



Future of manufacturing **Bosch Industry 4.0 Talent Program – Italy**

***Company initiatives to align apprenticeships
to advanced manufacturing***

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Eurofound reference number: WPFOMEFF18061

Related reports: This company report is one of the 14 company reports conducted in the framework of the project Future of Manufacturing in Europe by wmp consult – WilkeMaack GmbH and partners.

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This is a publication from *The Future of Manufacturing in Europe (FOME)* project.

FOME is a Pilot Project proposed by the European Parliament and delegated to Eurofound by the European Commission (DG GROW).

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Contents

Introduction	1
1 Context factors	3
2 General information on the case.....	8
3 Project design, planning and implementation	11
4 Outcomes, impact and lessons learned.....	16
5 Commentary and conclusions	19
References	21
Annex	22

Introduction

Scope of the research

This case study report is part of the study ‘Policy developments and practices of apprenticeships in selected EU Member States and world competing regions’ carried out in five EU (Denmark, Germany, France, Ireland and Italy) and two non-EU countries (Australia and USA). The study is conducted in the frame of the Pilot Project ‘The Future of Manufacturing’ (FOME), proposed by the European Parliament and delegated to Eurofound by the European Commission (DG Internal Market, Industry, Entrepreneurship and SMEs).

One of the objectives of this study is to provide an analytical overview of apprenticeship systems in the selected countries and to review changes to the current systems following labour market shifts, changes in employment, career and mobility patterns and technological and structural change. Particular emphasis is placed on the impact of new technologies and the need for a high skilled and adaptable workforce in manufacturing and advanced manufacturing. This research is carried out in response to the increasing interest in apprenticeships among policy makers to tackle skills mismatches but also to integrate young people into the labour market. The appeal of apprenticeships is also growing particularly in a context where new technologies are transforming work organisation and production processes across all sectors, particularly manufacturing. The findings from this research will feed the policy discussions around the role of apprenticeships for the future of manufacturing and inform policy making in the context of current or planned reform of apprenticeship systems and the necessary links to be established between education/training and industrial policies.

The case study report builds on the information contained in the national report on apprenticeships in the advanced manufacturing industry in Italy that was elaborated during the first phase of the study (Eurofound, 2018).

The case at a glance

This case study concerns a company higher apprenticeship program set up by Robert Bosch SpA and Cefriel¹, aimed at the creation of a new occupational profile, Industrial IoT Specialist, a job that is functional to the company’s strategy to become a leader and point of reference in Italy for the design, development, in-house application and provision of industrial automation technologies. Thus, as regards the four different forms of adaptation of apprenticeship that are addressed by the research², the case concerns the types (b) creation of new occupations/emerging occupations and c) creation of company apprenticeship/training programmes.

Assessment of the case study against selection criteria

The selection of the ‘Bosch Industry 4.0 Talent Program’ has been motivated by different reasons. First, it is a company-based apprenticeship program framed within national and regional

¹ Cefriel is a centre for innovation, research and training in the information and communication technology sector. The shareholders include Milan Polytechnic, Milan ‘Statale’ University, Milano-Bicocca University, Insubria University, Lombardy Region and 15 leading multinational companies.

² These are: (a) modernisation of a specific occupation; (b) creation of new occupations/emerging occupations; (c) creation of a company apprenticeship / training programme; and (d) organisation of apprenticeships/training in (regional) clusters.

regulations, as well as a ‘Higher Education and Research Apprenticeship’ (Level III), so anchored in the Italian higher education and training system (university and non-university).

In terms of content and objectives, the ‘Bosch Industry 4.0 Talent Program’ concerns the development of professional skills to plan and manage the automation and interconnection of production processes within the framework of the ‘Industry 4.0’ concept, with a focus on ‘advanced manufacturing’ enabling technologies. The company aims at having a leadership position in these ‘game changing technologies’, both as user, by developing advanced manufacturing solutions, and as provider of technological solutions for companies.

Moreover, the programme is an example of good practice in the joint planning of apprenticeship courses between a company and a training institution operating in the same local context.

Institutionally, the programme is situated within the regional (and national) education, training and employment policy that also provides financial support, albeit it has no direct links with national industrial policy initiatives. However, it is indirectly linked to Cefriel’s participation in the ‘Intelligent Factory Cluster’, set up within the ‘National Industry 4.0 Plan’ (see Eurofound, 2018).

Structure of the report

The report basically falls in three parts: a general part with background information (including context factors); a descriptive part which outlines the set-up and implementation process; and an evaluative part which deals with outcomes and impact. In a final section, the programme is viewed in a broader perspective and in relation to the continued development of apprenticeships in the advanced manufacturing sector, and relevant conclusions are drawn – also in the light of subsequent developments.

Context factors

Regional/sectoral and/or company-specific set-up

This section is devoted to a description of the high-tech production sector in Lombardy in terms of employment, followed by a description of the case study company's activities and a discussion of the state of regional policies for higher education and research apprenticeships (known as Level III) and the appeal this tool holds for trainee students and enterprises.

As regards production, Lombardy is the leading Italian region in terms of turnover, added value and number of employees in both manufacturing and high-technology manufacturing. Eurostat data for 2016 (see table A.1 in the annex) shows that this region accounted for the 34.1% of Italian high-tech workers, and although there has been a decline of 3.9% between 2008 and 2016, this drop has been less rapid than for Italy in general (-9.6%) and the EU28 (-5.4%). In relative terms, too, out of the total labour force numbers of high-tech sector workers are higher in Lombardy, where they account for 1.7% in 2016, than in Italy and the EU28, where the shares are 1.0% and 1.1% respectively. From the point of view of gender, the situation is unbalanced, with women contributing 36.7% (Eurostat, 2017) to the total employed in high-tech sectors in Lombardy.

