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Fondata da Mario Arcelli

Resilienza alla (nuova) doppia crisi: persistenze e cambiamenti negli assetti e nelle strategie delle imprese italiane

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The Italian production system in the aftermath of the pandemic: firms' behaviours, production *filières* and productivity

Andrea de Panizza* Alessandro Faramondi* Silvia Lombardi*,⁰ Francesco Giovanni Truglia *

Abstract

The Italian economy did not recover the 2007 level of GDP until the end of 2023. This period has been characterised by stagnating productivity, but also by profound structural changes, including a sharp contraction of manufacturing and, overall, a slight increase in the average size of firms, a low rate of business creation, and the rapid ageing of employers. Recent years witnessed a surge in ICT adoption, accelerated by the pandemic. In this work, we address the issue reviving productivity, by focusing on the role of structural and organizational changes accompanied by the modernisation and digitalisation process. We empirically test the association between enterprises' productivity levels and some of their key structural characteristics and behavioural choices, as well as the participation in production chains, by making use of a unique set of integrated firm-level data based on information collected in the latest

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Italian Business census survey for the year 2022. Findings demonstrate the role of highly performing filières, especially for small enterprises. The analysis also confirms and qualifies the crucial role of innovation, technology adoption and human capital, all of which prove key determinants of productivity, net of very detailed controls, with specificities associated with company size.

Sintesi - Il sistema produttivo italiano nel post pandemia: comportamenti delle imprese, appartenenza a filiere produttive e produttività

L'economia italiana ha recuperato il livello di PIL del 2007 solo alla fine del 2023. Questo periodo è stato caratterizzato da una stagnazione della produttività, ma anche da profondi cambiamenti strutturali, tra i quali la contrazione del settore manifatturiero e, nel complesso, un leggero aumento della dimensione media delle imprese, un basso tasso di creazione di imprese e il rapido invecchiamento dei datori di lavoro. Negli ultimi anni si è assistito a un'impennata nell'adozione delle TIC, accelerata dalla pandemia. In questo lavoro, affrontiamo la questione del rilancio della produttività, concentrandoci sul ruolo dei cambiamenti strutturali e organizzativi accompagnati dal processo di modernizzazione e digitalizzazione. Verifichiamo empiricamente l'associazione tra i livelli di produttività delle imprese e alcune delle loro principali caratteristiche strutturali e scelte comportamentali, e della partecipazione alle filiere, avvalendoci di un insieme unico di dati integrati a livello di impresa basati sulle informazioni raccolte nell'ultimo Censimento per l'anno 2022. I risultati dimostrano il ruolo delle filiere più performanti, soprattutto per le piccole imprese. L'analisi conferma e qualifica anche il ruolo cruciale dell'innovazione, dell'adozione di tecnologie e del capitale umano, che si rivelano tutti determinanti della produttività, al netto di controlli molto dettagliati, con specificità associate alla dimensione aziendale.

JEL Classification: J24; L25; O14; O32.

Parole chiave: *Produttività di impresa; Filiere produttive; Comportamento di impresa; Innovazione; Adozione tecnologica*

Keywords: Productivity; Firm behaviour; Production *filières*; Innovation; Technology adoption.

1. Introduction

From 2001 to 2019 the Italian economy severely underperformed with respect to the other large EU economies: real GDP grew only about 4%, against 27-28% in Germany and France and over 36% in Spain, while labour productivity (value added per hour worked) increased by just 2% compared to close to 20% in Germany, France, and Spain¹. This can be associated to structural elements that - in a competitive context characterized by a rapid increase in both the role of formalized knowledge and the minimal efficient scale - have negatively affected the development of economic activities since the mid-1990s. Among these elements, it is worth mentioning the prevalence of small, less productive enterprises, the comparatively higher exposure to competition from emerging economies due to the Italian industrial specialization, the delay in the adoption of technological innovations and lower returns from them, which in turn is linked to the relatively low level of education of most entrepreneurs and employees (Istat 2018, 2019, 2021, 2023). Also, Italy experienced tighter constraints on economic policy due to its public debt burden.

