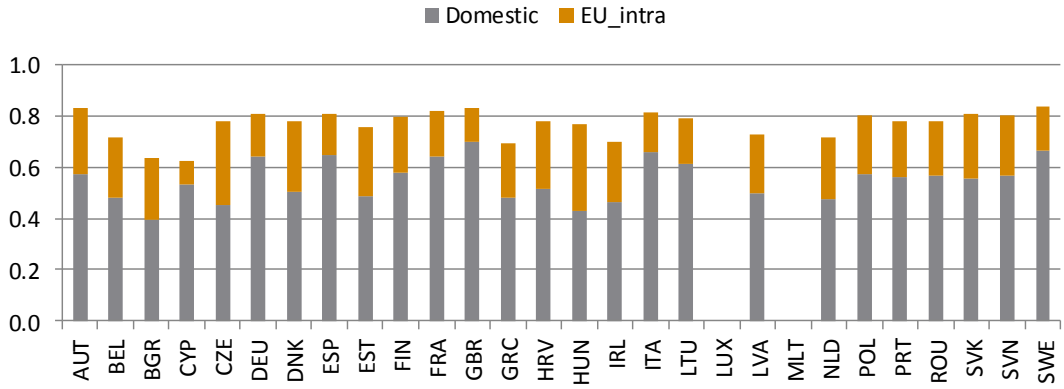


Figure 31. Country overview Rubber and Plastics, value added, 2013, in % of EU-28[88]

Within this industry, a major investment need has been identified in the **automotive tyre sub-sector**. This corresponds to the current complete dependence of the EU tyre industry on natural rubber imported from Asia. Although Europe is the second world's largest consumer of natural rubber (followed by China) and responsible for one fifth of the world tyre manufacturing, 100% of the natural rubber used in the European tyre industry is imported, mostly from South East Asia. Currently, the EU type industry is therefore dependent on the high price volatility of natural rubber coming from South East Asia which poses serious risks to competitiveness within the whole industrial value chain. At the supply side of the value chain, investment in required to find home alternatives. These could consist either in the use of other raw materials, including synthetic rubber or in the home production of natural rubber. At the demand side of the value chain, the investment needs are linked with the need of

[88] A and B: Eurostat SBS; C: WIOD-release 2016 (preliminary)

developing machines, which could more efficiently transform natural rubber or recycled rubber into tyres. Since the market for waste tyres is tightly connected with the production of new tyre (as eventually all the produced tyres need to be reclaimed), improving the efficiency of existing rubber recycling methods or developing new methods to recycle rubber more efficiently is an important industry need. This is not only because using less rubber to produce tyres result in lower costs and a decrease in the EU dependency on imported rubber, but because the recycling process leads to a reduction of CO2 emissions. A third area of investment needs consist in the need for coordinated cooperation among the different players in the value chain with respect to the decrease in the dependence on rubber coming from Asia due to the high price volatility of natural rubber coming from South East Asia.

To sum up, the development of alternatives to the use of natural rubber in the production of tyre or the establishment of methods to increase the efficiency of tyre manufacturing using natural rubber will be the key drivers for the modernisation of the European rubber industrial value chain. "Manufacture of rubber tyres and tubes and re-treading and rebuilding of rubber tyres" is the NACE industry category C22.1.1, which is within the category C22.1 "manufacture of rubber products"89. Through an extensive literature review and interviews, it has been decided to focus on the analysis on where investment is primarily required: in the creation of a domestic supply of natural rubber. The following sections detail the specific investment needs of the tyre rubber manufacturing sub-sector, their respective obstacles, as well as what could be the solutions to overcome those obstacles.

2.2.1 Understanding of the industrial value chain

World demand for rubber is forecast to rise 3.9% per year to 31.7 million metric tons in 2019. This demand increase is mostly a consequence of an increase in tyre manufacturing (Table 15), which represents about two thirds of rubber application. In turn, the growth of the tyre manufacturing industry is mostly driven by the rise of income levels in developing regions, particularly in the Asia/Pacific region, as it will lead to an increase in motor vehicle manufacturing and usage, fuelling demand for tyres and therefore rubber. In opposition, the demand for rubber will grow at below average rates in North America and Europe through 2019, due to the maturity of economies throughout these regions. Western Europe is forecast to represent the slowest growth in rubber demand through 2019. Tyre industry in Western Europe has suffered from producers shifting operations outside of the region and the permanent closure of tyre manufacturing facilities will limit the ability of the region's rubber market to recover from the recent period of economic troubles90,91.

Table 15. Automotive tyre submarket value forecast 2015-2025 ($bn, AGR %, CAGR%)[92]

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025

[89] http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

[90] http://www.rubberworld.com/RWmarket_report.asp?id=1618;

[91] http://www.prnewswire.com/news-releases/world-rubber-industry-300289614.html

[92] https://www.visiongain.com/Report/1451/Automotive-Tires-Market-Report-2015-2025

Market Value ($bn)	37.49	39.21	41.06	43.15	45.40	47.85	50.62	53.81	57.26	60.75	64.39	68.19
AGR (%)	-	4.6	4.7	5.1	5.2	5.4	5.8	6.3	6.4	6.1	6.0	5.9
GAGR 2015-20 (%)	-				5.2				-			
GAGR 2020-25 (%)	-						6.1					

Tyre applications represents two thirds of the rubber demand worldwide (2014) and that share is forecast to remain similar through 2019, as the global rate of growth for tyre manufacturing is projected to be similar for that of manufacturing in general. Besides contributing to an increase in demand for tyre rubber, rising output of motor vehicles will also drive the demand for demand growth for rubber in non-tyre components for the automotive manufacturing such as belts, gaskets, and hoses, which currently represent one third of the demand for non-tyre rubber applications. Synthetic rubber is forecast to continue holding a share of 55% of world rubber demand in 2019. Although the natural rubber will remain a crucial material in the tyre industry, the use of synthetic rubber is expected to be more common in some applications, particularly rubber gloves, medical products, and footwear.31,93

The worldwide rubber industry totalled about $220 billion in 2010, representing about 0.25% of the world GDP. About 65% of the rubber industry is tyre related. The tyre industry sales consist of about 60% passenger tyres and 30% truck and bus tyres, with the remaining 10% represented by farm service, aircraft, motorcycle, bicycle, and earth-moving tyres. Considering the numbers of tyres produced instead of tyres sales, approximately 80% of all tyres are passenger tyres. About eight passenger tyres are manufactured for every truck tyre produced.34

[93] http://www.etrma.org/uploads/Modules/Documentsmanager/etrma-annual-report-2012_8_def.pdf

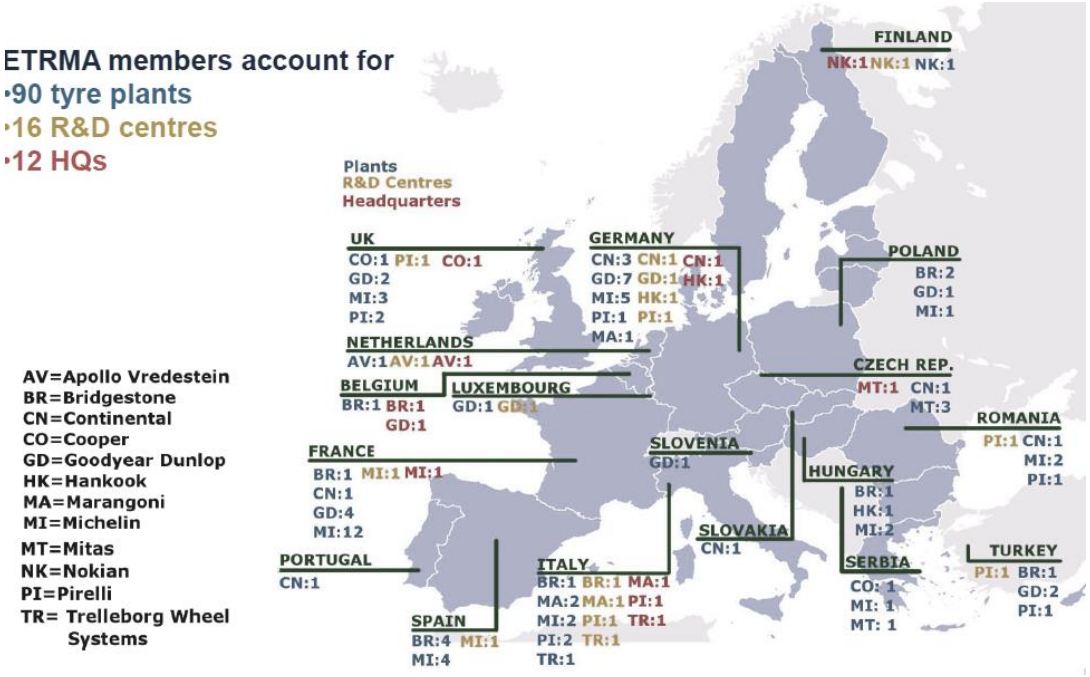


Figure 32. Members of the European Tyre & Rubber Manufacturers Association (ETRMA) in 2015[94]

Although there are over 70 active tyre manufacturers, the tyre manufacturing industry is dominated by Goodyear (US), Michelin (France) and Bridgestone (Japan) since the 90's. Together these three manufacturing companies are estimated to represent about 46% of the total tyre sales. Nevertheless, their combined market share shrunk over the past 15 years: from 57% in 2000 to 46% in 2012. This increased fragmentation in the tyre industry is mostly a consequence of the emergence of Chinese, South Korean and Japanese tyre brands. As result, the sales relative to the big three tyre companies, Pirelli (Italy) and Cooper Tise (US) together with the sales of Triangle (China), Hangzhou Zhongce (China), Cheng Shin (Taiwan), Hankook (South Korea), Kumho Tyre (South Korea), Sumitomo (Japan), Yokohama (Japan) and Toyo Tyre (Japan) represent a total of 75% of world tyre manufacturing. As indicated in Figure 32, 6 out these 13 tyre manufacturers have their headquarters (Michelin and Pirelli) or have a subsidiary company in Europe (Goodyear, Cooper Tyre, Bridgestone and Hankook)95,96,97,98.

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[94] http://www.european-rubber-journal.com/2016/01/18/european-tire-makers-post-strong-2015/

[95] http://www.futuremarketinsights.com/reports/industrial-rubber-market

[96] http://www.hanserpublications.com/SampleChapters/9781569905371_9781569905371%20Raw%20Materials%20Supply%20Chain%20by%20Dick%20and%20Rader%20SAMPLE%20PAGES.pdf

[97] http://www.european-rubber-journal.com/2016/01/18/european-tire-makers-post-strong-2015/

[98] http://www.european-rubber-journal.com/2016/01/18/european-tire-makers-post-strong-2015/

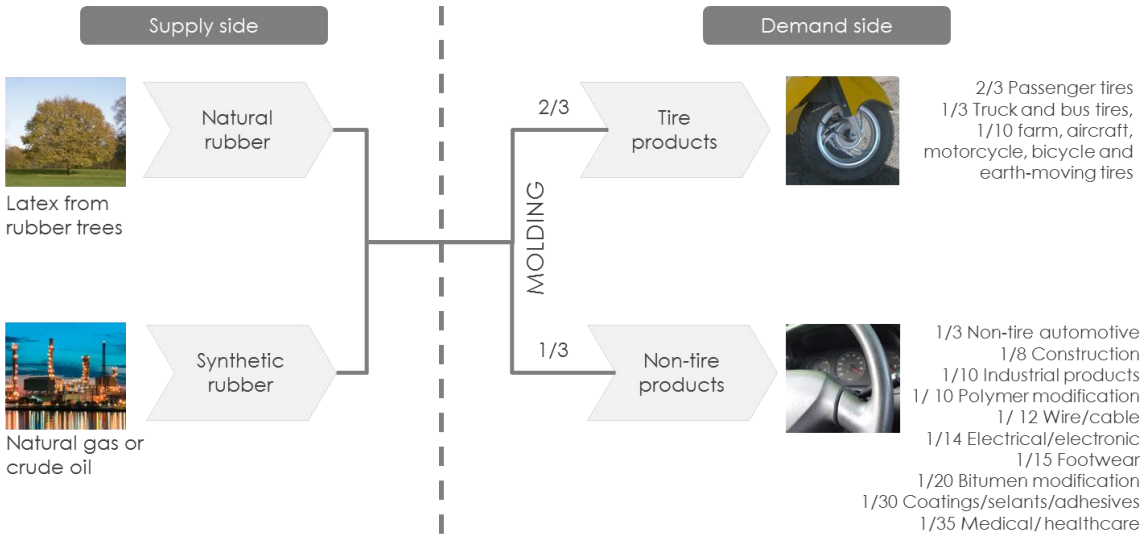

Figure 33. Value chain of tyre rubber manufacturing[99]

Rubber can be produced either by the natural rubber or from the petroleum products. In the first case, rubber trees are tapped, then the latex is collected in cups and the coagulated cup lumps formed into slaps. Rubber slabs are sent to factories where they are passed through shredding, washing and creping processes. The final products are then dried, transformed into palletised rubber blocks and distributed worldwide100. In the second case, the hydrocarbon feed stocks needs to pass through several chemical reactions (polymerisation) to be transformed into synthetic rubber. The rubber is then processed and delivered to factories.101,102 In both cases, different steps are required for the transformation of both natural and synthetic the rubber into the finished consumer products. Figure 34 indicates the value of rubber machines' segments in the EU in 2015.

[99] Content from: http://www.etrma.org/uploads/Modules/Documentsmanager/20101109-etrma_statistics_final.pdf

http://www.etrma.org/uploads/Modules/Documentsmanager/etrma-annual-report-2012_8_def.pdf

[100] http://www.halcyonagri.com/what-we-do/

[101] http://www.cefic.org/Policy-Centre/

[102] http://www.slideshare.net/trivedi88/gujarat-chem-tech-presentation-23-feb-2011

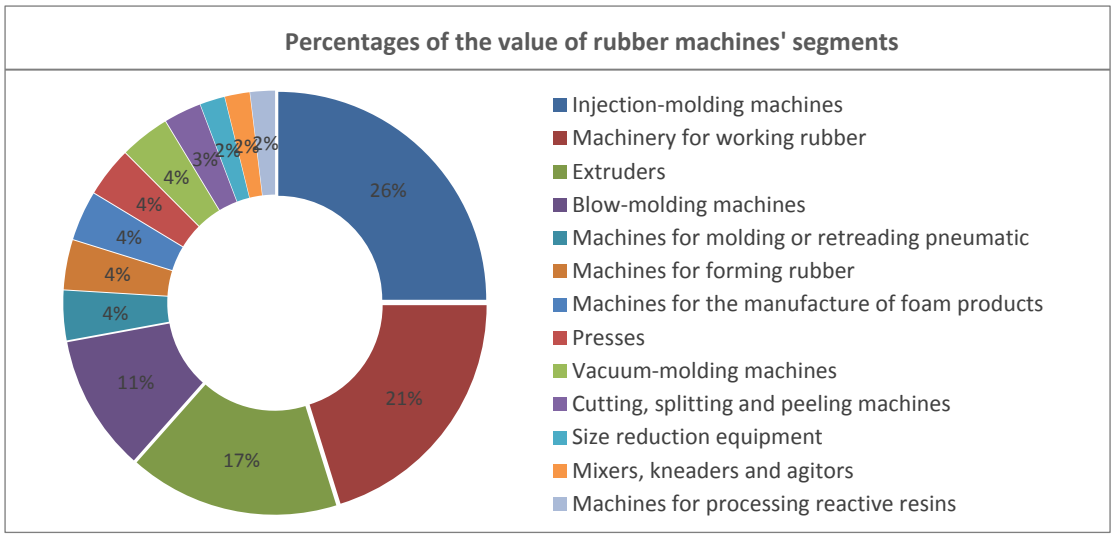

Figure 34. Value of rubber and plastics machines in the European Union in 2015[103]

Tyres are manufactured by combining rubber with carbon black, sulphur and other raw materials to ensure performance, efficiency, reliability and safety. Natural rubber still remains the main raw material used in manufacturing tyres, although synthetic rubber is also used. In order to develop the proper characteristics of strength, resiliency, and wear-resistance, however, the rubber must be treated with a variety of chemicals and then heated. According to Hyde, a typical tyre is often made by more than 30 different grades of rubber. The different types of rubber - natural rubber, polyisoprene rubber, polybutadiene rubber, emulsion styrene butadiene rubber and solution styrene butadiene rubber - provide different performance characteristics, which are optimised in the tyre design process104. Based on information from interviews, natural rubber is always required for the production of tyres, since only rubber from natural sources (not synthetic rubber) is able to absorb heat accumulated in tyres while working. The larger is the tyre, the higher is the percentage of natural rubber in the tyre.

In the European Union, the European Chemicals Agency works together with the European Commission and the EU Member States regulates the use of chemicals in the production of tyres. According to the interviewers from the tyre industry, this regulatory framework corresponds to the world's most complex legislation for the tyre rubber manufacturing industry. However, it is important to note that the used tyres imported to produce new tyres do not need to be in accordance with this legislation105.

Once tyres are manufactured, a label is mandatory in Europe and South Korea for all passenger and light truck tyres. This has been established through tyre labelling programs implemented in 2012. The adoption of similar measures in other countries are forecast to

[103] http://www.quest-trendmagazine.com/en/machinery-industry/rubber-and-plastics-machinery/market-shares-of-eu-countries-at-rubber-and-plastics-machines.html

[104] http://www.madehow.com/Volume-1/Tire.html

[105] http://www.etrma.org/activities/chemicals/reach

accelerate the shift toward more fuel-efficient tyres, and thus greater polybutadiene rubber and solution styrene butadiene rubber consumption[106].

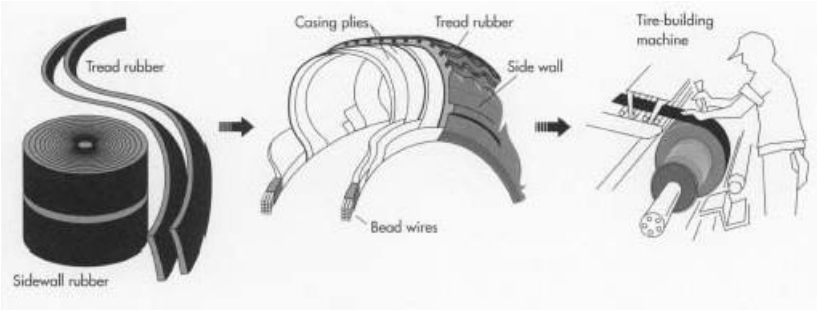

Figure 35. Tyre manufacturing process[107]

2.2.2 Identification of investment needs

The tyre manufacturing industry uses about 70% of all the natural rubber and, in terms of volume, it is forecast to consume the double of natural rubber in the next 30 years. As a result, the availability natural rubber may become problematic in some regions of the globe. Although Europe is the second largest consumer of natural rubber (followed by China) and responsible for one fifth of the world tyre manufacturing, 100% of the natural rubber used in the European tyre industry is imported, mostly from South East Asia (Figure 36) 48,108.