As pointed out by all stake-holders interviewed (see annex), Lombardy has seen the gradual structuring and consolidation of broad networks of education and higher education institutions, scientific research organizations and businesses, linking large companies and SMEs with the regional VET and higher education systems³. In a context that is already highly productive for many manufacturing sectors (especially mechatronics, allied automotive industries and metalworking, according to the regional metalworkers trade union, Fiom-Cgil Lombardia), the synergy among training, business and research sectors has facilitated the development of skills and competencies required by the key enabling technologies for advanced manufacturing. As reported by the local employers' association (Assolombarda, 2016a), Industrial Internet-of-Things, Advanced Analytics and Big Data, Advanced Automation and Collaborative Robotics, Cloud Computing, Man-machine Interfaces and 3D-printing are widespread in the R&D projects of innovative manufacturing enterprises in Lombardy.

These are the pieces of a puzzle which, according Assolombarda (2016b), may contribute to the structuring of an 'Industry 4.0 Ecosystem' comprising not only technological innovation (the creation of Cyber-Physical-Systems in accordance with the 'Industry 4.0' model) but also a holistic and strategic revolution in the traditional manufacturing business model.

According to the employers' association, companies operating in the region believe that the development of this ecosystem requires a strategic leadership role to be played by technology providers, rather than machine producers, since they are thought to be the most likely to invest and best suited to the development of enabling technologies for 'Industry 4.0'. On the other hand, the business world also highlights unfavourable conditions for implementing 'Industry 4.0' such as weak institutional support, excessive bureaucracy, partially obsolete VET programs and the resistance offered by small businesses to change.

The company selected for the case study is Robert Bosch SpA, which replicates in Italy the four main business areas that historically characterize the activity of the German parent company Robert Bosch GmbH:

³ Most relevant cooperation networks for dual learning in Lombardy are coordinated by 'ITS Lombardia Meccatronica', Cefriel, and 'Enaip Lombardia'.

- *Mobility Solutions*, involving the development, production and aftermarket of electrical, mechanical and electronic equipment for the automotive industry. This area accounts for about 60% of Bosch GmbH's total turnover (EUR 73 billion in 2016).
- *Consumer Goods*, which includes the production of appliances and building and gardening power tools (approximately 25% of total turnover).
- *Industrial Technology*, which provides industrial automation solutions (drive and control technologies) for businesses. Since this business area is closely linked to the concept of 'smart factory', it is the one most affected by 'industry 4.0' innovations.
- *Energy and Building Technology*, a business area linked to the production of security systems, thermal plant engineering, and energy and building solutions.

In terms of turnover (2.3 billion in 2016), Robert Bosch SpA shows the same distribution over the four business areas as on the global scale.

In Italy there are 22 legal entities with 30 locations. Of these, some have national coordination functions at the commercial or governance level, but most are production plants acquired from existing companies (generally more or less successful SMEs) or plants created from scratch.

As for the institutional dimension of dual learning, policy makers are seeking to structure a regional system for dual learning. The Lombardy Region Councillor for Education, Training and Work stressed the region's determination to unify the policy guidelines for training and work into a single department, overcoming the previous division. In terms of law, this has led to the incorporation of Regional Law 19/2007 (which regulated the state-regions joint authority over education and regions exclusive authority over training) and Regional Law 22/2006 ('promotion of job creation and the right to work') into Articles 1 and 2 ('innovation in the educational and training system' and 'labour market', respectively) of Law 30/2015.

For the regional law makers this was the first step to go beyond the approach that separates education and training from work, with the first logically and chronologically preceding the second. The new approach aims to promote the growth of a dual system at all levels of the educational, training and labour systems, following, according to the interviewee, three defining features: quality, innovation and internationalization.

While significant progress has been made with Level I apprenticeship (for further data see the following section), the Councillor admits that problems remain in relation to Level III (corresponding to EQF Level 6 or higher). Despite the region's efforts of promotion (so-called 'Public Notices for Higher Training and Research Apprenticeship' have been issued in recent years), uptake of apprenticeships in higher education (undergraduate, master's and PhD programs, higher technical education) has been limited. According to policy makers interviewed in the context of this study, the reasons for the difficulties of Level III are largely cultural. While in Level I apprenticeship programmes that are anchored largely to technical and vocational training, hands on experience in the workplace is generally seen as a significant positive component for the career path, in higher education the perception still prevails that education and work should remain separate.

The lack of appeal of Level III apprenticeships, particularly in manufacturing, is also highlighted by the Lombardy branch of the Fiom-Cgil trade union. With regard to companies as well as workers, the situation is seen as unfavourable in terms of both demand and supply of apprentices. In the opinion of the metalworkers' union, companies prefer to avoid committing themselves to on-the-job training or having to comply with the required bureaucratic steps, delegating the training of future engineers completely to the university system. Among higher education students there is a widespread awareness that a degree in engineering disciplines greatly

facilitates entry into labour market, offering a more rewarding contractual status than the one provided by the apprenticeship contract.

According to the employers' association, Level I and III training apprenticeships are, by their very nature, 'niche' tools that are used by companies for specific purposes. According to the employers association view, professional apprenticeship (Level II, by far the most widespread in Italy, as discussed in the National Report) should be considered as a tool for the mass inclusion of young people in the workplace, while training apprenticeships, especially those in higher education and research, should be contextualized differently. They are related to business practices focussing on the development of projects and opportunities for collaboration between enterprises and educational institutions. Opportunities opened up, in their opinion, by involving consortia that include training actors and business actors (like Cefirel or Higher Technical Education institutions), though co-management would be more complicated with training institutions tied to a traditional education and training model.

Relevance of dual apprenticeship

Despite being much less widespread than professional apprenticeships, persons participating in dual apprenticeships have increased markedly in the last four years (see table 1), thanks to efforts by policy makers to make the training and employment systems more tightly integrated. In particular, a clear discontinuity has been seen in Level I apprenticeships, which, between the years 2015-2016 and 2016-2017, saw a fivefold increase in the number of students. The impetus was provided by the region's investment within the framework of the National Dual System Pilot Scheme (State Regions Agreement 24 September 2015), introducing the so-called 'Apprenticeship Endowment' (€6,000 per student for training institutions activating IeFP – initial vocational education and training apprenticeship courses).

