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SME Innovation and Development in the Context of Industry 4.0

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Abstract

In the years 2013-2014, when the financial crisis that began in 2007 became ruinous for a large number of small companies, the governments of several European countries launched plans to help supersite enterprises. The types of aid have all been oriented towards promoting the innovation of production and logistics processes and have assumed quite similar characteristics in different countries. For this, it's usual to talk about Industry 4.0 plans in each one of the 15 European countries in which these measures to help companies have been financed. The common goal of these programs is to innovate SMEs in terms of automation (of machines), integration (of lines) and interconnection (of the production system with its management). For SMEs it would be a great opportunity. However, their managers - who usually are at the same time, owners, operations managers and technicians) face great difficulties in accessing funding from an Industry 4.0" plan, due to lack of information and limits on their knowledge of new digitization technologies. To help managers / technicians to analyze the critical issues of their own company and prepare a request for technical and financial support from Industry 4.0, Politecnico di Torino and Gruppo Banca di Asti created the PMInnova Program, offering advice for check-ups, project development and participation in regional and European calls. This contribution will introduce the problem of supporting SMEs in the context of Industry 4.0, in the context of Industry 4.0, by evaluating costs and benefits which could be obtained, by answering the following questions: 1. Which are the measures of Industry 4.0 that favor the integration and the digitization in a SME? 2. How could an Industry 4.0 measure be applied to an SME with expected strong impact?

Keywords: Industry 4.0; Small-Mid Enterprises;

1. Introduction

In the last five years, plans have been launched in various countries to support the development and innovation of SMEs, with the common objective of counteracting the effects of the economic-financial crisis that began in 2007. Starting from 2014, fifteen European programs for "Industry 4.0" have been launched. One of the first countries to study and promote the development of “Industry 4.0” is Germany, followed by France, Italy, Austria, Belgium, Czech Republic, Denmark, Spain, Hungary, Lithuania, Luxembourg, Holland, Poland, Portugal, Sweden. [see the European Parliament, ITRE Committee, 2016], as well as by USA.

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The common objective of the initiatives in the various countries is to renew production and logistic processes as well as personnel organization of micro, mini and small enterprises. The innovation promoted concerns the interconnection of each machine with all the production management process, from the development of new products design up to the control of the final quality level. Therefore, the interconnections regard the automated integration of machine with the factory logistics system, on one hand, and the supply and distribution networks, on the other hand. [1][2]. The programs “Industry 4.0” of all countries had the starting goal of defining the characteristics and the requirements of an integrated architecture that interconnects the productive perspective and the increasingly powerful tools of Information Technology, thus to give rise to a "smart factory", that is, the environment in which "human beings, machines and resources communicate with each other as naturally as in a social network" [3]. The fourth industrial revolution, in fact, not only involves the production process, its efficiency and productivity, but also the ability to interconnect and make all the resources able to work together (physical assets and people, both inside and outside the factory), and exploit a new production factor: data, information and scheduling plans [4][5]. Therefore, the enabling technologies of the "Industry 4.0" program are manifold, and can be summarized in three areas (as an example is the Italian law 232/2016 [6]):

(1) the availability of digital data and analytics of Big Data, together with low-cost sensors and cloud computing;
(2) robotics and advanced automation, with new man-machine interactions;
(3) pushed connectivity, using intelligent sensors (Internet of Things).
(4) Digitization has given a further push to the processes of transformation of the company, along some precise guidelines [7]:
   a) interconnection, i.e. the machine's ability to exchange information with internal systems (management system, planning systems, design systems) and external systems (customers, suppliers, partners), through links based on documented, public and internationally reconfigured specifications;
   b) virtualization: a "virtual pair" (digital twin) of the real system or its components is created and supplied with data in order to predict the evolution of the behavior of the system by means of simulations (Wang and Wang, 2018);
   c) decentralization: the various cyber and physical components that make up the production system have appropriate strategies (e.g. to correct process drifts) in an autonomous manner;
   d) remote interaction: the devices are remotely accessible so as to be able to detect operating data and introduce corrective measures;
   e) real time processing and reactions, i.e. the presence of functions that allow to collect process data in real time and to adopt the necessary actions or corrections.

However, in the practical application of the Industry 4.0 plans, the technology roadmap is still not clear in industry nor in academy [8]. The literature review done for this paper shows that Industry 4.0 projects remained cost-driven initiatives: it is rare to find papers where precise indications on the convenience of using some actions of the Industry 4.0 program are given [9]. This is particularly evident in the case of micro, small and medium-sized enterprises (SME). Usually, the SME manager is also the founder of the company and the holder of the knowledge and techniques on which the industrial process was built and developed. These figures of manager/technician, and also owner, are very tied to their original technical knowledge. Therefore, they resist to accept that their company becomes the object of innovation programs that meet the constraints of the "Industry 4.0" plans 10].