[106] https://www.ihs.com/products/world-petro-chemical-analysis-rubber.html

[107] http://www.madehow.com/Volume-1/Tire.html

[108] https://ec.europa.eu/easme/en/sme/5686/recycling-waste-tyres-devulcanized-rubber

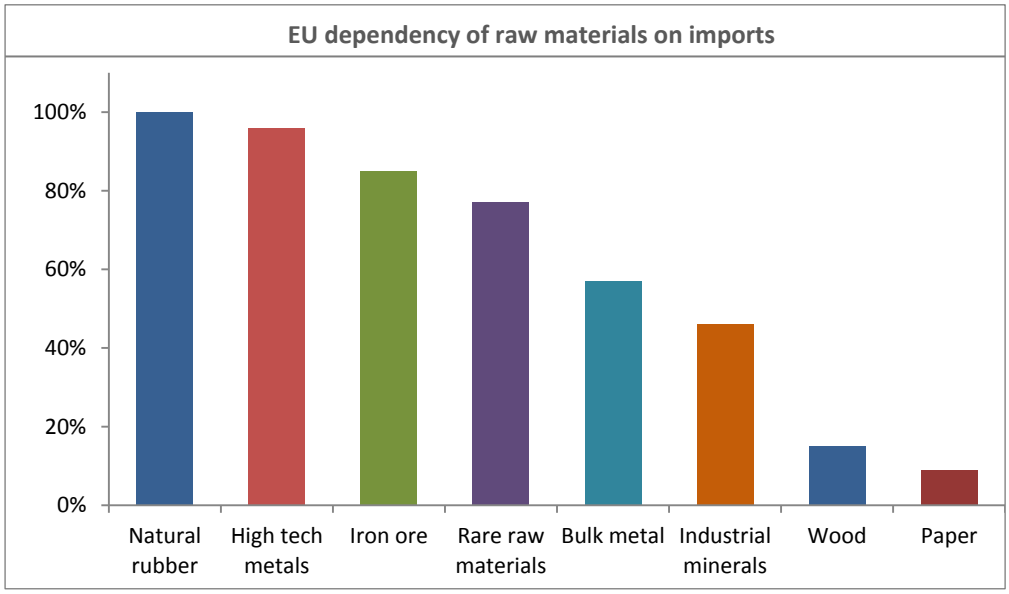

Figure 36. Dependency of different raw material on imports from outside the EU[109]

Currently, the EU type industry is therefore dependent on the high price volatility of natural rubber coming from South East Asia which poses serious risks to competitiveness within the whole industrial value chain. Besides a need for transparency and predictability in the market, European rubber sector requires private and public investments to modernise the industrial value chain in order to reduce its dependence on imports of natural rubber from third countries, particularly from South East Asia (Thailand and Malaysia).

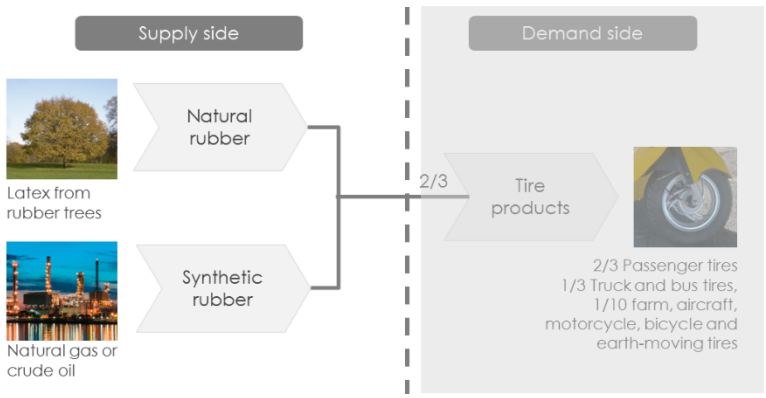

Figure 37. The supply side of the tyre rubber manufacturing[110]

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[109] http://www.recybem.nl/en/raw-materials-future

[110] Content from: http://www.etrma.org/uploads/Modules/Documentsmanager/20101109-etrma_statistics_final.pdf

http://www.etrma.org/uploads/Modules/Documentsmanager/etrma-annual-report-2012_8_def.pdf

At the supply side of the value chain (Figure 37), there are many investment needs due to current total dependence of the EU on the natural rubber from Southeast Asia. Besides the needs to negotiate trade agreements on rubber with other regions of the globe, it is necessary to find home alternatives. These could consist either in the use of other raw materials, including synthetic rubber or in the home production of natural rubber. Overall, the climate is not favourable to the production of natural rubber in the EU Member States. However, the first tyre prototypes have been already obtained from natural latex from Mexican shrub Guayule (Parthenium argentatum Gray) and the Russian dandelion (Taraxacum koksaghyz), indicating the technical performance and economic potential of the rubber extracted. The guayule is regarded as the more promising crop for cultivation in the Mediterranean areas, whereas the Russian dandelion is more suited to the northern and eastern countries of Europe 111,112. In addition, tyre manufacturing companies, like Goodyear Tyre and Rubber, have developed synthetic rubber which is expected to reduce its dependency on natural rubber113. Although this measure could reduce this dependency, it also raises other concerns: environmental concerns since synthetic rubber is produced from natural gas or crude oil; and financial concerns as the companies become dependent on the fluctuation in price of these fossil fuels.

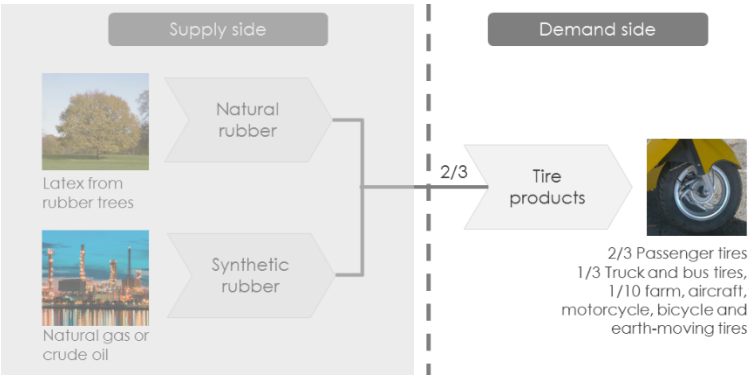

Figure 38. The demand side of the tyre rubber manufacturing[114]

At the demand side of the value chain (Figure 38), the investment needs are linked with the need of developing machine, which could more efficiently transform natural rubber or recycled rubber into tyres. Thus, investment is required to develop innovations, such as the Rubber Printing System, that reduce rubber wastage in production, increase efficiency and cut costs on the process of transformation of rubber into tyres115. Since the market for waste

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111 http://www.neiker.net/primeros-neumaticos-a-partir-de-caucho-natural-producido-en-europa/?lang=en

112 https://ec.europa.eu/programmes/horizon2020/en/news/home-grown-rubber-keep-tyres-turning

113 http://www.european-rubber-journal.com/2004/03/29/goodyear-claims-new-synthetics-can-reduce-nr-dependency/

114 Content from: http://www.etrma.org/uploads/Modules/Documentsmanager/20101109-etrma_statistics_final.pdf

http://www.etrma.org/uploads/Modules/Documentsmanager/etrma-annual-report-2012_8_def.pdf

115 http://www.rea-jet.com/News/news-0044-Tire-2014-PM

tyres is tightly connected with the production of new tyre (as eventually all the produced tyres need to be reclaimed), improving the efficiency of existing rubber recycling methods or developing new methods to recycle rubber more efficiently is an important industry need.

This is not only because using less rubber to produce tyres result in lower costs and a decrease in the EU dependency on imported rubber, but because the recycling process leads to a reduction of CO2 emissions116. European Tyre Recycling association (ETRA), an European organisation devoted exclusively to tyre and rubber recycling, aims at formalising Tyre Recycling as an independent, multi-sectoral industry involved in a long chain of activities which protect the environment and enhance the quality of life through the creation of new businesses117. There are about 280 tyre recycling companies in Europe118. Genan, the largest scrap tyre recycler in the world, is based in in Houston, Texas, USA, but it has four large recycling plants in Europe119.

A third area of investment needs consist in the need for coordinated cooperation among the different players in the value chain with respect to the decrease in the dependence on rubber coming from Asia. Investment on the following is specifically required to modernise the industrial value chain to overcome the EU dependence on imported natural rubber:

1) Coordinated investment into the development of alternatives for rubber in the tyre manufacturing;
2) Coordinated investment into developing methods to produce natural rubber in Europe;
3) Coordinated investment into the development of methods to increase the efficiency of producing tyres using natural rubber (namely, by reducing wastage of rubber);
4) Cooperation on the development of techniques to increase the efficiency of the recycling process of natural rubber.

Although coordinated investment is the quickest way to reduce EU dependence on imported rubber, most companies are reluctant to share knowledge on technology and innovation. This is mostly because the strategies indicated above imply the share of technology and innovation knowledge among the different industry players and therefore an increased risk of the need of sharing intellectual property. Despite this industry concern, there are several actions, which indicate that tyre manufacturers have been more open to cooperate in this matter. For example, the EU-PEARLS consortium which links stakeholders in the EU aiming at developing, exploiting and using in a sustainable way guayule and Russian dandelion to establish complete new value creation chains for natural rubber and latex from these plants120. Nevertheless, most initiatives still benefit one manufacturer at a time. In those cases, the majority of the manufacturers involved in the projects or initiatives consist in SMEs, as the big tyre manufacturing companies are more reluctant than SMEs in sharing technology and innovation with their competitors.

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[116] http://www.recybem.nl/en/raw-materials-future

[117] http://www.etra-eu.org/joomla/about-us

[118] https://www.environmental-expert.com/waste-recycling/tire-recycling/companies/location-europe

[119] Information collected on October 20016: http://www.genan.eu/about_genan-103.aspx

[120] http://www.wur.nl/en/Research-Results/Projects-and-programmes/eu-pearls-projects/About-us-1.htm

Geographical dimension of the investment needs

In terms of geographical scope, investment is required in South European countries for production of NR from guayule (e.g. Spain and Italy) and in Northern and Eastern countries for NR production from the Russian dandelion (e.g. Finland). Due to the high cost associated with the establishment of facilities and production techniques of NR in Europe, investment in Eastern European countries (e.g. Poland, Slovakia, and Slovenia) should be prioritised. In regards to the improvement of the quality of synthetic rubber for the production of tyres, investment should be dedicated to programmes in the Northern countries, particularly in Norway, due to the fuel resources existent for the production of synthetic rubber. Finally, the need of investment in the development of techniques which reduce wastage of natural rubber during the tyre manufacturing should be allocated to programmes in countries where the companies (world´s largest tyre manufacturers) are based: Germany, Italy, France and UK.

2.2.3 Assessment of investment obstacles

In the previous section, investment needs across the tyre rubber manufacturing value chain were identified. As there are several obstacles to these specific investment needs, this section explores the type of obstacles, as well as identifies in which stage of the industrial value chain they are observed.

On the supply side, there is a lack of investment in home production of natural rubber. This is mostly because this represents a high cost investment, which requires the cooperation among the main tyre manufacturing players in the EU. Although there are several EU projects aiming at developing methods to establish ways to produce natural rubber in the EU, tyre manufacturing still need to invest in facilities, equipment and qualified human resources in order to concretise the developed methods. In the case of investment for the development of alternatives to natural rubber, as well as techniques to reduce wastage of natural rubber during the process of tyre manufacturing, the big industry players are often reluctant to cooperate. As a result, most investment programmes are dedicated to SMEs which are more open to share knowledge and which do not compete with the main industry players. On the other hand, SMEs have a critical scale issue in terms of resources capacity and financing. In the specific case of investment for the development of alternatives to natural rubber, it is important to note that the environmental impact of the use of these alternatives in the production of tyres is scrutinised (e.g. FISSAC121 and AUTOREVAL122 projects). Therefore, ideally, the developed alternatives should not be developed using fossil resources and should not increase the CO2 emissions when used in the tyre manufacturing industry.

On the demand side, the main obstacle to the investment in research and development into tyre or rubber recycling is the lack of cooperation between academia and industry. There are several EU projects aiming at improving tyre or rubber recycling process. In most cases, they are primarily dedicated to SMEs and often only include one industrial player. This is the case of the Novel Devulcanisation Machine for Industrial and Tyre Rubber Recycling

[121] http://cordis.europa.eu/project/rcn/196821_en.html

[122] https://ec.europa.eu/easme/en/sme/7558/automotive-residue-valorization

(DEVULC)[123] and the Recycling waste tyres into devulcanised rubber (RETIRE)[124] projects in which only one SME takes part (Phenix Tecnhologies and Gumos Technologijos, respectively).

As in other industrial sectors, the major obstacle to coordinated investment packages is associated with the lack of cooperation between competitors. This is because tyre manufacturing companies are reluctant to share knowledge on technology and innovation, and in some cases, even intellectual property. According to the interviewees, the industry has been open to cooperation in the downstream services of the industrial value chain, such as commercial and distribution agreements. Nevertheless, cooperation among the industry players has been weak and often relies on complementary capabilities rather than on the development of innovative products or techniques.

2.2.4 Possible solutions to remove investment obstacles

Although the growth of the tyre manufacturing industry necessarily rely on the development of alternatives to natural rubber or methods to use more efficiently natural rubber in the future, coordinated investment actions could accelerate the process. The investment solutions suggested for tyre rubber manufacturing provides an overview on the investment required for the modernisation of the industrial value chain in the tyre manufacturing sector. On the supply side, these related to the home production of natural rubber, the development of alternatives to natural rubber or techniques to reduce the wastage of natural rubber during tyre manufacturing. On the demand side, the investment need consist in the required development of tyre or rubber recycling process, which could decrease costs and the current dependence of the EU on imported natural rubber. In both sides of the value chain, there are several obstacles to the investment needs. These are primarily associated with the current lack of cooperation between academia & industry and among industry players. By analysing the investment needs and obstacles, several coordinated investment solutions have been proposed. These solutions relate to both demand and supply sides of the industrial value chain. These consist in the coordinated investment for the development of alternatives to natural rubber or methods to produce natural rubber in Europe and in the cooperation on the development of tyre or rubber recycling processes. In all cases, besides sharing costs, industry players could also share resources, such as facilities, or knowledge. Sharing knowledge is however much less common and difficult, as companies do not have any interest in educating their competitors. In the following section, an example of a coordinated investment solution related to the production of natural rubber in Europe is provided.

[123] http://cordis.europa.eu/project/rcn/196391_en.html

[124] http://cordis.europa.eu/project/rcn/197045_it.html

Example of a coordinated investment solution: joint investment programmes

An investment from a company often has a positive impact on the other companies in the value chain. If many companies invest in a coordinated manner, there is a synergetic positive effect in the whole industrial value chain. In the case of the tyre manufacturing industry, an investment either in the home production of natural rubber or in the reduction of the natural rubber wastage can potentially decrease the dependence of all EU tyre manufacturers on imported natural rubber.

It is however important to note that coordinated investments involve multiple actors from the different parts of the tyre rubber manufacturing value chain. These could be internal actors such as the tyre manufacturers and distributors or external actors like the government and research institutes. In order to design an efficient coordinated investment programme, benefits, costs and commercial interests of all these actors need to be taken in consideration.

It is worth to reference the effort which has been made by the EU Member States in securing energy supply. Despite strategically more relevant than rubber, the EU investment for establishing a domestic supply of energy is an example on how EU could take measures to create a domestic supply of natural rubber. EU has been investing in R&D projects aiming at increasing gas storage capacity, increasing capacity to transport gas from Western to Eastern Europe and completing electricity interconnections to the Baltic States. Besides investing in renewable energy sources and energy efficiency, supply security has been enhanced through investments in domestic hydrocarbon production, including potentially from unconventional sources where this can be done in accordance with appropriately high environmental and social standards. These investments may lower prices in part by improving the EU negotiating position with existing suppliers, boosting relatively low cost indigenous production and, in the case of gas storage, helping to smooth seasonal price fluctuations125.

Without a comprehensive and operational strategy for innovation in the energy industrial value chain bringing together supply, demand and regulatory aspects, the EU risks losing its comparative advantage to Asian and American competitors. This is true in both Europe's supply of innovation and in the deployment taking place in Europe. This is already the case with some specific technologies such as solar photovoltaics (PV). Just in 2013, the EU-28 lost 50,000 jobs in renewable energy, mainly in solar PV. The EU faces similar risks in other areas such as in battery storage and in electric, hybrid and hydrogen mobility126.

The main actions at an EU level to modernise the energy industrial value chain consist in:

- Providing clarity on the long-term direction: Europe needs to ensure consistency with the visions that are emerging at the national, regional and local levels.

[125] http://www.eib.org/attachments/efs/restoring_eu_competitiveness_en.pdf

[126] http://i2-4c.eu/wp-content/uploads/2016/09/i24c_EURICS_final.pdf

- Designing the market to better pull energy innovations across the 'valley of death' and to scale: Predictable market-pull instruments (such as feed-in premiums, certificates, bonus-malus schemes or public procurement) must also be available for energy-related innovations, to create investor confidence and help move them from the demonstration to the deployment phase.
- Accelerating the empowerment of local and regional authorities: clustering opens the door to the exchange of best practice, pooling of investments, the better assessment of the 'bankability of projects', and the development of financing strategies (e.g. business cases, use of public procurement, of loans, etc.).
- Being more results-oriented and selective in nurturing energy innovation: Finite budgets need to be allocated to different technologies and solutions. In Europe, public funding is particularly important, all along the energy innovation cycle, but especially at the early stage[127].

Coordinated investment solutions

In the context of the rubber tyre manufacturing case, it is required to design investment programmes on topics of common interest in order to motivate companies from the different sides of the industrial value chain. This is the case of the proposed joint investment programmes for stablishing methods to produce natural rubber in Europe. Companies in the downstream side of the value chain could share their facilities and knowledge, whereas companies in the upstream side could share their transport resources and distribution channels. Besides the internal industry players, these programmes should involve research institutions so that knowledge can be easily transferred from academia to industry. In this case, it needs to establish an agreement to protect intellectual property from both parties. Overall, investment programmes need to ensure that all parties have benefits (commercial, in the case of companies) and decrease costs.

[127] http://i2-4c.eu/wp-content/uploads/2016/09/i24c_EURICS_final.pdf

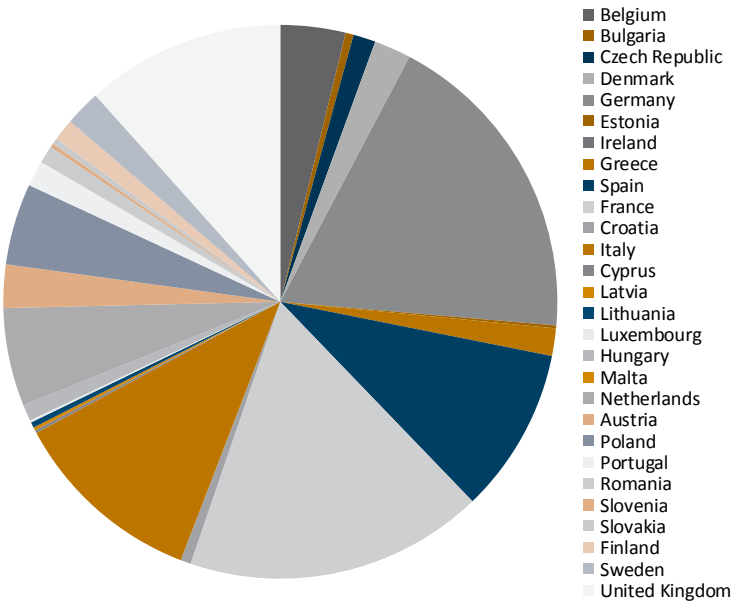
Case Study 3: Food, beverages and tobacco products – Food traceability

Food, beverages and tobacco products is one of the five key industries to be analysed in the study.

Food, beverages and tobacco products (NACE rev. 2, C10-C12), short food industry, is a sector dependent on interindustry supply. It has one of the largest backward linkages (e.g. to agriculture, chemicals, rubber or fabricated metal products); while forward linkages are small, as it basically sells its products to final demand, i.e. households (in the input-output framework, food products are directly sold to final demand and do not appear in the wholesale and retail sector). The value added multiplier is the third largest within the manufacturing industries. Of this, the domestic value added component is pronounced, while the intra-EU component is smaller. The food industry is also the largest sector in the European Union in terms of production, value added and employment. It showed the largest gross investment in tangible goods in 2014. Changes in production and value added shares ranked highest between 2011 and 2013. SME intensity is in the medium field (48% of turnover generated by SMEs, manufacturing average lies at 38%).