Albeit on a smaller scale compared to Level I, higher education apprenticeships have also grown significantly over the same years and, national statistics (ISFOL, 2016) show that in 2015 Lombardy alone accounted for 26% of the total number of Level III apprentices in Italy⁴.

Table 1: Number of persons taking part in dual apprenticeships in Lombardy, 2013 - 2016

	2013 -14	2014 -15	2015 -16	2016-17
Professional apprenticeships (Level I)	110	194	484	1,985
High education and research apprenticeships (Level III)	139	103	311	574

Source: Lombardy Regional Department for Education, Training and Work (2017).

A closer look at the number of students who started a higher education apprenticeship in the 2016-2017 academic year in Lombardy by type of course (see table2) shows that more than half of the students are studying for a University Master⁵. In this context, the training organization

⁴ *Apprendistato professionalizzante* (Level II) is not included in the data because it is merely considered as a job-placement contact, rather than a dual apprenticeship device. Further details are provided in the National report for Italy.

⁵ Notice that the University Master (Master Universitario) is a post-graduation specializing course in the Italian tertiary education system and it should not be confused with a Master's Degree (*Laurea Magistrale*,

most active in the Lombardy region is Cefriel, with 66 students doing Level III apprenticeships (data from the Lombardy Region Department for Education, Training and Work, 2017).

Table 2: Number of persons doing higher apprenticeships in Lombardy from 2013 to 2016

Type of course	No. Apprentices
Master Courses	155
ITS (Higher Technical Education)	92
Degree (three-year and masters')	29
Ph.D.	8
Total Apprentices	284
Amount of funding	2.75 million €

Source: Lombardy Regional Department for Education, Training and Work (2017).

In light also of these data, some of the stake-holders interviewed (Cefriel and Fiom-Cgil) both agree that there is a structured 'Lombard system of apprenticeship' (and dual learning in general) in VET courses up to EQF level 4. However, they underline that work remains to be done to develop and consolidate the uptake of apprenticeships in higher education.

Needs and challenges related to manufacturing and advanced manufacturing

All stakeholders interviewed agree on the crucial role played by information and communication technology skills in the present and future development of production processes in advanced (and traditional) manufacturing in Lombardy. In particular, the company and the trade union have the same views as regards changes in production processes and the need for skills. They believe that at present processes and products are undergoing major changes, the first because of the increasing degree of interconnection between machines and the different phases that make industrial automation ever more widespread; the second due to the high degree of customization. Because of these phenomena, they think that it makes sense to try to meet the need for skills through specialists with 'cross cutting' professional profiles that can coordinate and integrate production processes with the phases of purchases from suppliers and sales to customers.

However, the trade union adds that while these skills are important for the highest levels of manufacturing companies, with regard to technicians and workers, VET course content and curricula need to be adjusted to provide more skills in the field of computer science. In this respect, the trade union thinks that the view of policy makers is not based on a clear plan and is not able to keep pace with changes in manufacturing technologies and consequently, is not able to adapt content and curricula. While the establishment of Higher Technical Education (ITS) is in this sense an important step, the capacity to compete with other educational careers is yet to be ascertained. Furthermore, the trade union believes that the biggest challenge should not be neglected, and so far little is being done in this respect, with regards the up-skilling and re-skilling of a significant number of employees who may lose their jobs because of industrial automation processes.

in Italy). EQF level 6 is required to access Level I University, EQF level 7 is required to access Level II University Masters.

The need for co-ordination and integration of business functions is also underlined by the training organisation. They emphasize how the development of advanced manufacturing processes and technologies is subordinated to the need to revolutionize the whole dimension of big data, data analytics and data visualization.

Assolombarda (2016c) highlights that although the technological innovations that characterize manufacturing in ‘Industry 4.0’ are sufficiently available in the market, there is still a lot of work to be done on human capital, developing the skills needed to capitalise on new technologies. In this sense, the basic skills considered most important by Assolombarda are catered for in the main areas of the training package offered by the Cefriel Level I University Master referred to in this case study: computational thinking, coding, modelling, technical mathematical thinking and skills, algorithmic problem solving. In terms of technical and professional skills, the employers’ association agrees that the ICT sector is crucial, with the Data Scientist playing a key role in aspects such as Big Data, Cloud Computing, Machine Learning, Wearable Sensors and Collaborative Robotics.

General information on the case

Background and reasons of initiating the practice

The main reasons that led Robert Bosch SpA to start the ‘Industry 4.0 Talent Program’ were to set up in-house training to develop the strategic skills needed for industrial automation, for which Bosch is both a supplier to other companies and end user.

From a historical and cultural perspective, the manager interviewed highlighted the great impetus given by the parent company for the implementation of dual-learning programs worldwide, consistent with its roots in the German context which, historically, has always shown a strong preference to the dual model. In addition, being owned by a foundation (that owns 92% of the company), Bosch reinvests its profits in accordance with a corporate mission mindful of the repercussions of its activities on the social fabric in which it operates.

In turn, strategic motivation derives from the dual value ‘Industry 4.0’ enabling technologies have in business terms. In fact, Bosch is both a provider of industrial automation advanced solutions, developed by the industrial technology business unit, and an end user of these solutions within its own production processes, which have reached different degrees of advancement as regards digitization and interconnection in the plants in Italy (as mentioned, some plants were built from scratch, others were acquired from existing SMEs).

Although there were historical and cultural reasons behind the institution of the ‘Industry 4.0 Talent Program’, as well as the need to adapt to technological changes deriving from the strategy of the parent company, it was designed and is coordinated by the TEC Competence Centre (Training, Experience, Skills) of the Milan office (Robert Bosch SpA headquarters), which is linked to management and training of human resources.