Along this period, and especially during the 2010s, the system of enterprises underwent some notable structural changes. Overall, there was an increase in average size of firms, mostly due to the exit of smaller units, albeit at a slower pace with respect to partners; the creation of new enterprises was very low, resulting in fast ageing of independent workers (as a proxy for entrepreneurs) with respect to employees; other changes include the reduction of the share of sole proprietorships with respect to corporations, or the increase

¹ At current prices, labour productivity grew by 41% in Italy, 52% in France, 55% in Germany and 65% in Spain.

of BERD and R&D personnel, mildly reducing the gap with France and Germany (see Istat 2021).

More recently, shocks associated with the pandemics (supply-chain shortages, sharp fall in the activity of some service activities) and, in its aftermath, with the surge in demand and the energy crisis linked to the war in Ukraine, resulted in a polarization of enterprises in terms of performance (see infra, Costa et al. 2024), whereas technology adoption received a remarkable push by the need to introduce organizational changes to stay in the market and by investment incentives.

Structural and organizational changes, accompanied by a process of modernisation and digitalisation, could foster recovery and revive productivity after a long period of stagnation, in which growth was the prerogative of a limited core, while most enterprises struggled to keep up with changes in competition. To address this issue, and to outline the development trajectories of Italian companies, in this paper we analyse the association between enterprises' productivity levels and some of their key structural features and behavioural patterns. Specific elements considered include firms' engagement within production *filières*, the level of workforce formal education and the presence of training activities, business management models, the use of a bundle of technologies, the presence and intensity of investment in intangible assets. To this end, the paper focuses on a sample of the (over 200 thousand) enterprises with at least 10 persons employed in Industry and Service activities in 2022, drawing on structural data from enterprises and employer-employees registers, joint to qualitative information from the multipurpose survey associated to the permanent census on enterprises (hereafter Business census survey) carried out by the Italian National Institute of Statistics with reference to 2022 (Istat, 2023). This latter offers full coverage for the about

80 thousand firms with at least 20 persons employed and a 1 to 5 sample (of almost 28 thousand) for the 136 thousand smaller units.

The analysis builds on a robust strand of literature on the links between productivity and its key determinants, among which innovation and technology play a prominent role. Its novelty, stemming from the wealth of information available, lies in the ability to include as explanatory variables for productivity (a) a wide array of innovation-related elements, (b) the features of the supply chain to which the enterprises belong, and (c) very detailed controls for their main activity. In addition, it embraces the whole Italian economy. The findings of previous studies are qualified, as it is possible to disentangle the role of individual elements, and this is examined separately for units of different size-classes.

The paper is structured as follows: Section two presents evidence from previous research as a benchmark. Section three introduces the empirical strategy adopted, while Section four briefly presents background information on the Italian productive system in terms of dynamics, sectoral structure, technology adoption, and production *filières*. Section five discusses the analytical results and caveats, while Section six presents some concluding remarks.

2. Literature review

Economic literature acknowledges firm behaviour as a determinant in performance and survival across shocks (among others, with reference to Italy see Costa et al. 2022 and Costa et al. 2023; for the US see Gordon and Sayed 2022). The pandemic prompted many studies on the effects on enterprises and their reactions to the crisis, while considering productivity as a characteristic rather than an outcome. Hereunder, we briefly review recent empirical evidence on the determinants of firm productivity before and through the pandemic shock, with specific reference to the case of Italy, and to the variables used in the analysis, presented in Section 3 below.