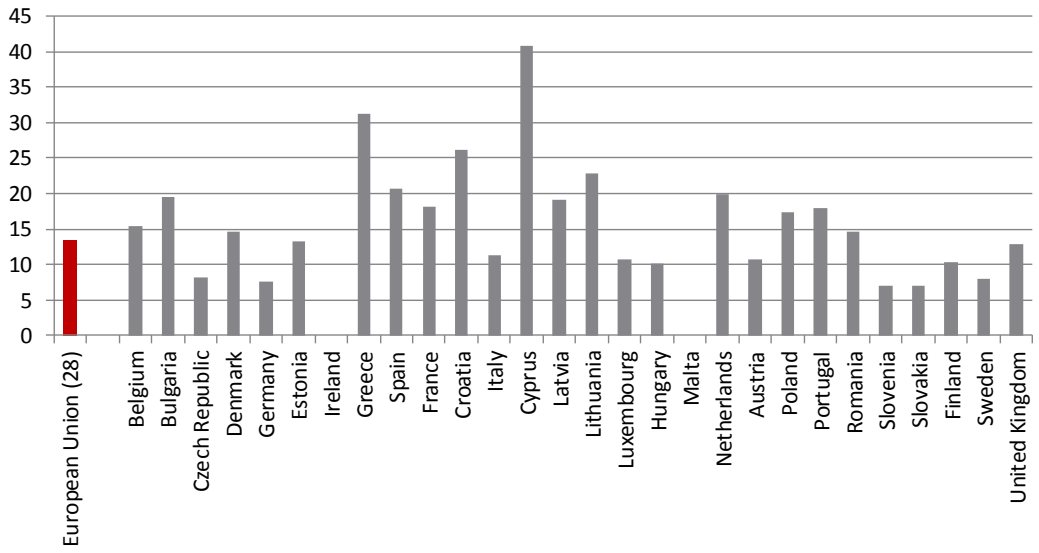
Within the European Union, about 17% of value added is generated in Germany, followed by France (16%), the United Kingdom and Italy (both 11%), and Spain (9%). The countries most specialised on the sector (i.e. measured by the share of machinery in total manufacturing value added) are Bulgaria, Greece, Spain, France, Croatia, Cyprus, Latvia, Lithuania, the Netherlands, Poland and Portugal (above 15%) The EU value added multiplier ranges around 0.8 but is smaller for a small range of countries (see figure below).

A. Food, beverages and tobacco products, value added, 2013, in % of EU-28[128]



[128] Colors/countries change clock-wise starting at 12.00.

B. Food, beverages and tobacco products, value added, 2013, in % of manufacturing



C. Food, beverages and tobacco products, Industrial value chains: value added multiplier, 2014

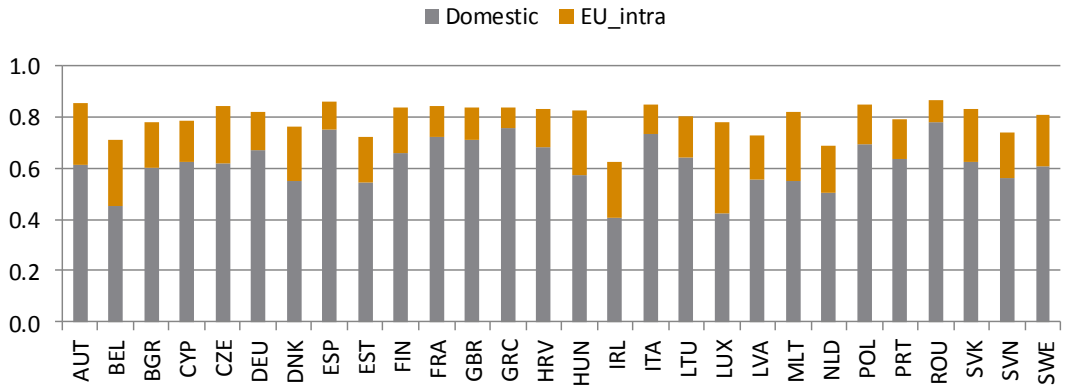


Figure 39. Country overview Machinery and equipment n.e.c., value added, 2013, in % of EU-28[129]

This case study focuses on a major investment need, which has been identified, particularly in the food value chain: food safety and, more precisely, **food traceability**, which are key drivers for the modernisation of the European food value chain.

[129] A and B: Eurostat SBS; C: WIOD-release 2016 (preliminary)

"Manufacture of food products", "Manufacture of beverages and "Manufacture of tobacco products" corresponds to the NACE industry categories C10, C11, and C12, respectively. While food safety and food traceability do not have a direct correlation to these categories, they are of paramount importance to the food value chain, being also a priority for the EU and its citizens. The SBS data on the 3-digit level revealed that the turnover/value added for the two sub-industries of beverages and tobacco was small, and therefore this case study focuses on the food industry only.

In fact, the General Food Law Regulation provides some basic criteria for understanding whether a food product is safe, and defines that only safe food can be placed in the EU market. In addition, the EU consumers are more and more concerned about food safety. Food traceability comes as key risk-management tool in the EU's food safety policy, supporting operators and authorities of the food value chain in the process of withdrawing or recalling unsafe products from the market. In addition, the Europe 2020 Strategy defines Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bio economy as one of the societal challenges, with research and innovation addressing food and feed security and safety, across the whole value chain.

Extensive desk research and interviews with key actors allowed for the identification of the need to invest in food traceability. This case study presents the specific investment needs in this regard, the obstacles to investment, and the possible solutions, which could overcome those obstacles and contribute to the modernisation of the industrial value chain.

2.3.1 Understanding of the industrial value chain

The food value chain is considered to be very complex. Every food product presents a different food supply chain, and the EU food actors operate across various markets and produce and sell a wide range of food products. Generally, the EU food supply chain can be characterised as the linkages between the agricultural sector (farmers), the food processing industry, and the food distribution sector (wholesale and retail).130 This case study considers a more comprehensive structure of the food value chain, consisting of the following stakeholders:131

1) the producers – engaged in the research, growth and trade of food commodities;
2) the processors – involved in the processing and manufacturing of the food products;
3) the distributors (wholesalers and retailers) – in charge of selling the food products;
4) the consumers – who purchase and consume the goods; and
5) the governments, NGOs and regulators – with the mission to monitor and regulate the whole value chain.

Figure 40 illustrates the roles and main issues faced by the different stakeholders.

[130] SUSFANS H2020 Project (GA no. 633692), D1.1: A Framework for Assessing and Devising Policy for Sustainable Food and Nutrition Security in EU: The SUSFANS conceptual framework, August 2016

[131] The food value chain: A challenge for the next century, Deloitte , 2013

Stakeholder	1. Producers	2. Processors	3. Distributors	4. Consumers
Role	• Research and development • Farming • Ranching • Trading	• Harvesting • Butchering • Processing • Value add processing • Manufacturing • Marketing and sales	• Distributing • Retailing	• Shopping • Consuming
Key issues	• Mangement capabilities (e.g., brand and risk management, skill gaps) • Strategy (e.g., market strategy, M&A for scale) • Financial issues (e.g., input and sale price volatility)	• Strategy (e.g., going global, regulatory • Achieving scale (e.g., M&A) • Supply chain strategy (e.g., vertical integration, security, safety)	• Strategy (e.g., consumer) • Supply chain strategy (e.g., vertical integration, traceability)	• Food prices (e.g., high prices, price volatility) • Food security (e.g., availability) • Food safety (e.g., traceability) • Health and wellness (e.g., obesity)
Stakeholder	5. Goverments/NGOs/Regulators			
	• Public health and safety • Public policy			
	• Food and product safety • Security (e.g., resource, land and food availability and allocation) • Policy and support			

Figure 40. Stakeholders of the food value chain. Source: Deloitte, 2013

It is relevant to note the differences in the food value chains of fresh products and processed foods. While the food processors / industry is one of the most relevant actors in the processed foods value chain, the linkage between producers and distributors in the fresh products is done by the brokers / food cooperatives which aggregate the offer. In addition, robotics and sensors systems are most relevant in the case of processed foods, and it is in these segments that investment is mostly needed.

Global food demand

A very relevant aspect that needs to be considered in the food industry relates to the rapidly growing food demand, which is set to rise by 60% by 2050, following the population growth prospects. In 2015, the world population met the 7.3 billion mark. This number is expected to rise up to 10 billion in the next hundred years, which will create a massive pressure in the global food supply, in particular in lower or middle-income countries.

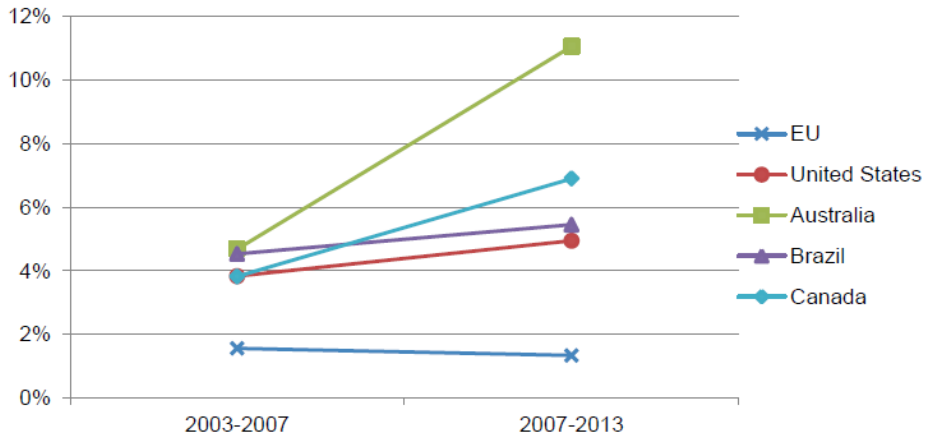


Figure 41. Population growth rate (in %) between 2003-2007 compared with 2007-2013. Source: WB

Different demographic challenges are being faced in the EU, as the population growth rate has decreased in the past years. Nowadays, 10% of the world population is living in Europe (738 million). This number is expected to decline to 707 million (10%) in 2050,132 and the proportion of over-60's in the EU is expected to rise from 24%, as of today, to 34% in 2050.133

The European food and drink industry

The food and drink industry is the largest manufacturing sector in the EU in terms of production, value added and employment, playing a significant role in the EU economies. Data collected by the FoodDrinkEurope association134 indicates that this industry has a turnover of €1,244 billion (2013) and 1.8% of EU gross value added (2012). The industry employs 4.2 million people (2013), being indeed the leading employer in the EU, distributed among 289,000 companies.

It is important to note that SMEs generate 49.6% of the food and drink industry turnover (when the average in manufacturing lies at 38%) and 63.3% of its employment (2012). The external trade accounts for €91.7 billion in terms of exports (representing 18% of global exports), and €64.1 billion in regard to imports (2014).

On another hand, and specifically focusing on the food retail, it is relevant to note that the top 10 European food retailers have not changed during the period of 2000-2011. In fact, their EU market share has increased from 26% (2000) to 31% (2011). Figure 42 presents the

[132] OECD, An OECD Horizon Scan of Megatrends and Technology Trends in the Context of Future: Danish Agency for Science, Technology and Innovation, June 2016

[133] SUSFANS H2020 Project (GA no. 633692), D1.1: A Framework for Assessing and Devising Policy for Sustainable Food and Nutrition Security in EU: The SUSFANS conceptual framework, August 2016

[134] FoodDrinkEurope Annual Report / 2016. Sources: Eurostat, UN COMTRADE, OECD (http://www.fooddrinkeurope.eu/uploads/2016-annual-report/)

market share of the top 10 retailers in the EU: Leclerc, Auchan, Schwarz Group, Ahold, Aldi, Edeka, Tesco, Rewe Group, ITM (Intermarché), and Carrefour. 135

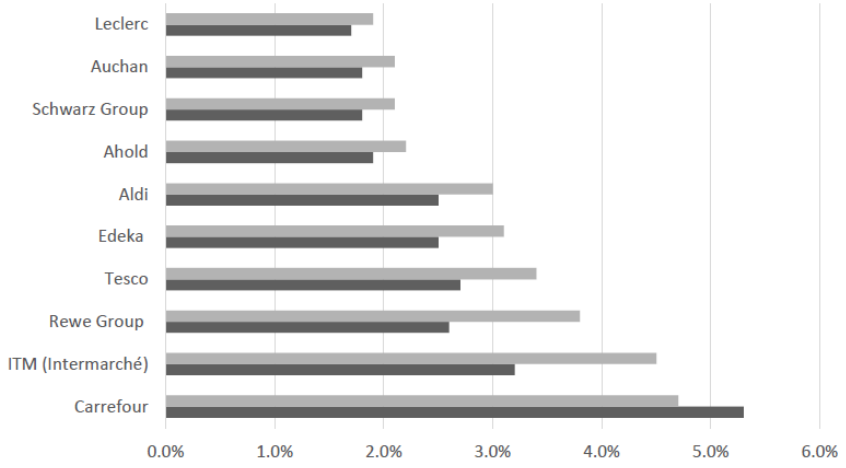


Figure 42. Market share (edible grocery) of top 10 retailers in EU (2000-2011). Source: EC, 2014

A benchmarking study from the EC which looks at the European food and drink industry against that of the main EU's trading partners (US, Australia, Brazil and Canada) reveals that the European industry is also the largest in terms of turnover, enterprises and employment, accounting for 1.5 times the size of the US food and drink industry. Nonetheless, the turnover per enterprise is found to be the lowest in the group, corresponding to only 10% of the Brazilian turnover per enterprise and 15% of the US turnover per enterprise. This is justified by the average size of the enterprises, and the fact that micro and small and medium enterprises in Europe account for a very large part of the industry, as mentioned above.136

The same study provides information about export and import rates. In terms of exports, the EU grew at a faster rate than the other countries, except for the US; while the imports grew at a slower pace than the benchmark countries. The trade balance for the EU is thus positive, having improved from below €3 billion negative in 2003 to over €10 billion positive in 2012.

[135] SUSFANS H2020 Project (GA no. 633692), D1.1: A Framework for Assessing and Devising Policy for Sustainable Food and Nutrition Security in EU: The SUSFANS conceptual framework, August 2016

[136] The competitive position of the European food and drink industry, European Commission (ECSIP consortium), February 2016

Table 16. Trade in food and drink products (C10-C12) in 2012 and growth 2008-2012

	Export			Import			Trade balance
	Value (€ mn)	Growth (%)	Market share (%)	Value (€ mn)	Growth (%)	Market share (%)	(€ mn)
EU28	86,413	6.3	12.1	75,858	0.5	11.3	10,556
USA	59,429	8.3	8.3	70,637	6.1	10.5	-11,208
Australia	14,328	4.8	2.0	8,731	8.7	1.3	5,597
Brazil	35,278	6.2	4.9	5,711	12.6	0.9	29,566
Canada	21,346	5.8	3.0	20,039	7.3	3	1,307

Source: European Commission, 2016

On another angle, it can be observed (Figure 43) that the food industry accounts for 13% of the turnover of the manufacturing industry. Regarding the number of enterprises, bakery is the largest sub-sector, having more enterprises than the total of any other-subsector. The main sub-sectors in terms of turnover are meat, "other food" products (which include the production of sugar and confectionery, prepared meals and dishes, coffee, tea and spices, as well as perishable and specialty food products), beverages and dairy manufacturing. The largest sub-sector in terms of exports to third countries is beverages manufacturing. Fishing processing is the largest one in imports.

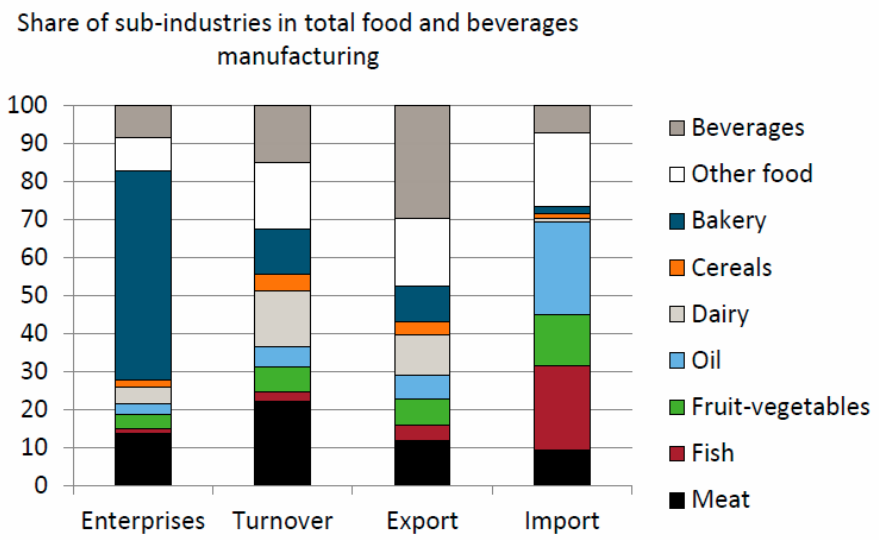


Figure 43. Number of enterprises, turnover and external trade of selected sub-sectors of the food and drink industry in EU-28 (2012). Source: European Commission, 2016

The main competitive advantage of the EU food industry consists of food safety levels, and the quality and image of the food and drink products. Only by continuing to comply with the legislative framework it is possible for Europe to maintain its competitive position.

Nonetheless, further scientific and R&D developments may lead to the amendment of food quality and safety regulations.[137]

Food industry trends

While food has been a stable and consistently growing industry, it faces continuous transformation and the industry stakeholders have to adapt to different operating environments and different business practices in order to answer the market needs and remain competitive. Notwithstanding the complexity of this value chain, there are several major trends that can be currently identified in the food industry. These correspond to:

- the changes in consumer demands, requesting traditional and local and/or organic food productions and redirecting the industry to a more localised operation;
- the transparency and questioning of what the food products are and where do they come from;
- the impact of big data and technology in the industry; and
- the polarisation and specialisation of the industry, influencing the rise of more specialised players.

More and more, consumers demonstrate concerns regarding the safety of food products, which naturally includes the imported products. The concerns lie in issues such as agricultural practices, food hygiene, and adulteration in food production processes, weak/fragmented regulatory controls, contamination at different steps of the processing chain (leveraged by an increasingly global food supply chain), counterfeiting, labelling, food scandals, food safety hazards and food borne illnesses. On average, 300 food recalls are reported on an annual basis, which translates in over 75 million food borne illnesses and 325,000 hospitalisations.138

There is a growing interest from the demand side in knowing where the products come from, how they are processed, the cleanness and freshness of the products, and their pricing levels, driven also by the easier access to information and the Internet, which is an equaliser of price transparency.

Specifically regarding the origin and contents of the products bought, consumers are being more selective, paying more attention to the food labels, and going further by wanting to know the specifics about the source of each ingredient and not tolerating irresponsible practices.139 The environmental impact (in the food products but also in the equipment industry) and animal welfare are also raising concerns, which consequently have an impact in the value chain stakeholders. Thus, not only the government and regulations influence the need for food transparency, but also the consumer demands.

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[137] The competitive position of the European food and drink industry, European Commission (ECSIP consortium), February 2016

[138] Food-Related Illness and Death in the United States, Centers for Disease Control and Prevention, Volume 5, Number 5,

October 1999

[139] The food value chain: A challenge for the next century, Deloitte , 2013

Response to industry trends and consumer demands

Representing almost 50% of the food and drink industry in the EU, SMEs face the pressure of these trends, in particular the consumer demands for standardised and price competitive products, as well as the growing presence of large retailers and the need to comply with the regulatory frameworks. In general, the success of food sector companies is dependent on the public's confidence in the safety of the products they consume. Preventing and mitigating food safety hazards and meeting the consumer expectations require being innovative, and upgrading the safety, compliance and transparency levels of processed products. Improving business development skills and production techniques is thus required for SMEs to accompanying the evolution of the industry and enduring their activity in the competitive markets.

Key players are already making investments to secure their supply chain, by developing planned responses to food recalls, improving food traceability and product labelling, and ensuring that production, processing and distribution is done in compliance with the required regulatory regimes. In order to improve the supply chain transparency, companies are putting in place track and trace technologies. Consumers are now more able to track their goods from the production to consumption through online solutions. For these systems to achieve their objectives, the various members of the value chain need to understand the importance of food safety and collaborate extensively.140

Sustainable food security for strong value chains is also a priority in the EU, which is, for instance, reflected in the wide number of EU funded projects in food safety, and in the Horizon 2020 Work Programme 2016-2017 of the Societal Challenge "Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bio economy".