As regards Cefriel, the University Master referred to in this case study follows on from the post-graduate activities conducted by the institute over the years, which make up a significant portion of its business. In line with a mission aimed at building synergies between academia and the business world, in 1989, Cefriel started offering a University Master in Information Technology, which, as of the beginning of 2000, has faced competition from the introduction of ‘Master’s Degrees’ (*Lauree Magistrali*) in the Italian system. As a result, since 2006 it has adapted its strategy, offering training courses structured around three directions: co-design with companies and with the employers’ association (Assolombarda), opportunities provided by policy tools, and knowledge spill from companies. Co-design is aimed to restructure every year (or every two years) the contents of the University Master courses in order to keep the pace with the needs of today’s business world. The second direction uses funding provided under the ‘Public Notices for Higher Training and Research Apprenticeship’ to integrate education with the acquisition of on-the-job skills. Finally, from a strategic point of view, higher apprenticeship is seen by Cefriel as a sort ‘Trojan horse’ to enter into business processes, observe routines and practices and learn how to apply certain technologies. In this light, knowledge spillovers arising from this are highly strategic for Cefriel’s business. The higher apprenticeship University Master ‘The Future of Engineering and Manufacturing: Industry 4.0’, set up in conjunction with Robert Bosch SpA as part of the ‘Industry 4.0 Talent Program’, is a synthesis of Cefriel’s three strategic aims.

General and detailed objectives and expected results

Robert Bosch SpA’s primary aim in the decision to design and implement an apprenticeship program, together with Cefriel, is to develop a team of in-house experts totally focused on the processes of digitization and interconnection of the various phases and components of the production processes, in line with one of Bosch’s business goals at the global level. Robert Bosch SpA hopes that those participating in the ‘Industry 4.0 Talent Program’ will become team leaders

for future Industry 4.0 projects in Italian plants. In this sense, the company wants apprentices to acquire an overview of how ‘Industry 4.0’ works not only in terms of technology but also as regards business processes, so that at the end of the apprenticeship they will be able to design, implement and coordinate production cycle innovation projects both for local plants and in terms of national business strategy.

The apprenticeship course lasts two years and includes a total of 400 training hours per year, which are done in the last week of each month, while the first three weeks are devoted to the working activities and the completion of projects in the various Robert Bosch SpA plants. Of these 400 hours, half (200) are devoted to on-the-job training, in line with the provisions of national law, which consist of training activities focused on the acquisition of basic and crosscutting skills (project management, teamwork, problem solving, public speaking), provided by the ‘TEC’ (Milan office).

Cefriel offers 200 annual hours off-the-job training in the form of Level I University Master Course, a postgraduate specialization course for students who have completed a degree, which corresponds to EQF level 7. Activities and content are structured around eight main areas (General aspects of Industry 4.0; the Internet-of-things, Big Data; Advanced Simulation; Model-based; Smart and Cooperative Robotics; Technologies, Sensors and Additive Printing; Deepening Courses) and are aimed at providing basic skills (computational thinking, coding, modelling, algorithmic problem solving complex system identification), technical skills (specialist knowledge of business sectors, business models, mastery of specialized tool provided by vendors of different industries, best technologies scouting) and soft skills (critical thinking, team work, interdisciplinary knowledges and competences).

As for work activities, apprentices are placed in the various Robert Bosch SpA plants in Italy, since the program, though based in Milan where governance functions operate, includes all the company’s production activities on Italian soil. By working in the company, apprentices have the opportunity to receive training and use their expertise to develop solutions, which, as mentioned, the company both uses and supplies. In this phase, the trainees are involved in project work to develop IoT technologies for the innovation of the plant’s production processes and for customers of industrial automation solutions, which Robert Bosch SpA supplies. At the end of the two-year apprenticeship, the company confers the job-title of “Industrial IoT Specialist”.

Linkages to national programmes and initiatives

The Program is part of the national ‘Higher Education and Research Apprenticeship’ (known as Level III), governed by Legislative Decree 81/2015. At the end of the course, apprentices are awarded a Level I Master’s Degree recognized at the national level (NQF/EQF level 7). The company issues a job-title (Industrial IoT Specialist), which is not formally recognised as a certification by public authorities.

Scope of the programme/initiative

The first edition of ‘Industry 4.0 Talent Program’ (begun in 2017) involved 18 trainees, who signed an apprenticeship contract with Robert Bosch SpA. Most of them were engineering graduates: mechanical engineering, computer engineering, bio-engineering, management engineering, and mathematics and data sciences. As far as duties are concerned, while the qualification awarded is the same for all (Industrial IoT Specialist), apprentices are placed in one of the many Robert Bosch SpA plants in Italy (not just in Lombardy) where they do projects aimed at developing solutions for digitization, interconnection and automation of manufacturing processes. These projects are structured on the basis of the production specialization of the individual plant and the level of advancement reached by the above mentioned technological

innovations. A third of the apprentices have been placed in plants in Bari (Apulia), which is at the forefront of ‘Industry 4.0’ technology adoption, and, with approximately 2,000 employees, is one of the largest Robert Bosch SpA plants. The others are in plants in Crema, Brembate, Milan (Lombardy), Nonantola (Emilia-Romagna), Turin (Piedmont) and Udine (Friuli-Venezia Giulia). In addition, a six-month training period is scheduled in plants of the Bosch Group in Germany.

Project design, planning and implementation

Needs assessment and type of change implemented

The program addresses a demand in the company for highly versatile skills. These skills concern the automation and digitalisation of the engineering component of production processes. Thus, the company is looking for technical expertise in the fields of mechanical engineering, mechatronics and automation. At the same time, Robert Bosch SpA feels that the level of computerisation in production processes should be higher, so the program aims to develop skills related to data science in general and big data in particular. Finally, since it is important for the company to ensure close coordination between the design phase and the sale of solutions for digitalisation and automation of production processes, the ‘Bosch Industry 4.0 Talent Program’ is also aimed at developing skills in the commercial area and facilitate communication with the specialised technical design departments.