Therefore, the scope of this paper is to illustrate the experiences done in some collaborations with managers and owners of small enterprises (SME), interested to understand and then apply Industry 4.0 actions, as they can be supported for Italian SMEs within the “Program PMInnova”, a strategic agreement of Politecnico di Torino with Gruppo Banca di Asti, Biella, Vercelli [11]. Experiences made in applying Industry 4.0 actions in SMEs have shown us that the manager of the small enterprise, usually the founder and technical manager, wants to know some "success stories" of innovations of SMEs that have been financed. This request, as shown in [8], derives from the fact that the rules by which one could ask for funding from the Industry 4.0 plan are complex: the SME manager wants sincere and reliable advice. The 2nd section will be dedicated to show how industry 4.0 actions have been applied in two SMEs. The next step (in the 3rd Section) is to make an SME manager able to prepare a technical report to be related to the financial request. Finally, Section 4 indicates possible developments of the present research by outlining the interest in terms of the preparation of specific guides for the application of "Industry 4.0" in various industrial sectors.

2. Some "success cases" in applying Industry 4.0: the PMInnova Program experience.

Started in February 2018, the PMInnova Program has so far registered more than 160 SMEs in its archive, and for seventy of them Politecnico has analyzed the current technical-organizational-functional status and evaluated the feasibility of their innovation and development plans in an "Industry 4.0" perspective [6]. In the following, two "success cases" (i.e., innovation projects that have been already approved by the “Industry 4.0” reviewers) are shown, omitting the company name for confidentiality reasons, but using real data and information [12].

2.1. Innovation of a mechanical production process supported by the "Industry 4.0" hyper-amortization of the investment

The first success case refers to an SME (which we will call SME//1) founded in 1989, based in the Turin area, with about 70 employees, dedicated to the production of components for automotive, made by steel, on the basis of a CAD drawings. The finished products (inflator for airbags; components for assembling the interior of seats, components for anti-vibration systems, joining members) are obtained from a steel wire with a cold molding process and, if required, a chip removal. The innovation project of SME//1 was the purchase and introduction into the production process of a machine for printing reels, drilling and internal threading. with 8 programmable complementary units, loading and unloading stations, CNC control and mini PC for connection to the company's management system (cost of about 500,000 euros). In this project, the most critical requirement - according to the "Industry 4.0" standards - to which the machine had to satisfy, was the "interconnection" to the factory computer systems, with remote loading of instructions and/or parts of programs. According to the system specifications required by "Industry 4.0", the characteristic of the interconnection of the machine with the factory information system such to transfer remote loading of instructions and/or parts of programs is satisfied if the machine exchanges information with internal systems (e.g. management system, planning systems, product design and development systems, monitoring, even remotely, and control, other plant machines, etc.) by means of a link based on documented specifications. In addition, to satisfy the other basic requirement, both physical and informative integration has to be allowed: physical integration if the machine is serviced, in input or output, from an automated / handling system, in turn integrated with another element of the factory (e.g. a warehouse, a buffer or another machine/system, etc.); or information integration in which the traceability of the products/batches made through dedicated automated tracking systems (e.g. barcodes, RFID tags, etc.), that allow the factory management system to record the progress, position of the batches or semi-finished products, exists. Based on the aforesaid characteristics, one can activate the request for tax credit in the form of "hyper- amortization" according to the following computation Table 1:

Table 1. Tax credit "hyper-amortization" for the small company SME//1.

Cost of the purchased machine	500.000 €
Over evaluation of 150% from Ind.4.0	750.000 €
Virtual cost of the machine	1.250 €
Tax saving of 24%	- 300.000 €
Net investment	+ 200.000 €

As seen from this "success case", it is clear that the demand for hyper-amortization for highly technological machines, interconnected and integrated into the existing process, is the one most considered by SME managers. However, there are other forms of financing in the "Industry 4.0" plan, and a different "success case" is described below.

2.2. Innovating the Management System of technical services provided by a micro-company, supported by the "Industry 4.0" tax credit for Research & Development

The second "success case" refers to a micro company (less than 10 employees) based in the Municipality of Asti, specialized in air conditioning and heating systems (installation and maintenance). The micro company, here called SME//2, has progressively expanded its business sectors, acquiring the necessary certifications, in order to offer a set of complementary interventions, from the installation of electrical systems and for the use of gas in houses and buildings, to the design and installation of anti-fire systems and also networks for compressed air distribution.

The analysis of the present organization status of SME//2 has suggested to innovate the SME by activating a "R&D program", thus making possible to request a tax credit for R&D, to reorganize the present structure and management of the SME, through the design of an ad hoc Enterprise Management System, with features to optimally manage customers' required interventions and the related team operations [13].

The R&D program has been developed according to the following steps.

a) Effective management of the order portfolio.
   Today, for any new request from a client, the SME//2 manager draws a rough estimate, assuming times and resources. This means operating in continuous transition condition, without a reference plan based on the acquired orders. A necessary evolution must include a "periodic scheduling" of the activities required by the next set of interventions, requested in the medium term, with an estimate of their duration and of the resources to be used (operators and means). This study - to develop a simple method, simply understandable and usable by the SME manager, good technician but with media culture - can originate from the Brooks algorithm whose logic is to define, for each intervention, a profile time of the necessary resources, according to the necessary time, being the time sampled at a rate of one hour of work [14].

b) Elaboration of the plan of the required intervention, after an inspection on the site.