EU Food Safety Policy – Food Traceability

Various national and European regulations (concerning food safety, nutrition and health, information on food, innovation in the sector, food exports and imports, and environmental sustainability) influence the food and drink industry's competitiveness. The European Food Safety Authority (EFSA) provides independent scientific advice to member national authorities on existing and emerging risks in food safety. The EU policies and regulations impacting positively the industry include141:

- Establishing and harmonising key legislation under the General Food Law (Regulation EC No 178/2002) and adopting coherent horizontal approaches at EU level (an example on food safety is "From Farm to Fork");
- Regulation on voluntary geographic indicators and traceability;
- Food safety regulation promoting high quality levels of European products.

[140] The food value chain: A challenge for the next century, Deloitte, 2013

[141] The competitive position of the European food and drink industry, European Commission (ECSIP consortium), February 2016

European food safety policy aims are twofold: to protect human health and consumers' interests, and to foster the smooth operation of the single European market. The EU thus ensures that control standards are established and adhered to in the areas of feed and food-product hygiene, animal health, plant health and the prevention of food contamination from external substances. The Union also regulates labelling for food and feed products. ***– Food Safety Factsheet (European Commission, 2016)***

In particular, the General Food Law Regulation puts in place a risk assessment approach and establishes the general provisions for imposing traceability of food and feed. Another tool set out is the Rapid Alert System for Food and Feed (RASFF), which enables the fast exchange of communication between Member States regarding health threats cause by food or feed.[142]

Under EU law, "traceability" means the ability to track any food, feed, food-producing animal or substance that will be used for consumption, through all stages of production, processing and distribution. ***– General Food Law Regulation***

Traceability is the ability to trace the history, application or location of an item or activity, or similar items or activities, by means of recorded identification. ***– ISO definition***

2.3.2 Identification of investment needs

While there have been several advancements in the EU in terms of technology, and the EU traceability requirements rank top in the global scenery of food safety regulations143, the interviews and extensive literature review reflected the need to modernise the food value chain in this regard. Further work must be conducted to understand why existing technologies are not adopted, and to support and encourage the smaller players to implement food traceability systems, with the ultimate goal of meeting the modern consumer demands. This investment need is thus horizontal to the industrial value chain.

Food traceability comes as a response to the need of detecting potential risks, which may emerge in food and feed, and to follow the modern consumer demands, allowing for accurate information to be provided to the public. In the EU, it is seen as the method to ensure that the food products consumed by EU citizens are safe and to respond to food crisis. Therefore, it is extremely important that when risks are identified, food operators and national authorities are able to trace them back to its origin, fast isolate the problem and avoid that unsafe and contaminated foods reach the consumers. Given that food and feed products are circulated freely in the EU internal market, strong cooperation between the Member States and compliance with the existing regulations is required for traceability to be effective.[144]

Food traceability is more challenging in longer supply chains and more elaborated food products. In the event of a food incident, food traceability enables the identification and

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[142] European Commission, Fact Sheets on the European Union 2016 - Food safety, 2016

[143] http://www.foodnavigator.com/Policy/EU-traceability-requirements-rank-top-in-global-table-of-food-safety-regulations

[144] European Commission, Factsheet on Food Safety, 2007

either the withdrawal or recall of the unsafe food from the market. In case the food has not reached the consumer yet, a trade withdrawal is conducted. In case the food has already reached the consumer, a product recall is undertaken. This process includes not only recalling the product from the market but also notifying the consumer of the incident, via in-store notices and publication of press releases. An example of a food recall was the situation in Ireland in 2008, when pigs were exposed to contaminated feed and, given that the traceability levels were below the requirements, all products originated in Irish pork had to be recalled.

To illustrate the investment needs in food traceability, the case study focuses on a simplified food value chain (Figure 44). The governments, NGOs and operators are also naturally involved and influence the entire value chain, as these actors monitor and regulate the food traceability process.

Figure 44. Value chain of meat manufacturing

Food traceability is thus extremely important to ensure consumer confidence and brand loyalty, which allows for companies to explore marketing opportunities. In addition, and as mentioned above, complying with food traceability regulations is also required by legislation, as a means to ensure food safety.

Food traceability is embedded in the food safety system and is a cornerstone of the EU food safety policy, being a legal obligation, which must be complied by the food value chain actors (Regulation EC 179/2002). Every food business operating in Europe and any food business bringing products into Europe need to have a traceability and recall system in place. The regulation requires that food businesses need to be capable of identifying one step back in the food value chain, and also one step forward. This means that all partners in the supply chain must be aware of food traceability requirements. Therefore, this process demands a strong synergy between all business operators, and it is of individual responsibility of each business operator (as the data is collected in the individual systems of the companies). As such, food traceability impacts the businesses in terms of costs, organisation procedures, and integration along the value chain.

Nonetheless, despite knowing their obligations in order to be in the market, food business operators are aware of the distinction between providing the origin of the product and guaranteeing its origin and responding to consumer demands. In fact, food traceability can go beyond the general obligation of informing the consumer of the origin of the product. It can include as well factors such as time (for instance, when the product was packed) and

quality. Indeed, there are optional traceability systems, which can be applied across the different segments of the value chain.

For example, according to interview results, large retailers face the difficulty of changing the consumer perspective on the quality and freshness of the foods, as there is a big lack of confidence in the fresh products. Traceability comes as a way to overcome this obstacle, demonstrating to the client that they can trust the products that are being sold. In specialised retail, the information may even consist of providing further comfort and information to the consumer, such as which farmer produced certain product, or demonstrating the face of the captain responsible for certain fish.

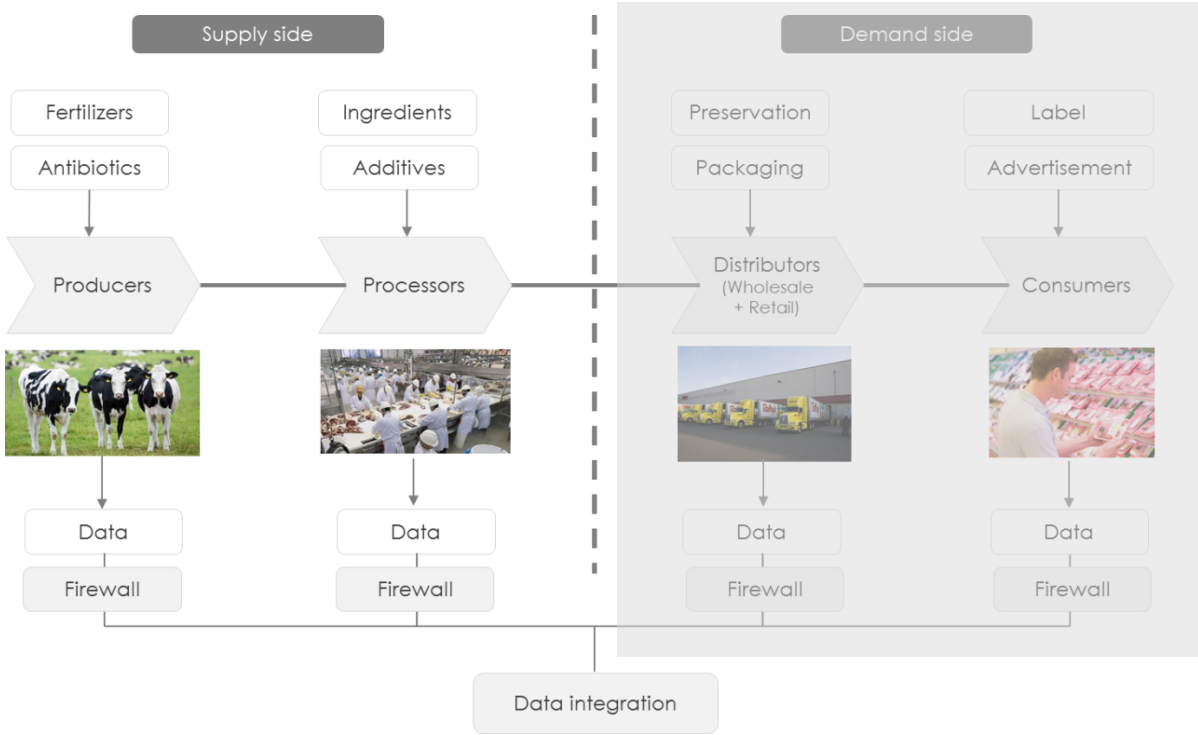


Figure 45. The supply side of the meat value chain – food traceability

The investment needs on the supply side of the value chain (Figure 45) are mainly focused on the implementation and maintenance of the traceability solutions.

For the implementation of traceability, businesses need to keep track of the advances in technology and of new and more efficient traceability systems. These developments push standards to higher positions, and businesses need to react to the new solutions in order to remain competitive. Bar codes and labelling enable operators to identify the source of products and where they are in the value chain.

The demand side needs to work closely with the suppliers in order to ensure that traceability is put in place across the entire value chain. However, more upstream activities are in great part performed by individual farmers, family based companies and SMEs, which generally lack the necessary skills and resources to implement traceability systems in the first place or, to some extent, to understand the legal requirements of the different sectors. In addition, these stakeholders are not familiar with the research developments and are not aware of the technologies available in the market. These smaller players need more support, in terms of

training and capacity building, and also in terms of access to information and technology transfer.

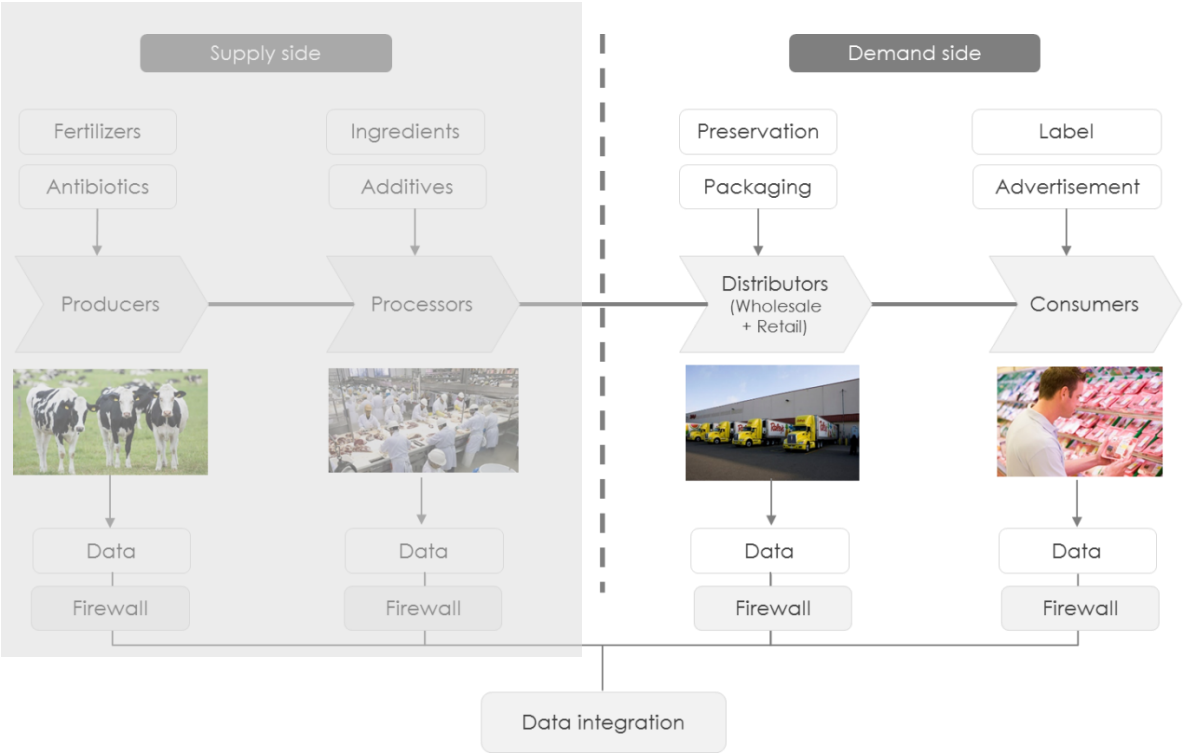


Figure 46. The demand side of the meat value chain - food traceability

On the demand side of the food value chain, the investment needs concern the improvement of the way the information reaches out to the consumer, and the logistics processes. There are various marketing opportunities that can be taken up by retailers, as a way of providing consumers with more information about the food products. This information can refer to the quality of the food ingredients, the food safety standards and animal welfare standards adopted in the product, the origin of the food production, the production methods, as well as the environmental impact of the food. In addition, food traceability has a direct correlation with the distribution segment, given that it incorporates the information systems and the necessary logistics processes.

Other two investment needs which were identified to modernise the traceability domain of the food value chain are of a coordinated natured:

1) Coordinated investment on digitalisation and Internet of Things developments, not only for the improvement of the traceability information systems and communications, but also for the identification of cheaper solutions;
2) Coordinated investment focused on the improvement of the synchronisation between stakeholders and the adoption of food traceability along the entire value chain.

The nature of the food value chain requires strong collaboration and cooperation among the actors, if a food traceability process is to be implemented. In this case, it was found that retailers are the segments most likely to initiate and lead the traceability process, as they are closer to the market and they understand better the consumer demands. Given the retailers' proximity with the consumers, higher investments need to be made in this segment, including in the way the information is provided and how the stores are designed. Furthermore, actors in the upstream activities are less capable of conducting such investments. For these reasons, cooperation along the entire value chain is of great importance for the systems to be efficient, from the farmer to the consumer.

In addition, although there are several solutions in the market, these represent high costs for the companies. Further investment on R&D needs to be undertaken in order to identify solutions which are more bearable by business operators. Moreover, new advancements can help improving traceability, making it more efficient and allowing for the system to work faster in case of a food withdraw or food recall. More innovative solutions can also help companies to make the right decisions when selecting their suppliers.

In conclusion, efficient food traceability systems require investment synergies to be undertaken across the value chain. Coordinated investments could accelerate the modernisation of the food value chain and support the role of business operators in regards to food safety.

Geographical dimension of the investment needs

In terms of geographical scope, it is important to note that EU countries reflect considerable differences in the size of their food, beverages and tobacco industries. However, while countries with a higher value added share in manufacturing would certainly benefit from improved traceability systems (Cyprus, Greece, Croatia, Lithuania and Spain), these industries rely strongly on domestic actors and domestic added value, being less internationalised as other industries. For these reasons, the investment needs described are felt regardless of the geographical area and therefore should be addressed in all Member States.

2.3.3 Assessment of investment obstacles

Several investment needs along the food value chain were identified in the previous section. Literature review and interviews allowed to understand as well what are the obstacles to these concrete investment needs and, in particular, in which segment of the value chain the obstacles are felt.

A general investment obstacle identified across the entire value chain concerns the low interest in investing in improved and more efficient traceability systems. While in an ideal market, total transparency would be ensured, the technological solutions available in the market represent high costs for the businesses. When the margins in the product are very low, there is a low interest from private investors in investing in those food chains. For instance, the margin of oranges (e.g. €0.60/kg) are much lower than that of fish (e.g. €15-20/kg). It is therefore very difficult to establish a traceability system in the orange value chain, while in

the fish the price can accommodate the investment made. In consequence, not only external entities are not interested in investing in improved traceability systems, but also most actors in the value chain are unwilling to make investment efforts in this regard. Typically, investments are mainly done by the larger players, specifically operating in the retail segment.

Another obstacle that was identified and which is mostly faced by the supply side is related to internal obstacles and lack of qualified professionals and training. The agriculture sector is characterised by low qualified workers, and investments in capacity building and training is thus required. While in some economies which invest strongly in agriculture may be more advanced, generally more skilled workers would be needed, who would be able to better understand the importance of food safety and follow the implementation of traceability processes more easily. Evidently, as since the industry depends heavily on the small producers, unskilled workers and weak access to knowledge and information is an obstacle in this regards.

The major obstacles to coordinated investments are also related with the high costs of the technology and lack of qualified personnel, less willing to adopt innovative solutions, in particular in primary and upstream activities. In addition, obstacles to coordinated investments include the size and resources of the company, which influence investment priorities. Indeed, SMEs cannot be as sophisticated as big players in these processes. Furthermore, it is important to note as well the interest from technology developers in the agri-food sector, which if higher it would support the industry development, and the difficulty in fast communication across the value chain.

In fact, advanced R&D developments have been made in traceability solutions, including in sensors and communication technologies. The greatest problem in their adoption lie in their high implementation costs, unbearable and also unattractive in terms of return on investment for most players. This issue is faced by many of the thousands of food chains, where margins are very low and therefore adopting new solutions is not sustainable in terms of price.

2.3.4 Possible solutions to remove investment obstacles

As mentioned above, the largest players in the food value chain are also the strongest investors in R&D and Innovation. These actors implement high-level food traceability processes not only to comply with the legislation, but also to respond to the life style demands of consumers, taking into consideration factors such as price or competition. In addition, larger players have higher quality standards that need to be met and stronger levels of corporate responsibility, thus they end up taking the initiative to implement these processes.

It was also observed in the study that while the largest players, especially retailers, are more inclined to improve the traceability of their products, a company's investment decision depends entirely on that of the others in the value chain, given the strong symbioses between the stakeholders. In fact, in a certain food value chain, large projects enabling coordinated or synchronised investments along the value chain could unlock the

modernisation in traceability. In order to reach the optimal efficiency, the coordination of the investments would need to be very well managed.

When questioned about private investment, the interviewees were of the opinion that it is difficult for it to be the solution to modernise the industry. A comparison between the food retail industry and the energy industry can be made: while in the former, the low margins on the products make external entities unwilling to invest, in the latter, the returns on investment are very attractive to private investors. However, public private coordinated investments could form the basis for the solutions.

For these reasons, European funding can support the modernisation of the industry, encourage the adoption of innovations, improve professional skills and support the development of new concepts, solutions, prototypes, as well as the implementation of new technologies.

Example of a coordinated investment solution: grant scheme

A similar industrial value chain to that of the food, beverages and tobacco products is the textiles (see section 3.1). Both industrial value chains are dependent on interindustry supply and are characterised as being low-tech and having a middle level of SME intensity. The textiles industry faces weaknesses to modernisation which are similar to that of the food industry: weak attractiveness for young people; weak innovation culture; lack of highly skilled professionals; few training institutions. It is considered that only with training, well-educated human resources and an efficient workforce the industry will be modernised and a strategic reorientation of businesses will be undertaken.145

Several programmes, mostly at national level, have emerged in the Member States in order to unlock the modernisation of the industry, given its potential to generate employment, increase exportations and contribute to domestic economic growth.

One example is the Textiles Growth Programme146 – Manchester, UK, launched in 2013 with the aim to support the national revival of textiles, and addressed at all businesses within the textiles sector (covering manufacturers from carpets to clothing, as well as industry suppliers, such as textile machinery manufacturers and designers). The programme is a £97M initiative, supported by the Regional Growth Fund (backed by £19.5M, of which £12.8M was released in the first year), being focused on creating and safeguarding jobs through a grant scheme.

Although the programme is prepared to support companies from all over England, it is mainly focused on Greater Manchester, Lancashire, West Yorkshire, Leicestershire, Nottinghamshire and Derbyshire. The programme is led by the Manchester-based N Brown Group, being also supported by other organisations, such as BIS, Manchester Growth Company, M&S and ASOS.

The programme was divided in 3 investment pots considered necessary to achieve the programme's objectives of sustained growth across the whole sector:

1. Capital Grants - support to capital projects;
2. Skills training;
3. Research and development in the textile industry.

The Textiles Growth Programme is a concrete case of a coordinated investment programme as it bridges the gap between the largest players – global retailers, and the domestic micro businesses and SMEs, with the aim to strengthen the local supply chains and foster growth. Investments in SMEs are focused on the workforce skills, design and innovation capacity, as well as modern plan and machinery. This allows for SMEs to meet the desired level of response to the increase demand for textile products in the UK.

Spending on this programme is set to be completed by May 2017. The maximum grant available in the programme to any one company is £2M.147 The figure below provides a summary of the state aid vehicles used by the programme.