As mentioned, to meet these needs the occupational profile of ‘Industrial IoT Specialist’ has been created, a job that is functional to the company’s strategy to become a leader and point of reference in Italy for the design, development, in-house application and provision of industrial automation technologies complete with training packages provided by the TEC competence centre, which is in charge of on-the-job training for apprentices, as part of what is referred to as the ‘manufacturing 4.0 paradigm’.

The higher apprenticeship examined in this case study is the result of extensive co-design activities involving the company and the training institute. It is also the result of an assessment made by Cefriel of its own needs for continuous adaptation and alignment of its training courses to the skills needs of large enterprises in Lombardy. In this perspective, as discussed in the section ‘Reasons for initiating the practice’, Cefriel usually limits the same training content to one year (as of 2006), while only in some cases is the same University Master replicated for two consecutive years. The implementation of the Master ‘The Future of Engineering and Manufacturing: Industry 4.0’ under the ‘Bosch Industry 4.0 Talent Program’ should be seen, therefore, within the strategy and practices for the re-design and progressive adaptation of University Masters offered by the training institute. In this sense, in the face of organizational, bureaucratic and regulatory difficulties encountered by universities in modifying their courses (which are mostly three-year and master’s degree courses), a lighter and more agile structure like Cefriel, together with the use of a flexible tool like the University Master, has allowed for continuous adjustment of contents and redefinition of curricula integrated with higher apprenticeship courses.

Concretely, with respect to the key dimensions of the implemented changes, the practice examined in this case study: i) has defined a new occupational profile in the company, ii) is part of a strategic business plan aimed at making ‘paradigm 4.0’ operative, iii) is in line with Cefriel’s established practice of adapting educational curricula; iv) since it is a University Master program, it also complements the ‘standard’ courses on offer in the Italian system of higher education (bachelor’s and master’s degrees) and higher apprenticeship.

Involvement of different actors

The actors directly involved in the design and development of the program are Robert Bosch SpA, as program designer and company where on-the-job training is carried out, and Cefriel, as off-the-job training provider. As regards policy for Level III apprenticeships in Lombardy and dialogue with the social partners, there is, respectively, the Regional Council for Education, Training and Work, the employers’ associations and the trade unions. Interaction between Bosch offices was smooth, as also between the company and the training institute. Certain criticisms,

which did not concern the design of the ‘Bosch Industry 4.0 Talent Program’, were raised with regard to the regional funding methods and timeframes for the Level III apprenticeship.

As for the company offices involved, the TEC Competence Centre was responsible for both designing and planning the ‘Bosch Industry 4.0 Talent Program’, and - after receiving the approval of the parent company – also coordinated the implementation of the program in the company’s various plants and on-the-job training. In the individual plants, HR management is involved, providing company mentorship, selecting tutors, and deciding with the apprentices and other company offices the project-work to be done during the two years apprenticeship. These interactions are structured around a multi-level program implementation supervision model, where trainees are locally coordinated by a mentor and the pertinent plant management with regard to project-work development, and globally by the TEC for on-the-job training. The TEC co-ordinates with the plants involved to ensure an organic monitoring of the implementation of the program, aimed at delivering what is defined as a holistic approach to the introduction of ‘paradigm 4.0’ in the company.

The involvement of Cefriel is the result of a recruitment partnership, established over the years by Robert Bosch SpA, with the technical universities (*Politecnico di Milano, Politecnico di Torino, Politecnico di Bari*) and with other Italian engineering faculties. On the basis of the three families of skills (engineering, information technology, marketing), seen as strategic for the development of what are defined as Industry 4.0 solutions, the company decided on Cefriel, after a phase of scouting that involved stakeholders from various training institutions, as a suitable partner to co-design and launch a higher education and research apprenticeship program (Level III apprenticeship in the Italian system). The design phase involved the company and training institute having a series of meetings, the main purpose of which was to define training methods, timeframe and contents so as to meet the needs of the various Bosch plants involved. The practice of regular meetings also characterizes the implementation of the project, with a view to monitoring the implementation status of the program and the joint effectiveness of on-the-job and off-the-job training, and to ensure the alignment of the mutual needs of training institute and company.

As regards Cefriel, its experience in off-the-job Level III apprenticeship training goes back a decade, to 2006, when it benefited from contributions provided by the first ‘Public Notice’ announced by the Lombardy Region for higher education apprenticeship funding, based on input from the employers’ association Assolombarda. Although the 2006 pilot scheme was well structured by the Lombardy Region, in the following years, Cefriel bemoans a lack of planning in the scheduling of new ‘Public Notices’ for the financing of higher apprenticeships. This creates uncertainty which makes conditions unmanageable both for companies and training institute, penalising their capacity to plan training content and place apprentices in the company. In addition, regional policy makers were not very receptive to suggestions made over time.

This aspect of the interaction between the actors involved is also problematized by Assolombarda, which, despite not having directly participated in the conception and implementation of the program examined in this case study, has partnered many higher apprenticeship practices. According to the employer’s association, to limit uncertainty and meet companies’ recruitment planning needs (it should be pointed out that an apprenticeship in the Italian legislative framework becomes a permanent contract), policy makers should ensure ‘Public Notices’ are published annually, providing ‘open’ funding (until the allocated sum has been used up) rather than imposing, as in current practice, a deadline that may conflict with company planning times.

On-the-job training content, covering Bosch production and organisational processes and soft-skills, is provided by the company, as mentioned when discussing the general and detailed

objectives and expected results, while the University Master (off-the-job-training) focuses on the technical and specialized aspects of enabling technologies.

Regarding the interaction between Cefriel and Bosch, there is an interesting finding from a study conducted by Assolombarda (2016b) on the development of ‘technologies 4.0’. In addressing issues pertinent to technology transfer between university research and business, the companies interviewed agreed that the lack of a coordination structure between companies and research in the Italian applied research system is compensated for in Lombardy by the activities carried out by university consortia, such as Cefriel and MIP within the Milan Polytechnic.