Key structural features of enterprises are commonly associated to differential levels of productivity, due either to their intrinsic explanatory power or as proxies for latent variables, such as capital intensity, market reach, territorial spillovers, organisational sophistication, etc. The most frequently used include enterprise employment size, industry, location, and age (Istat 2020, 2022, 2023 and 2024). These same variables are also acknowledged to have affected firms' resilience and recovery (for Italy and the role of government policies, see Fasano et al. 2022; for the EU, see Criscuolo 2021; worldwide, with a focus on SMEs, see Belitski et al. 2022). Size and age are also found to affect firms' survival rate (Piva and Guerini 2023), jointly to the sector they belong to; in fact, some sectors were hit harder than others by the crisis, as a direct effect of the pandemic and/or due to administrative restrictions (namely, shutdowns), bringing about financial distress (for Italy see Carletti et al. 2020; for France, see Guerini et al. 2020).

With respect to behaviour, digitalization, innovation, human capital, and their interactions, are the three most studied determinants of productivity. Italy presents a relatively low level of adoption of digital technologies. Technology adoption is acknowledged to play a key role in explaining productivity growth in advanced economies, and low levels of technology adoption are often associated to lower returns from technology. These figures are particularly crucial for Italy, which over the last 25 years showed a stagnating trend in aggregate productivity. According to a recent work by Calvino et al. (2022), the low productivity of Italian firms, and especially of SMEs, can be traced back to the low levels of workers' skills, management capabilities, and accumulation of intangible assets, which are therefore identified as elements to foster digitalization. The effect of the pandemic on firms' resilience and productivity further increased the attention in economic literature on the use of digital technologies. In some views, digital adoption has been for some firms a key determinant of their resilience, with the pandemic increasing returns from digitalization, due to the expansion in the use of digital platforms (Bloom et al. 2021; Apedo-Amah et al. 2021; Comin et al. 2022). However, literature also emphasized pre-pandemic levels of uneven adoption among firms.

Despite the pivotal role of innovation for productivity growth (Griliches 2007), Italy is structurally affected by an innovation gap with respect to leading EU economies (Bugamelli et al. 2012). In addition, strong complementarities between R&D and broader innovation activities in explaining productivity are highlighted for the case of Information industries (Duch-Brown et al. 2018). Innovation, in turn, is positively related to the level of education of labour force. Indeed, skilled human capital is key to unlock new trajectories of growth as it fosters the adoption of technology and its effectiveness in terms of productivity returns (Griliches 1997; Istat, 2021; Calvino et al. 2022). Digitalization of enterprises goes hand in hand with human capital, as firms with higher human capital show higher rates of adoption of digital technologies and achieve greater productivity gains related to the adoption of these technologies, especially SMEs. For the population of Italian small employer-enterprises, de Panizza and De Santis (2018) provide pre-pandemic evidence on the interactions between the education of entrepreneurs and that of the workforce, and their role in determining the diffusion of ICT technologies, innovative activities, and productivity. Finally, human capital is also

determinant in facilitating synergies among different industries, beneficial to both firms and production systems, which matters in the Italian production context that, in the last two decades, witnessed the slow-down in the development of technologically advanced service activities (de Panizza et al. 2020). In fact, human capital availability is a key determinant of knowledge intensive business services' (KIBS) contribution to manufacturing productivity also in a territorial servitisation perspective for Italy (Lombardi et al. 2022). High levels of education of the workforce help unleash the benefits of proximity to KIBS for manufacturers, especially in urban areas (typically hosting high concentrations of knowledge-intensive sectors and supporting infrastructures); in a similar fashion, medium levels of education play a key role in non-urban areas specialized in traditional, low-tech manufacturing sectors.

Finally, another strand of literature addresses the study of production networks by focusing on the role of production *filières* and Global Value Chains (GVCs) (for a comprehensive review, see Bianchi and Labory 2015), while stressing their international or domestic (and local) reach – i.e. localized agglomeration of productions (for Italy see, among others, Iuzzolino, 2004 and Sforzi, 2009; globally, see Porter 1990). Production organizations and *filières* in which firms are engaged represent meaningful units of analysis when explaining structural change. By taking into consideration the production network in which firms buy and sell their products, *filières* allow to jointly consider different segments of production processes and their vertical relations. In general terms, both international and local organizations of the division of labour of production chains are acknowledged to provide positive economies from the perspective of the firm. These may arise from economies of specialisation, as well as from the reduction of transaction costs, with positive impacts in terms of profits. The engagement within GVCs may entail several advantages, depending on the position and the type of governance of the chain. Productivity spillovers may arise also from supply linkages with MNCs, traditionally more innovative and productive, in turn resulting in market share gains.