[145] http://www.texmedin.eu/upldocumenti/131_THE%20TEXTILE%20AND%20CLOTHING%20SECTOR%20IN%20EUROPE.pdf

[146] http://www.businessgrowthhub.com/manufacturing-and-engineering/textile-industry

[147] https://www.gov.uk/textiles-growth-programme

State Aid Vehicles - Textile Growth Programme[148]

Category	Co. size	Max Grant	Intensity Ceiling	State Aid Scheme	Notes
All grants below EUR200,000	ALL	c. £150k	Up to 100%	De-minimis	1,2
Capital grants above EUR200,000 in Assisted Areas	Large Medium Small	£1M £1M £1M	0% or 10% note 5 20% 30%	GBER – Regional Investment & Employment Aid	3,4
Capital grants above EUR200,000 outside Assisted Areas	Medium Small	£1M £1M	10% 20%	GBER – SME Investment & Employment Aid	
Research & Development	Large Medium Small	£1M £1M £1M	50% 60% 70%	GBER – Research & Development Aid	
Training (all grants below EUR2.0M)	Large Medium Small	£1M £1M £1M	50% 60% 70%	GBER – Training Aid	1

The programme has a pool of specialist textile advisers, which help applicants build an eligible project for funding and guide them in their business strategy over the short, medium or long-term. These are experienced business managers, with extensive knowledge of the sector at all levels. Further support is provided on areas such as finance, manufacturing advice and international trade, along with skills and management development. The following is a list of areas in which support is provided in the scope of this programme:

- Apparel and footwear manufacture
- Manufacture of soft furnishings
- Knitting, weaving and dying
- Cut, make and trim
- Carpet manufacture
- Technical textiles
- Manufacture of textiles machinery
- Trading and wholesale

The programme is following the industry development, now worth £9bn to the UK economy, as it is predicted that investment in textile manufacturing will create 20,000 jobs in the country by 2020.149 The programme was considered "the first ever textile growth programme in in British history" and helped to create 1,600 jobs and 115 apprentice positions in England in its first year.[150]

The modernisation of the food industry could benefit from similar initiatives.

[148] Textiles Growth Programme - Grant Application Form Guidance Notes

[149] http://www.manchestereveningnews.co.uk/business/investment-textile-manufacturing-create-20000-8607693

[150] http://www.just-style.com/analysis/uk-textile-and-clothing-industry-poised-for-growth_id124343.aspx

Large RDI projects (e.g. funded by Horizon 2020) can fund pilot actions to demonstrate the benefits of food traceability, and also help to improve the existing technologies or to identify cheaper solutions. The interviews also pointed out to the lack of knowledge transfer and difficulty in bringing the existing technologies to the market. Actions to understand why the technologies are not being adopted and how companies can start using them are also necessary.

Initiatives focused on SMEs are also seen as beneficial for the industry, as a means to increase the technology based start-ups working in the agro-food sector. Innovative companies with qualified professionals are more able to work with technology and to understand the economic benefits of transparency. Grant schemes addressed at these needs could contribute to sustainable growth of the industry.

Tax incentives have been the greatest driver in facilitating investment. However, the current funding schemes would not contemplate these activities. Tax incentives going beyond R&D and focused on innovation and the implementation of innovative traceability systems can also unlock the modernisation of the value chain. In a specific food value chain, the investment size could be framed within the €250,000 - €1 million interval. Apart from tax incentives, an SME funding programme (through a grant scheme) could support the implementation of more complex food traceability systems at SME level.

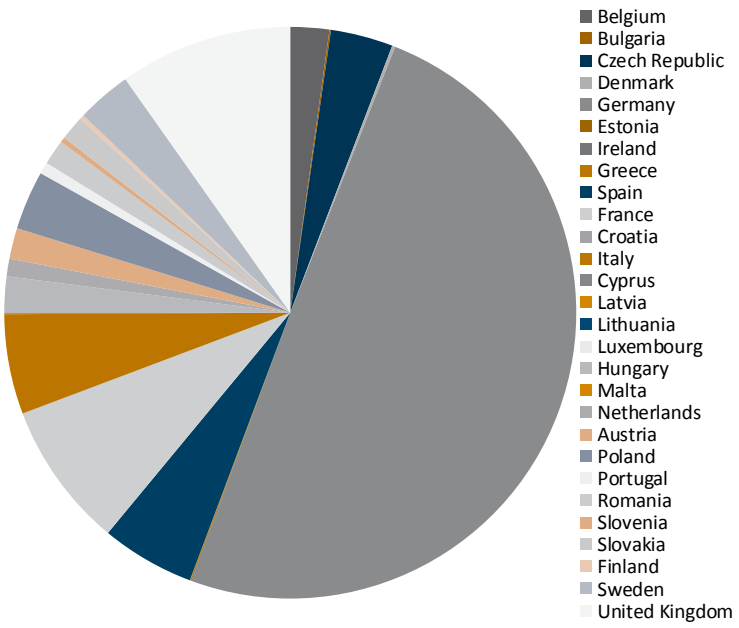
Case Study 4: Motor vehicles – Batteries for Electric Passenger Cars

The motor vehicles sector can be described as companies and activities involved in the manufacture of motor vehicles, including most components such as engines and bodies151.

Motor vehicles, trailers and semi-trailers (NACE rev- 2. C29), short motor vehicles, is also a sector dependent on interindustry supply (sourcing from the rubber industry, basic metals, fabricated metal products or machinery). It has the largest backward linkages within manufacturing, but also the smallest forward linkages as its output goes to final demand, either to households or investment demand. The value added multiplier is large and ranges in the middle field of all manufacturing industries. Of this, the intra-EU component is very much pronounced, as the motor vehicle industry is the most integrated sector within Europe. The motor vehicle sector is the second largest sector in the European Union in terms of production and ranks also high in terms of value added and employment. It shows the second highest values for gross investment and the investment rate. It scores worst in terms of value added multiplier change but high in terms of changes of production, value added and employment shares. Its SME intensity is the lowest within manufacturing (only 8% of turnover generated by SMEs).

Within the European Union, half of value added is generated in Germany, followed by the United Kingdom (10%), France (8%), Italy (6%) and Spain (5%). The countries most specialised on the sector (i.e. measured by the share of machinery in total manufacturing value added) are the Czech Republic, Germany, Hungary, Romania and Slovakia. The EU value added multiplier ranges around 0.8 but is smaller for a small range of countries (see the Figure below with country overview).

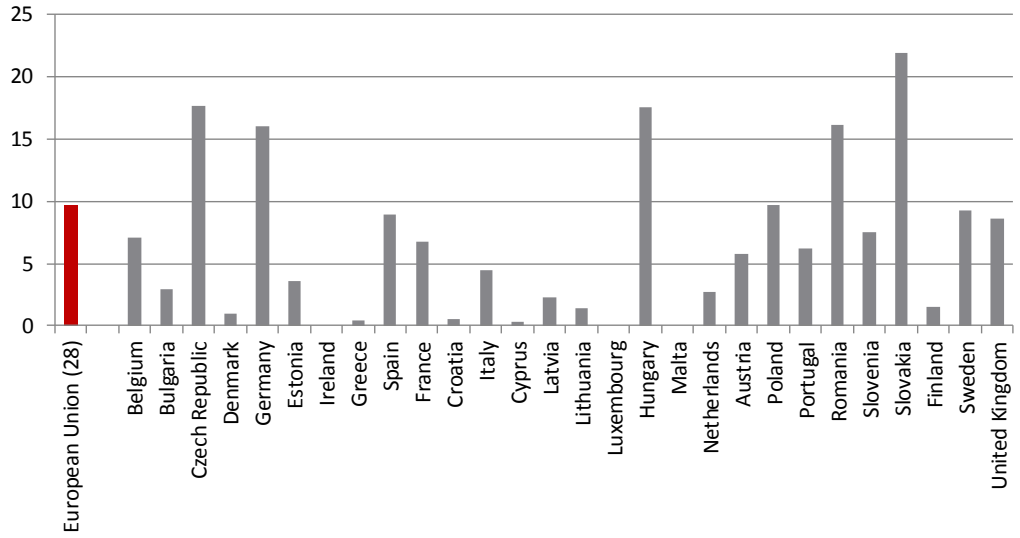
A. Motor vehicles, trailers and semi-trailers, value added, 2013, in % of EU (28)[152]



[151] https://www.britannica.com/topic/automotive-industry

[152] Colors/countries change clock-wise starting at 12.00.

B. Motor vehicles, trailers and semi-trailers, value added, 2013, in % of manufacturing



C. Motor vehicles, trailers and semi-trailers, Industrial value chains: value added multiplier, 2014

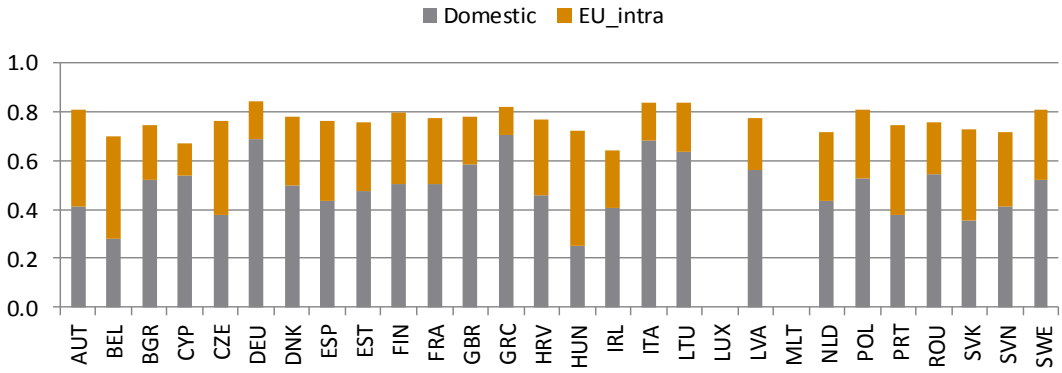


Figure 47. Country overview Motor vehicles, trailers and semi-trailers, value added, 2013, in % of EU-28[153]

Given the broad nature of the motor vehicles industry, for the purpose of identifying investment needs, obstacles and remedies, a further focus is needed to select a specific segment within the automotive industry where investment needs of a coordination nature occur. Therefore, through the development of extensive literature review, as well as interviews with relevant companies and associations from the sector, it is proposed that the case study would focus on the electric vehicles (EVs) segment, more specifically in the value chain for the development of batteries for electric vehicles (BEVs), in particular for the light passenger cars segment. This selection does not perceive that this is the only segment from the motor vehicles industry where investment needs of a coordination nature exists.

[153] A and B: Eurostat SBS; C: WIOD-release 2016 (preliminary)

Currently, the EU industry lacks the capability of mass production of BEVs in comparison with other competitors such as China. In this sense, the EU industry needs to differentiate itself from other players in several parts of the industrial value chain. At the supply side of the value chain, investment in research and development (R&D) is required for the cell production of the batteries and their assembly, finding innovative alternatives for these processes. At the demand side of the value chain, the investment needs are linked with the need of developing enhanced and leaner processes for the vehicle integration and recycling and reuse of the BEVs. In addition, a third area of investment needs consist in the need for coordinated cooperation for having shared facilities and infrastructures for R&D, as well as enhanced synchronisation among the different players in the value chain.

The automotive sector provides 12 million jobs in the EU, having strong economic links with other industrial sectors. However, air pollution continues to be one of the major problems concerning road transportation. In this sense, EU's policy in the automotive sector is related with ensuring environmental protection and safety and enhancing competitiveness and its internal market154.

For the cause of this study it is worth mentioning that BEVs are not confined within only one activity class of the NACE classification. It runs across various sectors and is as such for analytical reasons not readily observable. Nonetheless, the case of BEV is considered to be strongly linked with the classification under NACE classification 29.3.1 Manufacture of electrical and electronic equipment for motor vehicles. This is a subsector of Manufacture of motor vehicles, trailers and semi-trailers, which has been identified in Task 1.4 as one of the five sectors whose value chain has a relatively high value added multiplier within the EU economy. Furthermore, the SBS data on the 3-digit level shows that the sub-industry of the manufacture of parts and accessories for motor vehicles ranks first in terms of number of persons employed within the industry. In addition, the manufacture of parts and accessories for motor vehicles has the highest turnover and value added after the manufacture of motor vehicles, which is also one of the sub-industries considered for this analysis.

The following sections provide additional information on why the EVs segment and specifically the BEVs are regarded as critical in the motor vehicles value chain, as well as identify investment needs and obstacles. In addition, the case study proposes potential solutions that could remove the identified investment obstacles.

2.4.1 Understanding of the industrial value chain

The motor vehicles industry is the most integrated one within Europe, being a sector dependent on interindustry supply (sourcing from the rubber industry, basic metals, fabricated metal products or machinery). The motor vehicle sector is the second largest sector in terms of production and ranks also high in terms of value added and employment. It shows the second highest values for gross investment and the investment rate. High in terms of changes of production, value added and employment shares. Due to the variety of concepts within the motor vehicle industrial value chain, it is relevant to provide some definitions for further consideration in this case study:

- Passenger cars: motor vehicles with at least four wheels, used for the transport of passengers, and comprising no more than eight seats in addition to the driver's seat.
- Light commercial vehicles: motor vehicles with at least four wheels, used for the carriage of goods.

[154] https://ec.europa.eu/growth/sectors/automotive/policy-strategy_en

- Heavy trucks: vehicles intended for the carriage of goods. Maximum authorised mass is over the limit (ranging from 3.5 to 7 tons) of light commercial vehicles. They include tractor vehicles designed for towing semi-trailers.
- Buses and coaches: used for the transport of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass over the limit (ranging from 3.5 to 7 tonnes) of light commercial vehicles.
- Light vehicles: passenger cars and light commercial vehicles.
- Commercial vehicles: light commercial vehicles, heavy trucks, coaches and buses.[155]

This case study focuses on the analysis of the light vehicles segment, and particularly in the passenger cars industry. The passenger cars industry represents more than 80% of the total motor vehicle production in the world (this includes commercial vehicles). At the European level, this represents around 86% of all production in 2015. According to the study from ACEA, there are a total of 225 automobile assembly and engine production plants in the EU, being that the countries with the highest number of production plants are Germany, France, the UK, Poland and Spain. A geographical presentation of the motor vehicles production plants is displayed in Figure 48 and Figure 49[156].

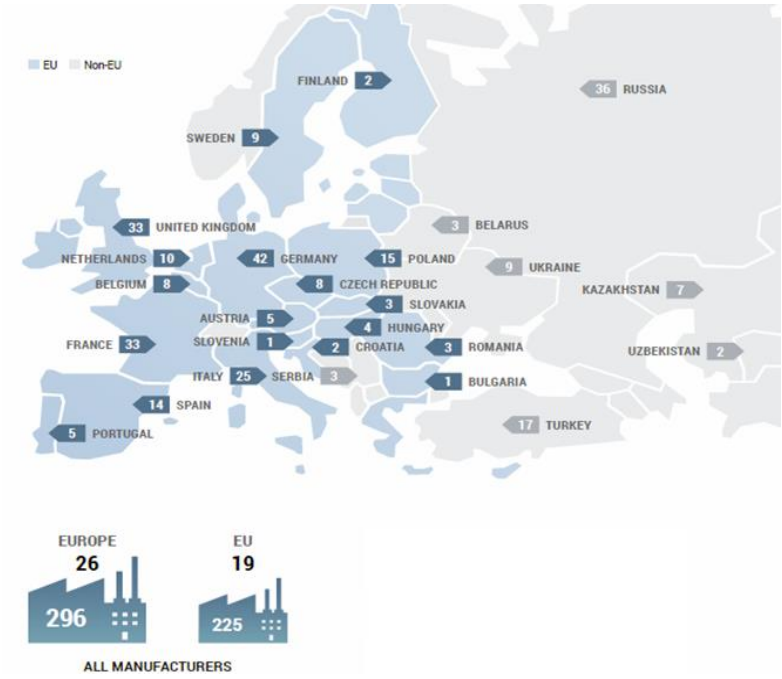


Figure 48. Automobile assembly and engine production plants in Europe[157]

Regarding the global passenger cars industry, the manufacturing process is regionally focused, mainly due to transportation costs, currency fluctuation risks and trade barriers, among others.158

[155] OICA Statistics - Definitions

[156] The Automobile Industry Pocket Guide - 2016 / 2017, ACEA (2016)

[157] The Automobile Industry Pocket Guide – 2016 / 2017, ACEA (2016)

In terms of total sales in the EU, the passenger cars segment has witnessed a growth of 9.3 % between 2014 and 2015, with a total of 13.7 million cars registered in the EU in 2015.159 It is expected that for 2016, car sales rise around 2% in the EU, reaching 14 million units. 160 In addition, around 75% of all new passenger car registrations occur in the five largest markets (Germany, France, the United Kingdom, Italy, and Spain). Therefore, and considering the above mentioned factors, the study focuses on the passenger car segment of the motor vehicle industrial value chain, which is considered most important for the European market.

Concerning the total market share, and as illustrated by market forecasts by KPMG in Figure 49, the motor vehicles is expected to grow its sales volume over the years, with a CAGR of 4,1%, shifting from 95 million Euros in 2016 to 111 million Euros in 2020.

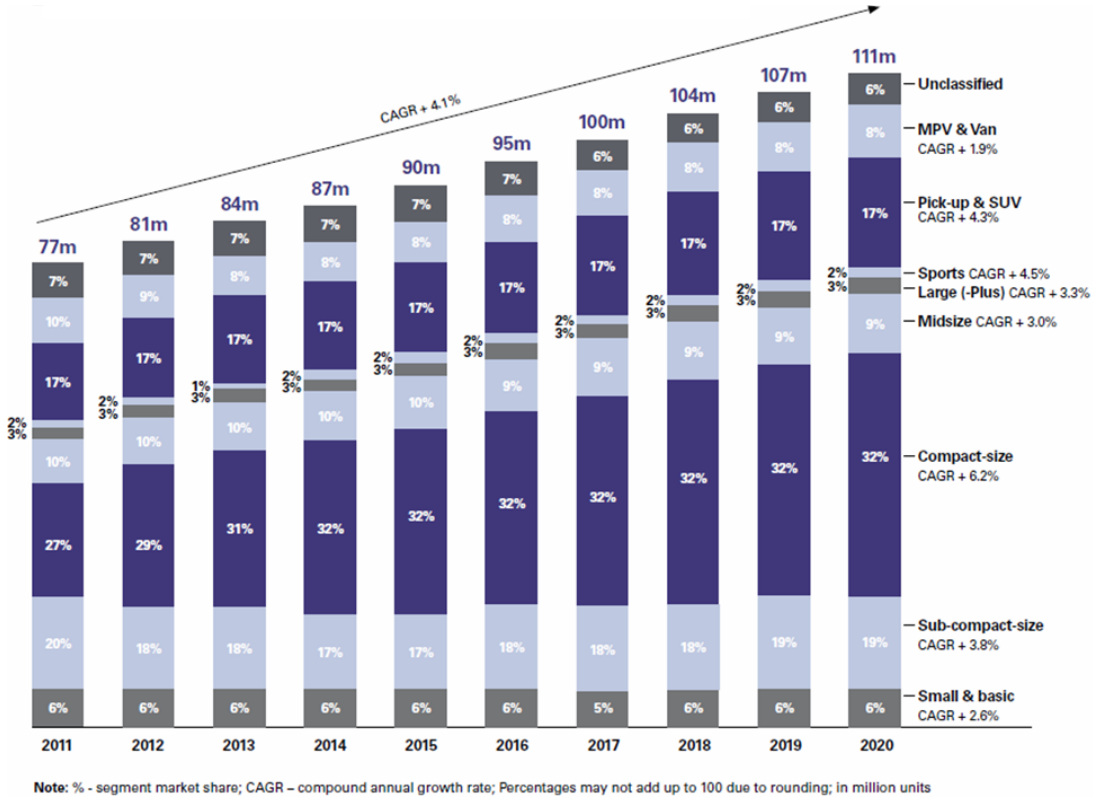


Figure 49. Light vehicle sales forecast by segment market share (2011-2020)[161]

In terms of market share among passenger cars in Europe, Audi, BMW and VW account for the top-three players with the highest share, while Opel, Fiat and Renault have the lowest market shares as of 2014.162

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[158] http://www.theicct.org/blogs/staff/2014-fuel-price-turbulence-evs

[159] The Automobile Industry Pocket Guide – 2016 / 2017, ACEA (2016)

[160] http://www.acea.be/press-releases/article/auto-industry-forecasts-modest-growth-for-2016

[161] KPMG's Global Automotive Executive Survey, KPMG (2015)

[162] European Vehicle Market Statistics Pocketbook 2015/16, ICCT (2015)

The market growth is dependent on the emerging economies, particular China, while the established markets will continue to slow their pace163. Specifically within the passenger segment of the motor vehicles, the electric vehicles (EV) market is growing at a fast pace, expecting to reach a total of 19.2% CAGR between 2013 and 2019, with the global market revenue projected to be of 271.67 billion USD (around 246 billion EUR). In this sense, for the purpose of this study, the EV are considered to be all the automotive vehicles with a power train that has electric motor as the primary mover – range extended electric vehicle (REEV), the battery electric vehicle (BEV) and the fuel cell electric vehicle (FCEV).