The social partners remain, however, in the background as regards the design and implementation of the ‘Bosch Industry 4.0 Talent Program’. The company underlines that the program was presented to trade union organisations, as well as Confindustria (national employers’ association) in the context of an ongoing partnership, linked also to innovation issues in the digitisation and automation of production processes. As regards the trade unions, though not critical, the regional Fiom-Cgil office has kept a low profile over the ‘Bosch Industry 4.0 Talent Program’. While underlining a good climate in terms of industrial relations in the plants located in the Lombardy region (whereas in the past there had been friction over the restructuring of the plant in Bari, in Apulia, which is also involved in the apprenticeship program), the union added that since Bosch is a multinational company, relations tend to change, depending largely on company investment strategies.

Financing

Off-the-job training was funded by the resources allocated in Lombardy Region Decree No. 7400 of 07/27/2016 which approved the ‘Public Notices for Higher Training and Research Apprenticeship’ (under article 45 of Legislative Decree no. 81/2015) by allocating €2,000,000 for the training of Level III apprentices. Cefriel received €180,000, corresponding to ceiling per trainee (€10,000).

The company benefits from the contributions of ‘FixO S&U’ for the employment of young people on apprenticeship contracts⁶, as well as salary, regulatory, economic and fiscal benefits in accordance with Legislative Decree 81/2015 and the ‘The Inter-Union Agreement of 18 May 2016 between Confindustria (national employers’ association) and Cgil, Cisl, Uil (national trade unions).

Other forms of local, regional and/or national support and expertise

No other forms of support are envisaged, apart from those already discussed for the co-design and implementation of the program in close collaboration with Cefriel and funding from the Lombardy Region.

Implementing the programme/initiative

The implementation of the program is totally in the hands of the company and training institute, which is responsible for off-the-job training activities.

After having presented the program at company headquarters, and received authorisation in December 2016, Robert Bosch SpA launched a promotional phase directed at students of various

⁶ FixO S&U, part of FixO Programme, is managed by Anpal Servizi S.p.A. and is aimed to promote the use of higher apprenticeship. Companies that hire young people aged between 16 and 29 with a higher apprenticeship contract (24 working hours per week, at least) benefit of a contribution of €6.000 for each apprentice with a full time contract (reduced to €4.000 in case of part time contract).

Italian universities, at the end of which around 2,000 applications were made. The selection procedure was based on different methodologies: an initial screening of CVs led to the selection of 400 candidates, followed by individual interviews and group assessments to choose the participants for the final stage, which took place in the form of a ‘hackathon’.

Although Bosch is a major undertaking, it encountered difficulties in recruiting 18 new human resources under an apprenticeship contract (which, as mentioned, is a permanent contract in Italian law), resulting in a delayed start for 15 of the 18 contracts envisaged (and of the program itself), postponed from 20th March to 10th April 2017. The other three apprentices were hired later and, thanks to Cefriel’s responsiveness, were able to make up for the missed off-the-job training contents. Apart from this delay, judged as negligible by the company, the initial timeframe was adhered to thanks to an efficient division of work with Cefriel, which dealt with all the paperwork needed for the start of a University Master in Level III apprenticeship.

As specified (in ‘general and detailed objectives and expected results’) on-the-job training and off-the-job training are distributed evenly over the 400 hours per year. As regards the company, the TEC competence centre, which presided over the conception and launch of the program, is also responsible for implementation and coordination. Activities are carried out both within the company, in the form of on-the-job training (in contact with the HR management of the plants and in-company mentors in question (see section 5.7 below for further details), and externally, in co-defining schedules and providing contents for off-the-job training in conjunction with the Cefriel. In order to ensure integration between the two training phases, a part of the off-the job training is done jointly by teachers from the training institute and professionals from Robert Bosch SpA.

Quality assurance mechanisms

Quality assurance mechanisms are based on internal quality standards, the planning of discussion phases involving apprentices, company mentors and company management, and, as far as the training institute is concerned, an external audit for certification.

For the company, quality assurance mechanisms involve regular coordination with in-company mentors, the training institute and the TEC training standards. However, work is still in progress since the apprentices only started on April 10, 2017, and the company is arranging meetings for constant discussion and exchange, beginning with individual interviews starting in December 2017 with all apprentices, human resources managers from the plants in question and in-company mentors. The goal is to create a profile for each apprentice so as to plan the next steps of their course and their role in the company once the apprenticeship is over.

As for the training institute, to ensure access to funds granted by the Lombardy Region, Cefriel has its own internal quality system to monitor all training projects and is subjected to an external audit for quality certification.

Skills of involved training and mentoring personnel

As mentioned, in-company training is carried out by the TEC competence centre, a company department dedicated to the training of both employees and external users (other enterprises in the Robert Bosch SpA value chain) of company products and services.

With regard to mentoring, each apprentice is assigned to an in-company mentor, chosen by the TEC competence centre from the *on-site* managers of the plant in question who are willing to play the role of mentors, and based on an assessment of the alignment and consistency of the mentor’s skills with those of the apprentice and the content and aims of the project-work to be developed by the apprentice. The ‘Bosch Industry 4.0 Talent Program’ does not envisage specific training for in-company mentors, as they have already participated in a corporate training scheme

(called ‘Lead’), which includes a module devoted to on-the-job mentoring, and have experience acquired over the years in tutoring apprenticeship courses (particularly Level II).

Off-the-job training is mainly provided by teachers of the Milan Polytechnic, flanked by Cefriel teachers and professionals from Robert Bosch SpA. The participation of company staff in off-the-job training is designed to ensure alignment between classroom content and the business processes apprentices work on while in the company.

Difficulties and challenges during implementation

Until now, the only implementation difficulties have concerned the alignment of off-the-job training schedules with some company needs, which required training to be speeded up in certain areas, thus leading to a change in the provision of University Master modules. Usually Cefriel provides a module only at the end of the previous one. In this case, to meet Bosch’s needs, three modules are provided at the same time during the February/March 2018 period.