Defining the executive project of an intervention currently requires the estimate of the start and end dates of the intervention, and the sizing of the team to be used. Therefore, the project of a new intervention involves the insertion of a new activity in the pre-defined timeline. The main problem to be solved in this phase is the updating of the various temporal profiles defined previously, due to an unexpected event that happened in one of the interventions in progress. The simplest solution (and understandable by the above-mentioned SME//2 manager) could be obtained by using a method of updating the time profile of the intervention "hit" by the event, without modifying the profiles of the other interventions. This is possible if the management of resources is based on the concept of "reserve resources", i.e. resources with reduced planned employment and therefore usable to support a team with a suddenly increased workload.

c) Definition of the program for carrying out the intervention.
This third phase requires the organization of: materials, from the warehouse or from suppliers; team, i.e. operators and equipped vehicles; controls, i.e. control strategy for the execution of the intervention and quality control of the plant, in progress and at the end.
The first two points require an appropriate management of the warehouse and the set of suppliers. The study of a simple tool that solves this problem allows, in fact, to reduce significantly the costs of storage and urgent supplies. The third point requires, above all, the adaptation to the micro-company of a method widely used in the large industrial enterprise, e.g. the TQM - Total Quality Management [15].

d) Control of the intervention execution.
The implementation of the intervention can present two types of problems: first, the occurrence of conflicts with operators from other companies operating in the same premises (e.g. bricklayers or tilers); second, the requests for changes in the work in progress, which involve changes to the initial work plan. The first problem is considered as an effect of an unforeseen event, for which the "event-driven" management method, outlined at step b, could be adapted. The second one is faced by defining modifications to the original estimate, varying the scheduling of resources and times, as in step c.

Table 2. Estimation of the “Industry 4.0” tax credit for R & D for SME//2.

R&D expenses in the current year for ad hoc EMS development	Average expenses in R&D per year, during the previous 3 years	“Incremental spending” (IS)	Credit Tax value for R&D, as in “Industry 4.0” rule (50% of IS)
30.000 €	14.000 €	16.000 €	8.000 €

3. Some schemes with which the manager can document innovations that can be financed according to "Industry 4.0" criteria

The success cases illustrated in the previous section help to outline some schemes with which a manager can document innovations of his own SME that can be financed by the "Industry 4.0" plan.

a) In case of requests for hyper-amortization, the basic document that the SME manager must contribute to rolling out is a "Technical Analysis" of his company, that means the analysis of the production process and of the production management system, from the acquisition of materials to the storage or shipment of products. Therefore, the technical analysis will include the following.
   a.1. For each product, the working sequence, i.e. the sequence of operations that has to be performed to obtain the finished product, and the corresponding sequence of the tool machines from which the operations are performed must be described [16].
   a.2. For each machine, the operations to be performed and the local controls must be described. More specifically, the manager should contribute in detailing: the mechanical operations that can be performed; the precisions guaranteed for each operation; the automations and sensors that the tool machine has, in order to perform operations and movements of pieces.
   a.3. With reference to the interconnections of the machine tool with the company context, it is necessary to perform (see also Figure 2):
   - The receipt of the piece drawing from the Project Room and the work sequence, in the form of a sequence of operations to be carried out and monitored;
   - The receipt of internal production orders (what, when, how many pieces) from the Internal Order Management Centre, e.g. from the Production Process Control;
   - The transmission of the execution of orders, to the Management System;

- The transmission of quality data, quantities, exceptions, stops, etc., to the Production Process Control and to the Management System;
- The receipt of material data from the Raw Materials Warehouse Management, activated by the Internal Order Management Centre.

b) In case of request for tax credit for R&D, it is also necessary to take care of an appropriate technical analysis report describing the R&D activities developed in the previous triennial period as well as in the current year. With reference to the SME//2 company, in order to show more clearly the contents of this report, the points that best characterize the R&D activities developed by the considered SME//2, are listed:
   - Details of the operations to be carried out in the "project phases";
   - Description of the interconnection methods between the management center, the management of the operations during the intervention and the teams in the work places;
   - Detailed definition of the procedures for monitoring the execution of interventions, possibly remotely, and the quality control of the operations execution and of the final installation;
   - Definition of the entire communication and management structure with intervention teams, with suppliers and customers.

4. Some concluding comments of practical use.

Developments of future research that this paper is suggesting, is to devote efforts in simpler and more interesting descriptions, specifically dedicated to manager-technicians-owners of micro or small enterprises, on the financing opportunities offered by the "Industry 4.0" plans:

- on the one hand, to define a "guide" for SME managers, to help in the selection of the most convenient and effective financing for their small company;
- on the other hand, prepare a simple presentation of the links that could be found between a project for "Industry 4.0" program and a project proposal, to be developed in collaboration with other SMEs from different countries but with similar problems for innovating through international collaborations.

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