The high operating cost of conventional vehicles, combined with its eco-friendly characteristics, is changing the consumers' mind-set regarding EV and driving its global market to a higher standard.164 According to the European Automobile Manufacturers' Association (ACEA), the total alternative fuel vehicle registration in the EU continues to grow (6.4% in 2015). Of these alternative fuel vehicles, EV registrations rose 26.8%, which was supported by the growth of both battery (33.9%) and plug- in electric vehicles (23.5%). Alternatively, new registrations of cars powered by propane or natural gas showed a decline of 22.4%.165

Concerning the EV market, Europe is rather strong in raw electrochemical materials and in the production equipment. According to the EU Batteries Directive (2006/66/EC), automotive batteries are defined as "any battery or accumulator used for automotive starter, lighting or ignition power", and industrial batteries are defined as "any battery or accumulator designed for exclusively industrial or professional uses or used in any type of electric vehicle". In terms of battery technologies for automotive applications, there are several classes to classify the different types of vehicles166:

- **Class 1:**
  - Conventional ICE vehicles
  - Start-stop vehicles
  - Micro-hybrid vehicles (basic)

  } **Lead-based battery**
- **Class 2:**
  - Micro-hybrid vehicles (adv)
  - Mild-hybrid vehicles
  - Full-hybrid vehicles (HEVs)

  } **Mix of battery technologies**

  Lead-based auxiliary battery
- **Class 3:**
  - Plug-in hybrid electric vehicles (PHEVs)
  - Full electric vehicles (EVs)

  } **Lithium-ion battery**

As previously mentioned, the present case study focuses in the EV segment of the passenger cars industrial value chain. In particular, lithium-ion BEVs are taken into consideration for identifying specific investment needs and obstacles within the sector. EVs are propelled by

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163 http://www.mckinsey.com/industries/high-tech/our-insights/disruptive-trends-that-will-transform-the-auto-industry

164 Electric Vehicles Market (on-road) (hybrid, plug-in, and battery) - Global Industry Analysis, Size, Share, Growth, Trends and Forecast, 2013 – 2019, TMR (2014)

165 ACEA Economic and Market Report: Q1 2016, ACEA (2016)

166 A Review of Battery Technologies for Automotive Applications, EUROBAT, ILA, ACEA, JAMA and KAMA (2014)

lithium-ion batteries, which is the only technology available capable of filling the Original Equipment Manufacturers (OEMs) requirements for vehicle driving range and charging time. It is expected that significant resources will continue to be used for improving the performance of lithium-ion batteries, in particular its system integration, cost, performance, safety, recyclability, among others.

In addition, it is expected that cell (a "cell" is the unit that contains the basic electrochemical components; a battery is defined as a set of "cells") design will lower its costs by 2025, improving the competitiveness of lithium-ion batteries.167 In 2030, it is expected that EVs will range between 10% and 50% of new-vehicle registrations, which will depend on the city development, regulations concerning gas emission and other incentives.168

In the BEVs, the value chain consists of seven steps from the component production until its utilisation and further reuse and recycling. The dotted line in Figure 50 separates the supply side and the demand side within the value chain.

Figure 50. Value chain of BEVs[169]

At the beginning of the value chain of BEVs, it is possible to find the manufacture of components, which includes raw materials that will be transformed into resources used under the production of single cells. The next steps concern the configuration of the cells into a larger module that will be further integrated into a battery pack: set of modules assembled together with systems that control power, charging and temperature. These first four steps constitute the manufacture of battery packs that will be further used by OEMs. The next step concerns the integration of the battery pack into the vehicle structure, followed by the further use of the vehicle by the client. The final step is related with the reuse and recycling of the battery used in the vehicle, including deconstruction and cleaning preparations of the battery.

Improvements that could be made in order to overcome hurdles are found all across the value chain, both on the supply and the demand side, as well as in a coordinated nature amongst the value chain.

In addition, interviews revealed that there is high demand for electric battery and thus a business opportunity – every relevant stakeholder in the industry is giving a big focus to

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[167] A Review of Battery Technologies for Automotive Applications, EUROBAT, ILA, ACEA, JAMA and KAMA (2014)

[168] http://www.mckinsey.com/industries/high-tech/our-insights/disruptive-trends-that-will-transform-the-auto-industry

[169] Batteries for Electric Vehicles, The Boston Consulting Group (BCG) (2010)

having electric battery projects. However, Europe does not have a big storage capacity, so there is a big need for raw materials, namely those that are imported from African and Asian countries.

Currently, the EU is strong in providing raw electrochemical materials and production equipment, but a gap is identified in the knowledge and experience for mass scale production.

2.4.2 Identification of investment needs

The constant need of reducing car emissions and limit its impact on the environment led to an increase in the adoption and production of Electric Vehicles (EVs). One of the main obstacles related with the adoption of EVs is related with the costs and technical requirements for developing alternative power trains to EVs, in particular in the battery development.

In this sense, there is an increased interest from the industry and research community in developing new electromechanical mechanisms that could enhance the batteries performance, life span, energy, power safety and costs. As previously described, there are several types of Lithium-ion batteries that can be adopted in EV, each of them with specific technical features. Additional, there is a high demand for reducing the battery costs of BEVs, namely on reducing manufacturing costs through scale and experience effects of the market. In order to enhance the competitive position of BEVs in Europe, it is important to strengthen the critical parts of the value chain. The investment need could be justified by the fact that improving a critical part of the value chain would benefit the entire chain, supporting the modernisation of battery development within the EU.

Through interviews with relevant associations and companies from the motor vehicles industry, the project team identified several areas where investments are needed, which could contribute to enhancing Europe's competitive advantage in battery production (in particularly, cell development innovation processes), improving its technological capabilities and increasing its position in the battery development for EVs.

Building on the findings from the other case studies, interviews have revealed that investment needs manifest in both sides of the value chain, in order to position Europe as a main player in the Batteries for Electric Vehicles (BEV) value chain.

Figure 51. The supply side of the BEVs value chain

At the supply side, there are several investment needs in particular regarding costs and performance of BEV, namely in the cell production. As previously stated, Europe is strong in producing raw electrochemical materials and in the production equipment, but lacks in the knowledge and experience on manufacturing batteries at the mass scale level. For producing batteries packs, in particular the module production, the manufacturing and assembly of single cells plays a major role. These actions need to take into consideration the performance factors that should be made available through improvements in cell materials and components (i.e. anode, cathode materials, binder, separator and electrolyte). These improvements will increase the competitiveness and performance of lithium-ion batteries170. In this sense, further investment on R&D for battery cells production and battery assembly, as well as cost reduction, are needed. Furthermore, the global supply chain is dominated by countries such Japan and China in every major component category, as well as in the cell manufacturing process. The development of key cell components and innovation in this field requires advanced chemical engineering knowledge. In particular, specific research on enhanced design parameters for BEVs to optimise the equilibrium between energy usage and power levels is needed.

The cost and performance of batteries can have a significant impact in the development of EVs. Specifically, there are potential investments needs in the improving of battery assembly for EVs and supporting the industry modernisation. Companies responsible for the pack assembly are normally located near their consumers, where R&D, engineering and design are considered highly valuable activities. According to the interviews developed, the demand for EVs in Europe is rising, which allows it to have competitive advantage in some specific areas of the value chain, developing the electric mobility process. As stated by one of the interviewees, Europe can have competitive advantage in the battery assembly part.

[170] A Review of Battery Technologies for Automotive Applications, EUROBAT, ILA, ACEA, JAMA and KAMA (2014)

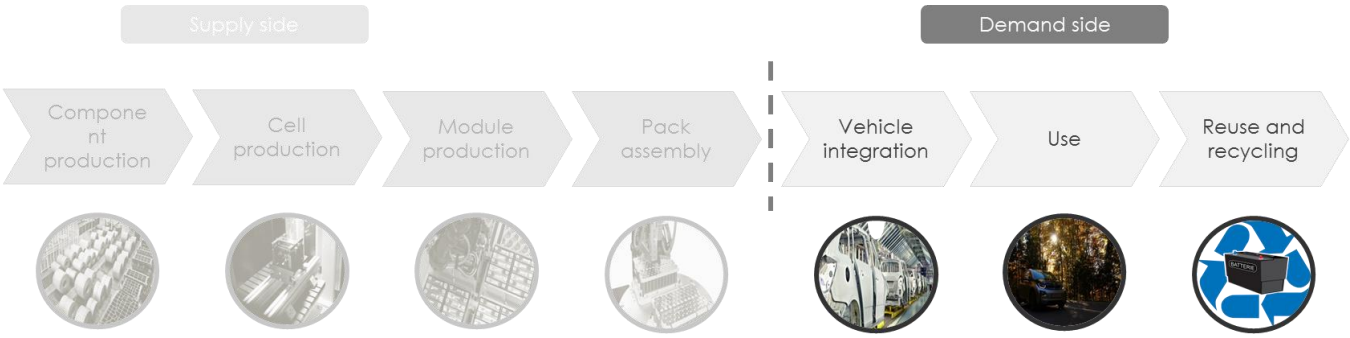


Figure 52. The demand side of the BEVs value chain

Regarding the demand side of the value chain (illustrated in Figure 52) there are several potential investment needs, particularly the ones related with the reuse and recycling of the batteries for EVs, which could be used for different applications, such as photovoltaic panels. The process of reusing and recycling BEVs has been witnessing higher demand over the years, with the establishment of new industrial recycling processes, as well as research projects to recover several of the battery's components. In this sense, an investment is identified for having enhanced techniques for the batteries recycling. Furthermore, with enhanced recycling and reuse techniques, it is expected that the battery costs are reduced. There has been an increase of key stakeholders that are trying to optimize the separation process of the battery's components after its use. In addition, it is also expected that synergies are created with the recycling industry in a way that it is possible to establish the needed capacity according to the expected volume from increased EVs sales.

In addition, within the segment of the vehicle integration, it is expected that improvements will be made concerning the systems integration of lithium-ion batteries into the electric vehicle, as there is a big demand from several OEMs that are very active in this area, such as VW. In particular, there is an investment need in research for optimising the mechanical properties (shape, weight and standardisation) of the Battery Management System (BMS) interface.171

A third area of investment needs consist in the requirement for coordinated cooperation among the different players in the value chain with respect to the application of lithium-ion batteries for EVs. Investment on the following is specifically required to modernise the industrial value chain for Europe to obtain competitive advantage in the batteries for EVs segment:

1) Coordinated investments in RTD shared facility or infrastructure;
2) Coordinated investment in developing methods to increase the performance of cells for lithium-ion batteries (namely by increasing cell power);
3) Coordinated investment in developing new methods and processes for assembly and packaging of the battery;
4) Coordinated investment in developing new methods and processes for enhanced vehicle integration of the battery;

[171] A Review of Battery Technologies for Automotive Applications, EUROBAT, ILA, ACEA, JAMA and KAMA (2014)

5) Coordinated investments in developing new ways of reusing and recycling lithium-ion batteries for EVs (namely for hybrid and electric applications).

Coordinated investments are the quickest way to modernise and improve EU's knowledge and competitive advantage in the development of batteries for EVs and continue to improve the EVs segment in the region. In this sense, these require cooperation and synchronisation of different actors along the value chain which is somewhat challenging due to companies' reluctance in sharing knowledge and innovation. Specifically, investment in providing a common platform for R&D progress in the cell development, pack assembly and vehicle integration would be crucial for developing innovative actions in the industrial value chain. This would be achieved in cooperation with universities, research centres, OEMs and battery/cell manufacturers. The Green Car Initiative and the SmartBatt project are two examples that provide innovation actions in a coordinated way between different types of stakeholders. The Green Car Initiative provides financial support to research in the green technologies; while the SmartBatt project (FP7) aimed to "develop and proof an innovative, multifunctional, light and safe concept of an energy storage system which is integrated in the pure electric car's structure"172. Nevertheless, the number of these joint initiatives is still low.

Geographical dimension of the investment needs

Regarding the geographical dimension of the investment needs, it is relevant to analyse the distribution of the industrial players and the universities and research centres involved in the industrial value chain. Regarding the supply side of the industrial value chains, the main producers of cells for BEVs are located outside Europe (such as Japan and China). Nevertheless, France and Germany play a strong role at the European level in terms of producing cell components for electric vehicle applications, while there are a high number of research papers published and research work developed in countries such as France, Italy and Spain. It is also relevant to highlight new innovative organisations that have been emerging across Europe that focus on new battery technologies and complementary applications. For example, one start-up from Estonia is focusing on the design and engineering of custom battery packs and is currently one of the most promising organisations in Europe. Another relevant example is an Austrian technological start-up that focuses on innovative battery technologies for high performance application in EVs. This is replicated throughout Europe where there are more innovative organisations focusing in this thematic and in providing new solutions for battery performance levels.

2.4.3 Assessment of investment obstacles

In the previous section, several investment needs within the lithium-ion BEVs value chain were identified and analysed. However, it is important to understand the several obstacles that might exist towards these investments. This sections aims to provide the main obstacles to the previous mentioned investments, both at the supply and demand side of the value chain, whether it can be related with the low current demand towards EVs, or specifically towards coordination gaps across the value chain.

Regarding the supply side, the main obstacles are concerned with the technical capabilities of the batteries, namely autonomy, safety, life span and power, as well as with its high costs.

172 http://www.smartbatt.eu/

Although there are some EU projects that focus on improving the performance and cost of the BEVs, there is still a lack of investment in developing methods to modernise the industry and the quality of the materials. The high value of battery costs is one of the main obstacles to the sector, although this is expected to decline significantly until 2020. In fact, the cost per kWh of a cell is expected to decrease 60% of its costs from 2009 until 2020. However, this cost decrease will be slower than the price of the battery packs as around 30% of cell's costs are independent of mass production. Another relevant obstacle concerns the incentives needed to support the development of investment in new applications for the cell production and battery assembly, namely regarding the regulatory framework – it is still uncertain at this point what would be the CO2 targets for 2030 in Europe, which will have a direct influence on the number of EVs registrations in Europe. In addition, the manufacturing process of the BEVs, in particularly the cell development, contains risks of environmental damage that should be carefully tackled.

Concerning the demand side, one of the main obstacles to investment is related with the low demand on EVs at European and World level. Although some progress has been made in the last years, the total market share of EVs registrations worldwide accounts for less than 1% of the total compared with other alternative methods.173 As stated by one of the interviewees from an automotive association, electric vehicles are still a niche market. In addition, there are obstacles concerning the lack of investment and improvement in the connected applications that might not be sufficiently mature to the market, e.g. battery charging process, battery insurance services, and battery replacement services, among others. According to the interviewees, the industry is opened to cooperation among different areas, providing opportunities for new organisations to be part of the automotive value chain. In addition, investment obstacles might arise for SMEs that do not have the same financial capabilities compared with OEMs that have high access to capital and finance. It is also relevant to note that car manufacturing has relatively low margins compared to other manufacturing sectors.

2.4.4 Possible solutions to remove investment obstacles

It is expected that in the next years the costs of producing battery cells, as well as the assembly process, will decrease, lowering the price of the EVs. With the mass production effects (specifically in Asia), it is expected that these costs decrease in the next years. As Europe does not have the same mass production capabilities compared with countries such as China, it is essential that it focuses on innovation processes that are able to further develop the EVs batteries value chain. In addition, further improvements are expected in the complementary services that are related with EVs, such as the charging system. The main question relies on how fast can investment in these areas accelerate the process. On the supply side, the main solutions are related to the development of techniques for cell production and assembly techniques and processes that allow enhanced performance of batteries for EVs, as well as lower costs in the medium to long-term. In particular, it is expected that investments through R&D joint initiatives occur, as well as support through tax incentives, reducing the environmental risk and promoting the development of more efficient solutions. Another solution is related with the development of an automated battery pack assembly line, which could reduce the costs for the BEVs and increase Europe's production and innovation capacity. On the demand side, the investment needs consist in recycling and reusing components from the batteries for EVs, as well as improving the process of battery integration into the vehicle, which could provide a competitive advantage to Europe in the assembly part (through the big OEMs) and in finding new utilisation

173 http://www.ev-volumes.com/country/total-world-plug-in-vehicle-volumes/

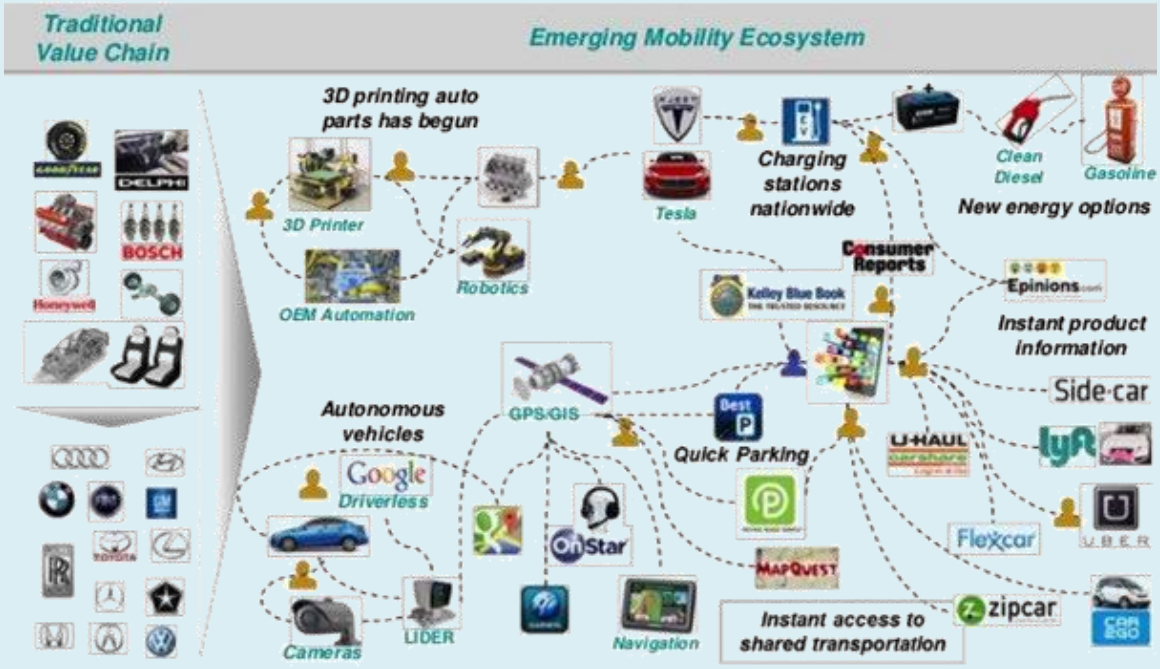
solutions for the recycling and reuse process. These are primarily associated with lack of cooperation between academia and industry. In this sense, solutions related with tax incentives to promote innovation in the production processes (including the assembly part), as well as joint R&D projects to enhance academia and industry cooperation would be feasible for this purpose. Furthermore, R&D investments for the development of new techniques and processes should be considered by the main industrial players. It is expected that with enhanced recycling and reuse techniques the battery costs are reduced. In addition, particularly related with the recycling and reuse, there is still a lack of regulatory framework for developing new processes, as well as a risk of environmental damage in doing so.