Otherwise, Bosch stressed that cooperation with Cefriel in program implementation (as also during the co-design phase) runs very smoothly. In particular, the training institute’s contribution has been acknowledged in addressing all the formal and bureaucratic aspects of setting up Level III apprenticeship training courses.

Outcomes, impact and lessons learned

Major outcomes and impacts on company and region

Outcomes and impacts on the company. The nature of the program, and the progress made so far, do not allow for evaluations of outcomes and short-term impact on the company. In the framework of a broad corporate strategy, the ‘Bosch Industry 4.0 Talent Program’ aims to help build and accelerate the transition to what is labelled ‘a new paradigm of production processes’. In this context, the higher apprenticeship training of future Robert Bosch SpA professionals through the program is just one of the components that define the innovative path initiated by the company.

Considering the uncertainty and unpredictability that characterize innovation (Nelson and Winter, 1982) and the co-occurrence of different factors (technology, organization, market) in this process, a univocal quantitative or qualitative short term assessment is not feasible. Nevertheless, the TEC competence centre, as the program coordinator, is designing evaluation tools (in the form of evaluation grids) to monitor the effectiveness of the course for the development of the apprentices’ skills and is arranging for regular meetings with the management of the plants and in-company mentors involved to monitor performance, and possibly redirect project work.

A final assessment of the program’s impact on the company will, nevertheless, have to be seen in the light of Robert Bosch SpA’s broad strategic objective, namely its ability to position itself as a leader in Italy in the development and provision of production processes and technologies that fall within Industry 4.0. It is clear that achieving this goal depends both on endogenous factors (e.g. the ability to adapt organizational processes, investment choices) and on exogenous factors (demand for technologies, competition).

Progression to ‘higher apprenticeship’, professional mobility and career progression for the individual. Successful course completion will lead to the attainment of EQF level 7, in line with the trainees’ future position, at the management level, in the company staff.

Impact on the local labour market. As for the reduction of unemployment levels, the impact of hiring 18 workers is clearly negligible. At a less specific level, the attainment of Bosch’s strategic goals, with a consequent growth in business volume, could have appreciable employment impacts. However, it should be specified that the impact could vary, depending on the local labour market, given that the program operates in all Robert Bosch SpA plants, only some of which are in Lombardy.

With regard also to a reduction in skills shortages, the small number of apprentices does not allow for a quantitative assessment of the impact of the program. From a broader perspective, the transition to ever greater levels of automation, digitization and interconnection of the manufacturing production processes is generating the need, as pointed out by Fiom-Cgil and by Assolombarda, to up-skill and re-skill an important proportion of the workforce occupied in these areas, accompanied by a strong need for ‘intermediate technicians’. In this sense, the ‘Bosch Industry 4.0 Talent Program’ is only one part of the policy and training tool framework in Lombardy. Meeting new skills shortages should be seen, therefore, in the light of other factors, such as the increase in the number of Level III apprentices, the capacity for cooperation between educational institutions and the business world and the development of ITS (Higher Technical Education). The last mentioned, in particular, is designed to meet the need for technicians in manufacturing (students study for the ‘Higher Technician’ certification, EQF Level 5) and is largely focused on the dual learning model (work placements and Level III apprenticeships).

Increased attractiveness of the entire region or sector and spill-over effects on other companies in the region. As concerns the potential increase in the attractiveness of the region or sector, a univocal assessment is not practicable and depends on the spill-over effects on other

companies. As for the program's contribution to the company's strategic objectives, it may lead to a growth in manufacturing in Lombardy (and in other local production systems in which Robert Bosch SpA plants operate), becoming a driver for the Robert Bosch SpA value chain. Since Bosch is both user and provider of advanced manufacturing technologies, the spill-over effect would come from the spread of innovations through sales channels (technologies and the training needed to use them). A second facilitator of knowledge spill-over is Cefriel, which, as mentioned above, is deeply embedded in technology transfer relations between academia and companies. Then there are other spill-over channels (e.g. local 'buzz' and labour mobility), which may also benefit the region of Lombardy.

Attractiveness and capability of apprenticeship

Attractiveness of dual apprenticeship for candidates. The number of applications, about 2,000 for 15 positions (later increased to 18), for the first selection phase, show that interest in the apprenticeship course proposed by the 'Bosch Industry 4.0 Talent Program' was strong and widespread. This is not an insignificant result considering that, as underlined by the Fiom-Cgil in Lombardy, higher apprenticeship, with its limited earnings (up to two levels lower in the staff hierarchy scale), is usually less appealing to engineering students, who, in a labour market such as the one in Lombardy, have no difficulty in finding a rewarding job. Presumably, the reasons for the strong appeal exerted by the program are to be found in the fact that both Bosch and Cefriel enjoy a positive reputation as successful organisations (brand names), and the ambitiousness of the project.

Characterisation of participants (age, gender, educational level). The participants in the program are aged between 23 and 29 (the maximum apprenticeship age), with an EQF level 6 (required to access a level I University Master) or higher. From the gender perspective there is a strong imbalance in favour of men, an imbalance that is even more pronounced among high-tech workers in general in Lombardy (see section 'Context factors').

Completion rates, retention rates. Completion rates and retention rates cannot be evaluated since the first year of the program is still in progress. Cefriel points out that according to data for other higher apprenticeship University Masters, 93% of apprentices remain in the company on completion of the course. So, a high retention rate is expected.

Key success factors and lessons learned

The absence of particular difficulties so far in the implementation of the program and the limited number of problem-solving activities do not allow for any conclusions to be drawn about lessons learned. Instead, factors can be identified that contributed to the success of the design, start and current implementation of the 'Bosch Industry 4.0 Talent Program':

- **Stimulus, support and cooperation of the parent company:** the design of the program must be seen in the light of the historical and cultural vocation of Robert Bosch GmbH as regards company training and dual learning practices. The start of the program was supported by the management of the parent company, which will contribute to the implementation by hosting trainees for a training period of six months in various plants of the Bosch Group in Germany.
- **Collaboration with Cefriel:** the identification and co-design of off-the-job training content was facilitated by the choice of a partner that has developed considerable expertise over the years in implementing University Masters for Level III apprenticeship in partnership with leading companies in the manufacturing sector in Lombardy. Moreover, on the basis of data collected by the employers' association (Assolombarda 2016b), Cefriel enjoys an excellent reputation in the local business fabric. The alignment of each other's needs as training

organization and company also went smoothly, as also compliance with bureaucratic requirements for the start of apprenticeship courses.

- **Smooth intra-corporate relations and cooperative climate**, facilitating the involvement of all Robert Bosch SpA plants in the implementation of the program.
- **Key role played by the TEC Competence Centre**, a department with a capacity for coordination and dedicated to the planning and delivery of company training.
- **Funding for apprentice training** was provided by the Lombardy Region - Department for Education, Training and Work ('Public Notices for Higher Training and Research Apprenticeship') and by the FixO Program.

Commentary and conclusions

Adjusting dual apprenticeship in the light of advanced manufacturing

Debate on the calibration of dual apprenticeships (Level I and III) in the light of advanced manufacturing practices should take into account that, in terms of regulatory framework, the tools used have not been specifically designed for the manufacturing sector and the regulatory framework of apprenticeship is not supportive enough (for details on the reasons see Eurofound, 2018). However, it may be argued that if used in a certain way, dual apprenticeship can play a relevant role in the development of skills relevant for advanced manufacturing enabling technologies. This is definitely the case for the company-based approach of the ‘Bosch Industry 4.0 Talent Program’, framed within a broad corporate strategy aimed at gaining a competitive edge in the technology market for automation, digitization and interconnection of production processes and the redefinition of traditional business models. From this standpoint, the use of the University Master tool with a single-company class has guaranteed the flexibility needed for the successful joint planning (company and training institute) of a program aimed at meeting specific training needs.

Secondly, it is to be noted that the higher apprenticeship University Master, as recommended by Assolombarda, also lends itself to the construction of inter-business pathways that could involve SMEs that, by themselves, would not have the capacity to absorb the number of apprentices needed to initiate a course.

Finally, a third way of using apprenticeship training for advanced manufacturing can be found in Higher Technical Education (ITS) courses, which are designed to respond to the needs of specialized technical skills in manufacturing.

Policy implications and transferability

There are three aspects involved in a discussion of the transferability of the experience examined in this case study. The first two are more general and regard: a) the regional policy measures for Level III apprenticeship; and b) the economic and production situation in Lombardy. The third concerns the specific characteristics of the ‘Bosch Industry 4.0 Talent Program’.

In terms of policy, it should be remembered that, starting with its decision to integrate policies for education and work into a single body of regulations, the Lombardy Region Department for Education Training and Work is making major efforts to promote dual apprenticeship and also support it financially, by issuing ‘Public Notices for Higher Training and Research Apprenticeship’. Although some stakeholders (Cefriel and Assolombarda) expressed their disappointment in the lack of continuity in funding, data for the last few years (see section ‘Relevance of dual apprenticeship’) show that the spread of dual apprenticeship, in particular as regards Level I, is growing significantly in Lombardy, unlike in the majority of other Italian regions (ISFOL, 2016). From this point of view, it may be argued that the commitment of regional policy makers constitutes one of the necessary conditions to increase the attractiveness of apprenticeships for companies and training organizations also in other regions.

As for the second aspect, it should be noted that the practice examined in this case study was also facilitated by the favourable conditions offered by a local context characterized by a strong and developed manufacturing sector, a significant high-tech workforce, and systematic practices of technology transfer between research and business. In this respect, automatic transferability to territories with a different production structure would seem impractical.

Finally, it should be remembered that the ‘Bosch Industry 4.0 Talent Program’ was conceived, co-designed and implemented by a large enterprise and a training institute with extensive

experience in dual training at the tertiary level of education. It follows that another condition for transferability is the capacity to allocate considerable organisational resources and use highly specialised design skills in the tertiary segment of the training chain.

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Annex

A.1: Number of persons employed (thousands) in the high-tech sector in Italy and Lombardy

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2016/ 2008 (%)
Employed persons in Lombardy	77,3	83,6	73,1	68,2	67,8	71,9	69,4	70,7	74,3	-3.9
Percentage of total employed in Lombardy	1,8	2,0	1,8	1,6	1,6	1,7	1,6	1,7	1,7	
Employed persons in Italy	241.1	247.8	236.1	218.9	218.0	214.8	216.5	213.8	218.0	-9.6
Percentage of total employed in Italy	1.0	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	

Source: Eurostat, High-tech employment statistics (2017).

A.2 List of interviewees

Type of organisation	Organisation	Interviewee
Company	Robert Bosch SpA	Employer Branding Manager, HRC-TEC
Government	Regione Lombardia	Regional Councillor for Education, Training and Work
VET provider	Cefriel	Digital Knowledge & Education Unit, University Masters Coordinator
Trade union	Fiom-Cgil Lombardia (metalworkers trade union)	General Secretary
Employer organisation	Assolombarda Confindustria Milano Monza e Brianza	Director of Education and Higher Training Unit
Employer organisation	Assolombarda Confindustria Milano Monza e Brianza	Director of the Training System and Human Capital Area

WPFOMEEF18061

Disclaimer: This working paper has not been subject to the full Eurofound evaluation, editorial and publication process.

The European Foundation for the Improvement of Living and Working Conditions (Eurofound) is a tripartite European Union Agency, whose role is to provide knowledge in the area of social, employment and work-related policies. Eurofound was established in 1975 by Council Regulation (EEC) No. 1365/75, to contribute to the planning and design of better living and working conditions in Europe.