The opportunities for coordinated investments solutions consist in coordinated investments for the development of competitive solutions for Europe's positioning in the batteries for EVs value chain, modernising the manufacturing process and providing new innovative solutions for the sector. Besides providing a common basis for research, assembly and processing costs, the industry would benefit if big players could also share knowledge as well as facilities with other relevant stakeholders in the value chain. This would allow improving Europe's innovation capacity in the BEVs sector, promoting cooperation between industry and academia, developing new techniques for the different stages of the industrial value chain. In addition, local government support actions to promote the use of EVs should also be considered as a solution for enhancing Europe's production capacity (e.g. through troll exemptions, free parking, free charging). For the main European OEMs to start producing more EVs, cheaper and more powerful solutions are requested to the lithium-ion batteries. In this sense, coordination on innovation actions of the sector should be a priority, allowing to an increase of EVs market share on the automotive sector. However, sharing knowledge is most of the times challenging for industrial players, particularly in a competition context, as stated by some interviewees.

Example of a coordinated investment solution: joint investment programmes

An investment in a specific player or stakeholder within the value chain has a positive impact in other organisations in the value chain. In this sense, having different organisations doing investments in a synchronised and coordinated matter can provide a positive innovation and modernisation cycle that will support the development of the value chain as a whole. This might be the case in the BEVs value chain when a cell producer makes an investment to improve the manufacturing process, and at the same time an organisation that assembles battery packs invests in modernising the installation process. Both investments will be able to reduce the costs of BEVs production and accelerate the development of innovative and enhanced solutions for developing BEVs.

In this sense, there have been several disrupting actions that allowed the motor vehicles value chain to modernise, in particular through the EVs, and more specifically, the BEVs. Regarding some measures that have been taken at the EU level, it is relevant to note that there has been an increasing investment in R&D projects that aim at increasing the sustainability of energy sources, as well as innovative technology that could provide competitive advantage towards other regions such as Asia and the US. Furthermore, the Green Car Initiative has been established by the European Commission in this sense, providing financial support to research in green technologies, which include (but not limited to) passenger cars, in particular EVs. According to the Green Car Initiative, Europe's priority should be on high-energy density batteries, electric powertrains, smart grids, among others. Some of the actions perceived under this initiative are related with the support of R&D projects to enhance the development of BEVs and the EVs segment, as well as complementary technologies[174]



[174] IBM Institute for Business Value, IBM Corporation (2015)

In addition to this, it is relevant to highlight the current transformation that the automotive industry has been witnessing in recent years. Besides shifting towards greener solutions for motor vehicles, new stakeholders have been entering the value chain, providing diverse solutions and technologies that were not available in the past. Disruptions such as software inclusion, internet solutions and big data applications are entering the automotive industry. The modernisation aspects that are related with the EVs are connected with these improvements, in particular those associated with electromechanical platforms. This change requires a comprehensive and operational strategy from the value chain actors towards innovation processes and solutions that can provide competitive advantage in regard to other markets. This brings opportunities and challenges at the EU level, with the creation of new jobs associated with the demand for EVs and other solutions, but reducing jobs associated with traditional fuel industries, especially in the supply side.

Coordinated investment solutions

In this sense, future work should focus on identifying complementary and coordinated ways of developing a joint investment programme that would involve the several segments of the automotive industry value chain, particular in the EVs segment, taking into consideration other areas such as automated driving and e-mobility software that allows the modernisation of the industry. Some priorities need to be established, particularly in the consistency of EU's regulatory framework at the national, regional and local levels, developing supporting market instruments and investment packages that allow the stakeholders to adapt its processes to the new trends and exchange of best practices within the value chain.

Case Study 5: Fabricated metal products – Co-engineering and Coating Reuse and Recycling

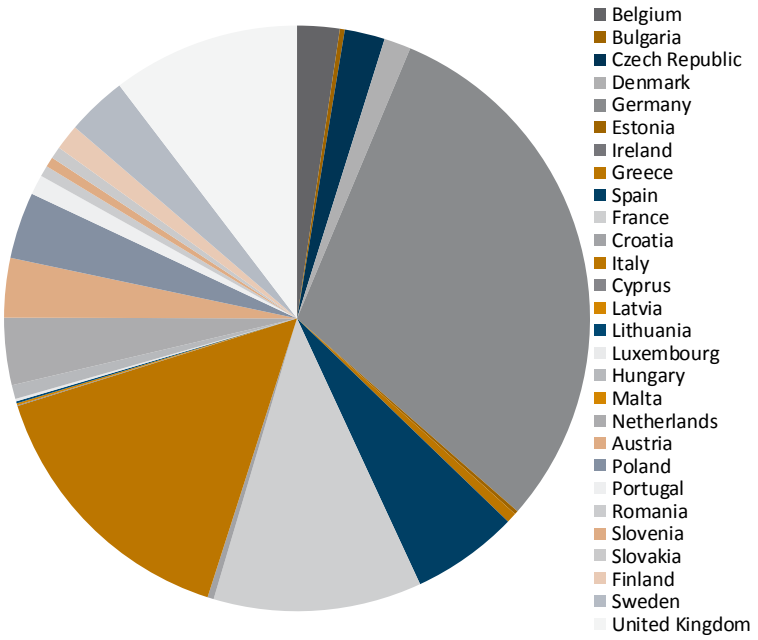
The fabricated metal products sector has been selected in Task 1.2 as one of five key industries to be explored in case studies.

Fabricated metal products (NACE rev. 2, C25) is a key industry, with large backward and forward linkages. Main inputs for example are sourced from the basic metals industry. It sells its products to a range of other industries from the motor vehicles industry, other transport equipment, machinery or electrical equipment to the repair sector. The value added multiplier is large and ranges in the middle field. It has a pronounced domestic value added component. The fabricated metals products sector is a medium-sized industry in the European Union in terms of production, but a large industry in terms of value added and employment. It scores in the middle field for changes, but has the second highest SME-intensity (74% of turnover generated by SMEs).

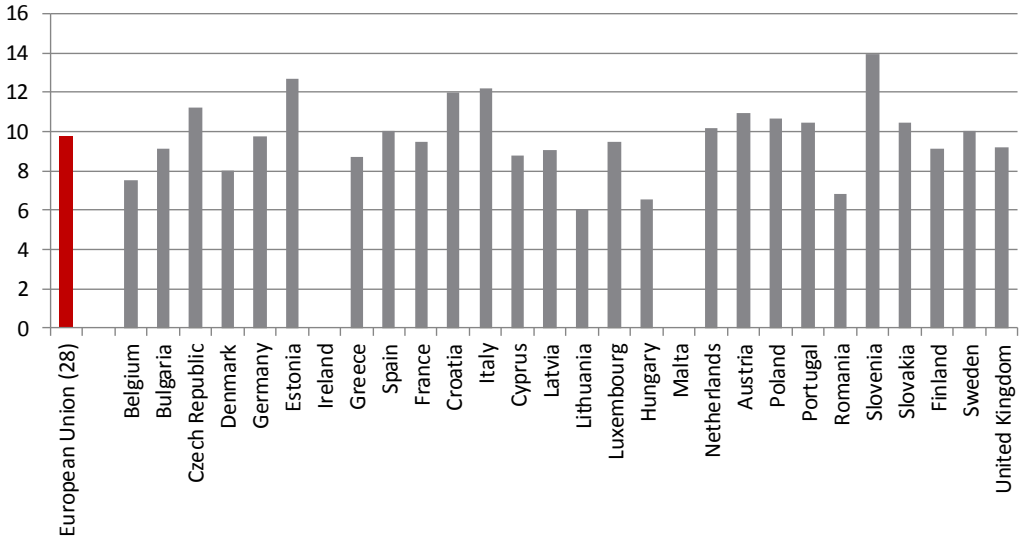
Investment needs with respect to intra value chain collaboration apply to all subsectors of the fabricated metal products sector. However, co-engineering might apply mostly to the "subsector manufacture of structural metal products (NACE 25.1)", since structural metal products are often further applied in other products, thus allowing for co-engineering. In the case of the reuse and recycling of coating powders, the relevant subsector of the fabricated metal products sector would be the subsector 'treatment and coating of metals and machining (NACE 25.7)'.

Within the European Union, about 30% of value added is generated in Germany, followed by Italy (15%), France (12%), the United Kingdom (10%), and Spain (6%). The countries most specialised on the sector (i.e. measured by the share of machinery in total manufacturing value added) are the Czech Republic, Estonia, Spain, Croatia, Italy, the Netherlands, Austria, Poland, Portugal, Slovenia, Slovakia and Sweden (above 10%). The EU value added multiplier ranges around 0.8 and is smaller only for a small range of countries (see the country overview in the figure below).

A. Fabricated Metal Products, value added, 2013, in % of EU-28[175]



B. Fabricated Metal Products, value added, 2013, in % of manufacturing



[175] Colors/countries change clock-wise starting at 12.00.

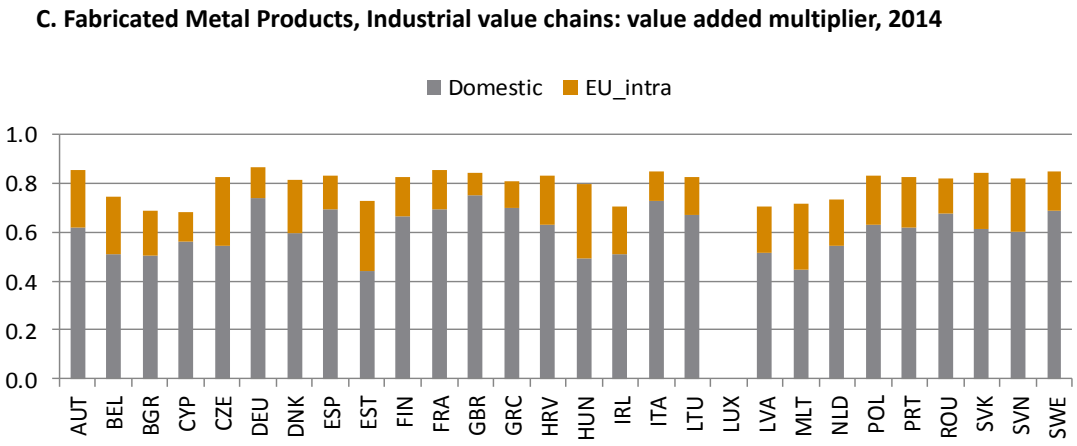


Figure 53. Country overview Fabricated Metal Products value added, 2013, in % of EU-28[176]

The fabricated metal products sector was identified as a key industry with strong forward and backward linkages with other industrial value chains. The fabricated metal products value chain finds itself reliant on raw material, metal scrap and semi-fabricated metal products and supplies its output to its clients. The work within the fabricated metal products part of the value chain is broken down into (i) product and process design, (ii) forging pressing stamping and roll-forming of metal and powder metallurgy, (iii) treatment and coating of metals and machinery and (iv) waste processing.

The fabricated metal products is characterised by several challenges regarding sustainable production and the use of Best Environmental Management Practices (BEMPs), including the need for increasing material efficiency and the valorisation of by-products and waste. An important channel through which these challenges can be met is promoting cross-value chain collaboration. The fabricated metal products sector is investigated from two perspectives: (a) intra value chain investment needs (i.e. investment needs related to collaboration within the value chain) and (b) inter value chain investment needs (i.e. investment needs related to collaboration with other value chains). Intra value chain investment needs were revealed in interviews and the literature review to be centred on co-engineering for improved environmental and economic products amongst fabricated metal producers and their clients. These investments needs include the need for (i) collaboration facilitation amongst partners by means of a joint investment platform, (ii) shared facilities for co-engineering and (iii) improved R&D funding and support.

The inter value chain investment needs were found to be related waste outputs from the fabricated metal products and their possibilities for reuse and recycling as opposed to landfilling. These proved to be inter value chain linkages, but can also feed back into the original fabricated metal value chain. Here the investment needs are (i) R&D on coating powder valorisation, (ii) network on coating powder valorisation and (iii) geographical coverage of recycling plants.

The fabricated metals products sector is one of the two 'key' industries (as opposed to the other three 'supply' industries) selected for this study due to its strong backward and forward

[176] A and B: Eurostat SBS; C: WIOD-release 2016 (preliminary)

linkages with other industrial value chains. Main inputs are sourced from the basic metals industry and other machinery industries and its outputs cover a wide range of other industries given the many application areas of fabricated metal products.

The fabricated metal products sector includes the manufacturing of products made solely from metal (such as parts, containers and structures), usually with a static, immovable function. The fabricated metal products sector is covered by NACE Rev. 2 Division 25, further composed into the following subclasses:

- manufacture of structural metal products (25.1);
- manufacture of tanks, reservoirs and containers of metal (25.3);
- manufacture of steam generators (25.4);
- manufacture of weapons and ammunition (25.5);
- forging, pressing, stamping and roll-forming of metal and powder metallurgy (25.6);
- treatment and coating of metals and machining (25.7);
- manufacture of cutlery, tools and general hardware (25.8); and
- manufacture of other fabricated metal products (25.9).

Within the different subclasses listed above, two subclasses focus on the core activities or processes in the sector, namely the forging, pressing, stamping and roll-forming of metal and powder metallurgy and the treatment and coating of metals and machining. Almost all companies in the sector use one or more of these activities or processes in their production process. The other subclasses describe products made in the fabricated metal products sector.

The output of the fabricated metal products sector can either be an end product or semi-finished products for other consumers or other companies, depending on the type of product and the business model of companies.

In 2010, the fabricated metal products sector comprised 388 000 enterprises in the EU-27 - the largest population of enterprises among any of the NACE manufacturing divisions. Together, these enterprises employed 3.6 million persons and generated a value added of EUR 149 billion. Germany had the largest share of value added in 2010 with 28.2%, followed by Italy (16.7 %), France (12.2 %) and the United Kingdom (9.0 %). SME's are particularly important in the fabricated metal products sector. In 2010, SME's employed 82.5% and generated 76.7 % of sectoral value added177. The fabricated metal products sector has a large value added multiplier (0.86 in 2014) with a pronounced domestic component.

2.5.1 Understanding the industrial value chain

A generic depiction of the value chain is displayed in Figure 54 Raw material and metal scrap (post-consumer and industrial) are inputs for the production of semi-fabricated metal products, preceded by basic metal processing such as mineral processing, smelting and refining. Semi-fabricated metal products include semi-finished casting products such as ingots, blooms, billets and slabs or coils, sheets, strips, pipes and tubes that need further processing before being a finished good. The fabricated metal products sector turns these semi-fabricated metal products into a wide range of products such as structural metal products, tanks, reservoirs and containers of metal, steam generators, weapons and ammunition, cutlery, tools and general hardware. These products are then delivered as end

[177] Eurostat (2013) - Archive: Manufacture of fabricated metal products statistics - NACE Rev. 2 - http://ec.europa.eu/eurostat/statistics-explained/index.php/Archive:Manufacture_of_fabricated_metal_products_statistics_-_NACE_Rev._2

products or semi-finished products for clients, which can be consumers or other industries, depending on the type of product and the business model of companies.

When zooming into the fabricated metal products segment, one can identify different steps that lead to the manufacturing of fabricated metal products. The first element of this value chain is the design of products, processes and infrastructure. The manufacturing or assembly of the products is conducted in many different ways, including forging, pressing, stamping and roll-forming of metal and powder metallurgy. The products are then treated and coated in order to improve the hardness of products, prevent corrosion or decorate the products. Finally, the waste generated in the manufacturing processes is processed.

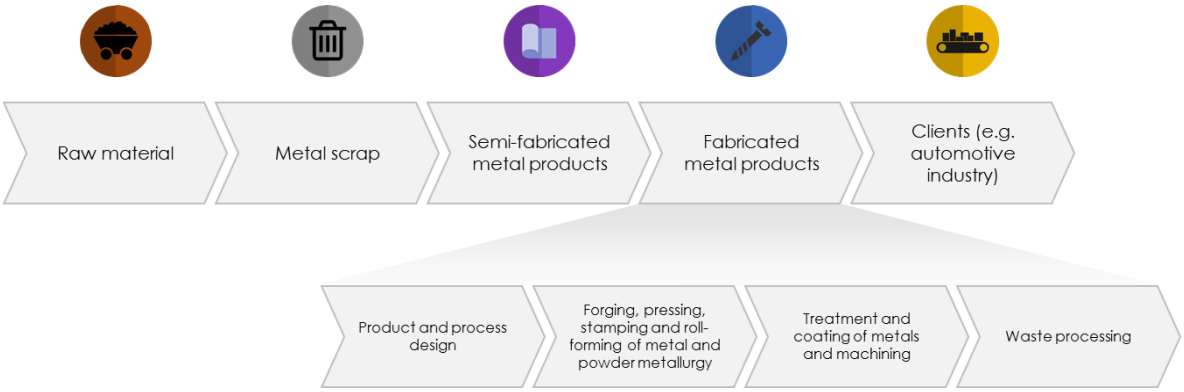


Figure 54. Generic value chain

2.5.2 Identification of the investment needs

The fabricated metal products sector faces a number of important challenges. On the one hand, it needs to remain competitive compared to foreign competitors, for which it must be able to continuously improve its products. On the other hand, interviewees indicated that the sector is characterised by several challenges regarding sustainable production and the use of Best Environmental Management Practices (BEMPs), including the need for increasing material efficiency and the valorisation of by-products and waste. An important channel through which these challenges can be met is promoting cross-value chain collaboration.

These cross value chain cooperation opportunities arise in several ways, as indicated in Figure 54. Firstly, there are cooperation opportunities between companies from the fabricated metal products sector and their clients, such as the automotive or construction industry, through concepts such as co-design, co-engineering and open innovation. This is referred to as the promotion of intra value chain collaboration. Investment needs with respect to intra value chain collaboration apply to all subsectors of the fabricated metal products sector. However, co-engineering might apply mostly to the "subsector manufacture of structural metal products (NACE 25.1)", since structural metal products are often further applied in other products, thus allowing for co-engineering. Another potential area is the valorisation of waste products created in the manufacturing processes of fabricated metal products, for example the reuse or recycling of coating powders in various applications in the chemical or construction industry. This is referred to as inter value chain collaboration, as it concerns interaction of the fabricated metal products value chain with other value chains (see Figure 55). In the case of the reuse and recycling of coating powders, the relevant subsector of the fabricated metal products sector would be the subsector 'treatment and coating of metals and machining (NACE 25.7)'.

Both the co-engineering and valorisation of fabricated metal wastes are types of BEMPs.178 For both areas we discuss below, in more detail, concrete examples of investment needs and how they can promote both environmental as well as economic gains.

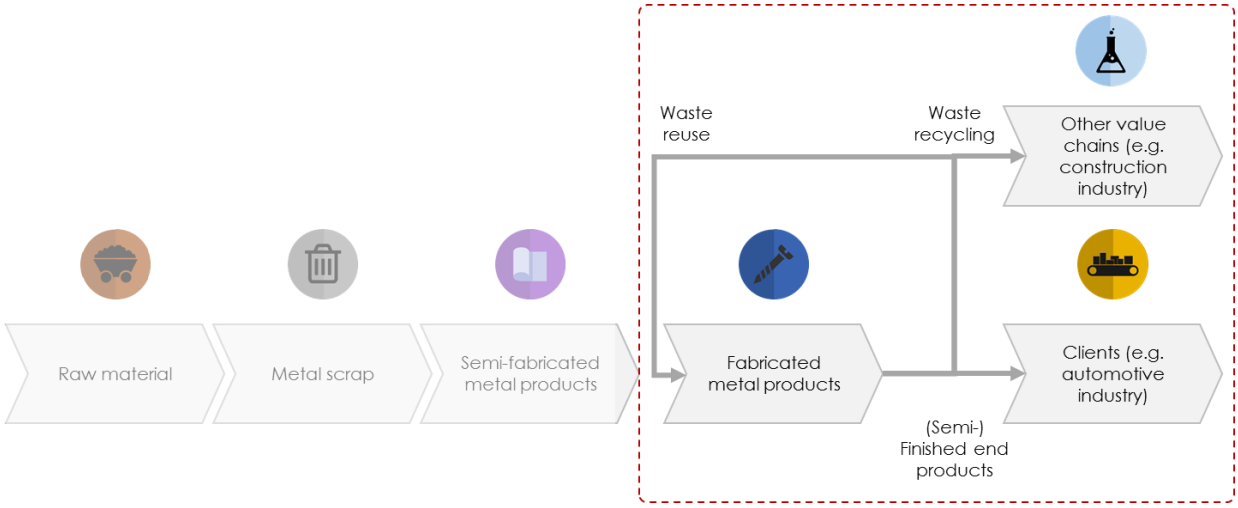


Figure 55. Potential interesting area for investment needs

Investment need 1: Intra value chain co-engineering

Co-design, co-engineering and open innovation serve as the first Best Environment Management Practice with potential economic gains. While often used synonymously, differentiate themselves through their details. Co-design has a creative focus and refers to the creative aspects of the design process in a cooperative manner in which experts such as researchers, designers, developers, potential clients and potential users come together in order to creatively cooperate179. Co-engineering indicates "participatory design and implementation by teams for decision-aiding approaches" 180 and is broken down into co-initiation, co-design and co-implementation. However, co-engineering could also refer to the coming together of engineers from several disciplines in order to build a product with a shared outlook181. Finally, open innovation is defined as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively"182.

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178 JRC, VITO, Sirris, Agoria (2016) - Background report on best environmental management practice in the fabricated metal product manufacturing sector

179 Steen et al. (2011) Benefits of Co-design in Service Design Projects. *International Journal of Design* 5:2, 53-60.

180 Daniell, K. A. (2012) Co-Engineering and Participatory Water Management: Organisational Challenges for Water Governance. Cambridge University Press: Cambridge.

181 http://www.volere.co.uk/reco.html

182 Chesbrough, H.W., Vanhaverbeke, W. and West, J. eds. (2006), Open Innovation: Researching a New Paradigm, Oxford University Press: Oxford.

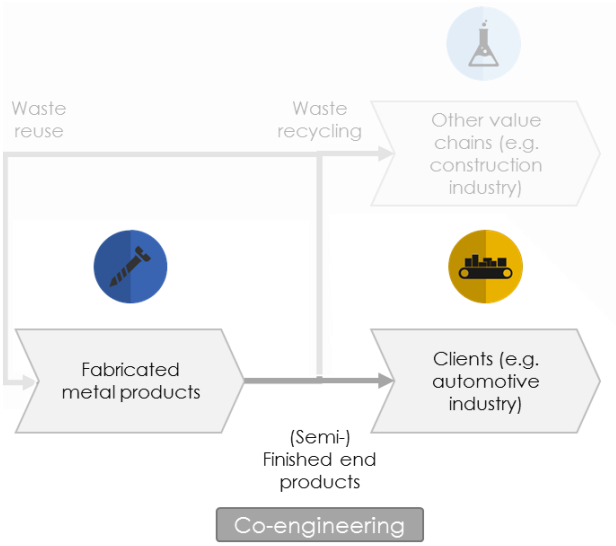

Figure 56. Co-engineering in the example of intra value chain collaboration

The co-engineering of products in the fabricated metal products value chain can lead to potential environmental benefits through working with downstream partners in the process, as depicted in Figure 56. Specifically, product design and engineering are targeted towards the minimisation of environmental impacts along the specific value chain of the companies involved. This means taking into consideration all aspects of production, use and reuse of resources in a joint design phase. The main outcomes of working together with partners to co-engineer a process and product are increased resource efficiency, with a subsequent cost reduction, as well as improved environmental footprint, improved business image and reputation toward environmental perspectives.

In the example of a Belgian company, Curana, that makes bicycle accessories, the open innovation process took and takes place in collaboration with a bicycle manufacturer, bringing highlights of innovation for bicycle parts. Curana indicates to experience higher turnover now, independently of actual bicycle manufacturing numbers in Europe.183

Through considerable innovation and knowledge sharing, businesses in a co-engineering environment are more resilient through their expanded network.184 Beyond the environmental benefits, the motivation behind co-engineering is largely related to the reduction of time to market, the determination of break-through innovations, the search for new partnerships and the improvement of the market position.185 In some industries, such as the automotive industry, co-engineering is already a well-established practice. Interviewees indicated that EU regulation plays a key role in driving co-engineering. Emission regulations for example drive collaboration between car manufacturers and their suppliers in order to create more light-weight and fuel efficient designs. In this case, fabricated metal products are often created in a co-engineering environment, with a lot of R&D inputs, which are

[183] JRC, VITO, Sirris, Agoria (2016) - Background report on best environmental management practice in the fabricated metal product manufacturing sector

[184] JRC, VITO, Sirris, Agoria (2016) - Background report on best environmental management practice in the fabricated metal product manufacturing sector

[185] JRC, VITO, Sirris, Agoria (2016) - Background report on best environmental management practice in the fabricated metal product manufacturing sector

required due to the strict CO2 emissions regulations of the EU. However, there is still a potential in increasing the rate of co-engineering and especially among SMEs.

The main needs of co-engineering are support for collaboration with complementarities, shared physical structures and research and development targeted towards environmental benefits in order to produce products that have both greater economic and environmental benefits.

In order to facilitate the process of co-engineering, investment that supports collaboration amongst partners is needed. This investment need arises from the need to collaborate with complementary partners that have assets that other partners do not share, and benefits the process of bringing a product to market, and a process to fruition that would otherwise be hampered without cooperation. These include the ability of companies to: (i) manufacture on a large scale, (ii) have brands (brand names) at their disposal and (iii) have the necessary distribution channels at their disposal, among others.186

Co-engineering for environmental friendly fabricated metal products that streamline the production and reduce waste can be achieved through shared physical structures, i.e. R&D facilities. These shared facilities for development and innovation can be either funded publicly or through a collaborative investment of several partners. The Open Manufacturing Campus187 presents such an example where open innovation occurs. Such facilities are able to support SMEs who do not have the necessary facilities to develop a shared product.

Fabricated metal product production with an emphasis on environmentally friendly outcomes and production processes are insufficiently targeted at the present. Especially research and development on the production of more environmentally friendly products in an open innovation, co-engineering setting needs more support in order to trickle into the current state of the art production mind-set.

[186] Vanhaverbeke W., Vermeersch I., De Zutter S., 2012, Open innovation in SMEs: how can small companies and start-ups benefit from open innovation strategies. 99p, available online at: http://www.sciencebusiness.net/eif/documents/Open-innovation-in-SMEs.pdf, last accessed October 10th 2016.

[187] http://openmanufacturingcampus.com

Investment need 2: Inter value chain reuse and recycling

The second BEMP is an inter value chain cooperation, and includes the possibilities of environmental and economic benefits through the reuse and recycling188 of waste by-products versus landfilling. Interviewees have indicated that particularly this aspect of recycling of waste through other value chains is in need of incentives in order to be fully realised.

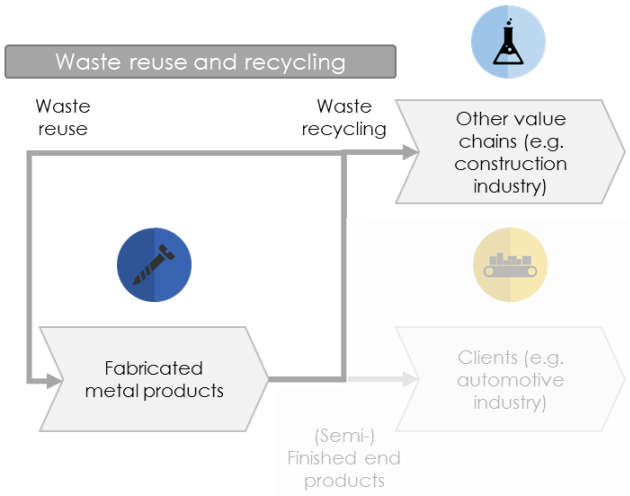

Figure 57. Inter value chain cooperation for recycling of waste

Composites. GMI Composites use the coating powders as a matrix material to manufacture light weight manhole systems using a sheet moulding compound process.[189]

The economic viability of the reuse and recycling of powder coatings waste depends on quality of the waste and the type of collaboration. For high value reuse and recycling options, fabricated metal products companies will not pay anything for removing their waste, in contrast to traditional collection and processing of special waste, for which they have to pay up to 450 €/ton (without transport cost). [190] The problem however is that the waste streams need to be large enough for the collection and transport to become economically interesting. From interviews it becomes clear that it is difficult to achieve industrial cooperation on the collection of the waste.

Investment needs therefore lie in promoting reuse and recycling systems A very specific example is the reuse and recycling of waste from the powder coating process. Powder coating is a dry powder type of coating, typically applied electrostatically and cured under heat to allow it to flow and form a finish tougher than conventional paint. Powder coating is

[188] The difference between recycling and reusing can roughly be defined as follows. Recycling means turning used products or waste into new products. Reusing refers to using an products or waste in unchanged form.

[189] JRC, VITO, Sirris, Agoria (2016) - Background report on best environmental management practice in the fabricated metal product manufacturing sector

[190] JRC, VITO, Sirris, Agoria (2016) - Background report on best environmental management practice in the fabricated metal product manufacturing sector

mainly used for coating of metals, such as household appliances, automobile parts and aluminium extrusions. The powder coatings can either be reused or recycled.

In the reuse option, the waste streams from the powder coating process have to be collected separately by colour and may not contain impurities (like dust). Chemical firms who produce powder coatings then reuse the powders.191 Another option is to recycle the waste from the powder coating process to produce other, new materials (composites, glues, etc.). Possible applications are to melt the powders to plastic parts, use them as a bonding agent for carpet padding, use them to make sound-proofing material, or to use them as additive to cement aggregate.

For recycling there is often no need to keep colours separate and small impurities (like grind, stones) are acceptable. An example of the recycling of powder coating waste is the collaboration between Steelcase and GMI Composites. Steelcase is an office furniture manufacturer in the fabricated metal products sector. The excess overspray and excess powder coating that is used for the steel parts that they produce, are now used as a resource for GMI for powder coatings from the fabricated metal products sector in order to apply this BEMP. Possible solutions for this are to promote development of new applications for recycled powders, as well as several other measures that strengthen the business case of powder recycling and increase awareness about it potential of recycled materials.

Geographical dimension of the investment needs

When analysing the geographical dimension of the investment needs, it is necessary to zoom into the relevant subsectors of the fabricated metal products sector. Detailed information can be obtained using data from the Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E). 192 The first investment need, on intra value chain co-engineering, cannot be specified towards a specific subsector, since this is an industry-wide opportunity. One could state however that investment needs are located in regions where there is a high concentration of SME's working in the fabricated metal products sector. A straightforward measure is the number of enterprises. In 2014, the number of enterprises were specifically high in Germany (21445), Poland (17470), Italy (14891), the United Kingdom (13319), Slovakia (12942) and Czech Republic (12075).

The second investment need, on inter value chain reuse and recycling and more specifically the reuse and recycling of coating powders, can be analysed using data on the subsector 'treatment and coating of metals and machining'. The largest share of this sector in terms of value added in manufacturing total in 2014 is noted in Slovakia (4.6%), followed by Switzerland (3.8%), Finland (3.7%), Slovenia (3.6%) and the United Kingdom (3.6%). One could state that there might be an opportunity for investment in the new Member States, given the relative importance of the subsector in this region, and the fact that a recycling network for coating powders is in its infancy and only to a limited extent established in Western Europe.

With respect to the nature of the investment needs it has been noted in the input output analysis conducted in Task 1.2 that the fabricated metal products sector has a pronounced domestic component. This implies that these companies are embedded in a network of suppliers and clients that is mainly of a regional or national focus. This in turn stresses the importance of regional solutions and cross-border solutions for neighbouring regions. This is

[191] For example, Fina Research or Du Pont de Nemours

[192] Eurostat (2013) - Archive: Manufacture of fabricated metal products statistics - NACE Rev. 2 - http://ec.europa.eu/eurostat/statistics-explained/index.php/Archive:Manufacture_of_fabricated_metal_products_statistics_-_NACE_Rev._2

reinforced by the fact that transport costs put a limit to the distance that it is economically beneficial to collect the coating powder.

2.5.4. Assessment of investment obstacles

The investment needs identified in the fabricated metals products case, relating to both the co-engineering as well as the reuse and recycling of waste products, each face both shared and individual obstacles, which are discussed below.

Obstacles to intra value chain co-engineering

In the case of co-engineering, the investment obstacles are linked to the collaborative nature of the work to be done with partners, the exploration of new opportunities, a lack of resources to develop a facility and a lack of awareness of the environmental issues at stake.

Co-engineering relies heavily on networks and strong ties between partners. Indeed there are many obstacles to cooperation and investment associated with the collaborative nature of the work. Firstly, the selection of partners is an obstacle if there is a lack of network, or a lack of awareness of what is being done in new innovative sectors. Especially SMEs might not have (access to) such networks or an overview of potential partners. Furthermore, interviews reveal that the location and language can be an obstacle to co-engineering. Interviews also reveal that companies are hesitant to collaborate as they also share the risks of the production. These risks are associated with the complementarity of the assets the companies have.193 Companies are concerned about the added benefits of collaboration in a co-engineering effort, as the guarantee of shared benefits as well as a burden is not always certain. Thus, partnerships should be selected carefully to ensure that these gaps do not become collective weaknesses.

In the development of new products and processes through co-engineering, there are obstacles inherent to the exploration of previously unknown markets. These are particularly related to the risks inherent to the innovative nature of the work. A lack of knowledge of the opportunities, the market size, the potential clients and the business model result in an information asymmetry. Often a clear perception of the costs and benefits are missing at the point of decision making.

The development of shared facilities often requires significant investment in addition to the willingness of partners to cooperate. Thus the investment need is blocked by a lack of available resources at the level of the companies.

Obstacles to the research and development of more environmentally friendly production processes is linked to the lack of awareness in general. Specifically, knowledge on the life-cycles of products and the possibilities to improve processes are limited.

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[193] Vanhaverbeke W., Vermeersch I., De Zutter S., 2012, Open innovation in SMEs: how can small companies and start-ups benefit from open innovation strategies. 99p, available online at: http://www.sciencebusiness.net/eif/documents/Open-innovation-in-SMEs.pdf, last accessed October 10th 2016.

Obstacles to inter value chain reuse and recycling

While reusing and recycling coatings on fabricated metal products is acknowledged to be potentially beneficial not only from an environmental also from an economic point of view, a number of obstacles prevent this practice from reaching its full potential. Action to promote this recycling oriented BEMP could be undertaken by several actors in the sector.

Actions by the waste producers (companies that coat metal products and thereby generate coating wastes) is rather unlikely to happen, as indicated by interviewees. This is due to several reasons. Firstly, the costs related to discarding coating waste are relatively small. As companies are likely to focus their time and efforts on their largest cost items, the coating waste receives little attention. Yet, as many companies in the fabricated metal products face this issue, costs are very significant in the aggregate. Secondly, to make recycling profitable, one needs large volumes, to be collected from several companies. Yet, as many waste producers are also competitors, they are unlikely to set up a recycling platform together.

The suppliers of coating powder could play a role in recycling of powders as well, yet so far they have shown little interest in this new business model. This is thought to be related to the fact that companies in the fabricated metal product sector often use powders from several different suppliers, which would make a potential take-back scheme with suppliers rather complex and expensive in terms of administrative costs.

However, a third (external) party that is able to collect and valorise waste from different companies would be able to overcome several of the aforementioned limitations. And indeed a few dedicated companies have taken up this role over the past years. Interviews with a leading company in this field illustrated the current obstacles that these specialised intermediaries face. The main obstacle is finding high value added applications for the recycled coating powder. Finding these applications involves investing in R&D and finding/convincing potential customers from a broad range of sectors to open up for recycled materials (from which the properties but not always the exact content is 100% known) as input to their business processes.

Another obstacle is the competition stemming from incineration, which is a cost-effective way to get rid of powder coatings, and draw a significant amount of waste powder from the market. In addition, also transport costs can hinder the business case of valorising coating powder. Especially when waste powder is produced much closer to an incinerator than to a recycling plant, incineration will be preferred by the waste producer. Furthermore, the quality of waste powders suppliers to the recycling intermediaries is not always good, also depending on the country where it is produced.

2.5.3 Possible solutions to remove investment obstacles

Following a discussion of the obstacles to investment in the two identified cases of the fabricated metal product sector, we now present for each of the cases a number of possible solutions that could help to trigger investment.

Possible solutions for intra-value chain co-engineering

As a first option, addressing the issues related to partnerships, indications from interviews and the literature foresee that a possible solution could be the use of a shared platform for network facilitation in order to support open innovation and co-engineering in this industrial value chain. Information gaps need to be bridged in order to overcome asymmetry outlined in the obstacles. Similarly the upscaling potential also requires fostering in order to ensure success. Furthermore, in order to overcome the obstacles related to financing for shared facilities, outcomes from the interviews suggest that funding that is made available could aid in this process. The environmental impact awareness obstacles affect several investment needs. Research and development can foresee, as a potential solution, specifically targeting the reduction of environmental impacts for fabricated metal products in order to stimulate awareness and innovation in co-engineering. This could, for example, be completed by new calls within the Horizon 2020 programme.

Interviews indicated that in the production of vehicles, fabricated metal products already show signs of improved R&D, especially due to regulations on CO2 emissions reductions targets. Due to the heavy regulation, much targeted funding for energy efficiency exists. Building on this, further funding is needed and should be targeted towards SMEs as they make up such a large fraction of this industry.

In order for firms to co-operate in an open innovation process, a clear advantage needs to be shared by the firms in their network, which is not always guaranteed. This obstacle can be addressed through network facilitation in order to ensure maximum joint advantages for partners. Network facilitation can be through shared platforms managing open innovation practices in order to organise and manage open innovation with regards to fabricated metal products. A network should also ensure that complementarities of companies need to come together. Companies are aware of the assets they have, however may lack knowledge on the partners that have the assets they lack.

Facilitation of asset exchange is indeed another point for improvement in open innovation. Until now co-engineering and open innovation is mostly done at the firm level, based on close personal relationships or shared visions. Through network management and facilitation, SMEs can share in the same vision and overcome some of their personal hurdles. In addition, targeted efforts can help to support especially SMEs in their licencing agreements in order to ensure that they have a better bargaining position. The interviews provided a successful example of how a German state facilitated a network related to The EU Eco-Management and Audit Scheme (EMAS). The German state offered to fund 50% of the investments in network facilitation and technical consultants for training purposes, if a group of companies would come together and show that they are committed.

Possible solutions for inter value chain reuse and recycling

The main policy options to support better valorisation of powder coatings are the following. Firstly, there could be more R&D funding dedicated to the development of new applications for recycled coatings. Such R&D project should involve intermediaries processing coating

powder caste, as well as well as research partners from across the EU and potential customers (i.e. 'value chain R&D projects' including several partners from across the value chain).

In order to promote collaboration between actors from different value chains, apart from dedicated R&D projects also networking tools can facilitate cooperation. Such network could promote exchanges between different actors in the value chain, and especially aim for a strong involvement of potential users of recycled materials from a broad range of industries, as awareness about the potential of using recycled materials remains limited today. Through such a platform, participants should also be able to get objective information about characteristics of recycled materials, such as safety properties, as well as regulatory aspects (e.g. end of waste status). All of this should help the field of coating recycling, which is still in emerging phase, to reach critical mass.

Also on the regulatory side there are means to promote the recycling of coating powder. Especially the status of low value added waste valorisation options such as incineration is important, as they compete for waste flows with higher value added applications. It will need to be evaluated if and how the new EU circular economy package will shift this balance.

Lastly, the number of plants where high value added recycling takes place is at this moment limited. Yet, for large scale deployment of coating powder recycling more plants spread around the EU would be needed. When a batch of powder coating waste is generated far away from such a recycling plant but close to an incinerator (which are much more widespread), transport costs will steer the choice in favour of incinerating. Public investment incentives may promote establishment of more plants across the EU.

For both the intra and inter value chain cases, new financing solutions to promote investment would be valuable. A number of these have been proposed by the European Commission in a report on Boosting Open Innovation and Knowledge Transfer in the EU.194 Specifically, the smart funding ecosystem, or a financing model akin to it, could be a solution for SMEs in open innovation for the fabricated metal products. This is indicated to involve a co-investment scheme, which makes of use targeted public EU funding that is used as leverage for investments from the private sector.

[194] EC (2014) Boosting Open Innovation and Knowledge Transfer in the EU. DG Research and Innovation.

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