During the pandemic, the disruptive effect of Covid-19 on global value chains as well as localized production *filières* was a matter of concern, as sourcing was severely limited by governments' constraints to economic activities and trade: relevant issues to this respect include the increase of re-shoring and nearshoring practices, and international supply chain disruptions (Alessandria et al. 2023). However, GVCs proved to be resilient (CSC, 2023) and trade in intermediate goods (entering new production processes abroad) has returned to pre-financial crisis levels (even above, in most advanced and emerging countries, excluding China). In the same vein, Castelli et al (infra) show how productivity levels are intertwined with the participation of enterprises to global production networks, and the role of the latter in the quick adaptation to changes in market conditions by Italian firms, particularly for smaller business units.

3. Empirical strategy

3.1. Data sources

The study of firm characteristics, behaviours and their effects on productivity in the aftermath of the pandemic makes use of a unique firm-level data set, which integrates three data sources: (i) qualitative information obtained from the Business census survey carried out by the Italian National Institute of Statistics; (ii) economic results derived from the Structural Business Statistics (SBS) Business Register (BR) for the year 2022; (iii) human capital information derived from BR-employment register for the year 2021 (latest year available).

The primary source of our data set is Business census survey conducted by Istat over the 2022/2023 period with reference year 2022 on a sample of about 280,000 enterprises with at least 3 persons employed, representative of a universe of 1,021,618 units equal to 22.5% of Italian enterprises. Close to 80% of these are micro. In terms of data collection, firms with more than 10 employees were asked for a more detailed questionnaire, which collected determinant insights to our purposes as detailed information in digitalization and innovation. Therefore, we decided to use such sub-population of the sample in our analysis. Overall, enterprises with at least 10 employees, although they account for slightly more than 20% of the surveyed population, contribute 55,6% of persons employed and 79,8% of value added² of industry and services. In addition, Business census survey provides in depth information on production *filières*, that is, supply chain defined as a sequence of tangible or intangible economic activities, from the procurement of raw materials to the sale of the good or provision of service to final consumers. Overall, firms are asked to self-assess their participation to one or more production *filières* among a set of 28^3 .

3 The definition of the *filières* was carried out by Istat in collaboration with Confindustria. In order to technically identify production *filières*, sector-specific focus groups were also held with enterprises to acquire preliminary information on the target population of the supply chain. Production *filières* contained in the questionnaire are the following: Agribusiness; Home and office furnishings; Clothing, footwear, clothing accessories, also for sports use; Publishing; Pharmaceuticals, personal, animal and household care and cleaning products; Health and social care; Road transport; Road transport infrastructure and services; Transport by rail and cable; Rail and

^{2 189,000 (}or 18.5% of the total) are small enterprises (10-49 employees), while medium-sized enterprises (50 to 249 e) and large enterprises (with 250 employees and more) account for 2.2% (22,861 units in absolute values) and 0.4% (3,969 units, of which 1,622 with 500 employees and more).

Finally, qualitative information from the Business census survey has been improved with economic information on turnover, value added, international trade (exports) from the Business register of the main economic variables (legal unit register – Frame SBS) and with level of education of the workforce from the Italian Linked employer-Employee (LEED) Archive (*Asia Occupazione*)⁴.

3.2. Methodology

The empirical analysis is focused on a cross-section multivariate regression to test the effects of a set of behavioral, organizational and production choices on firm productivity (LnProductivity), measured as the log of value added per employee. The reference year is 2022. Specifically, for each firm i of the sample, our equation model is:

$$LnProductivity_{i} = \beta_{0} + \alpha Fili\grave{e}re_{i} + \gamma Behaviour_{i} + \beta_{1}HumanK_{i} + (1) + \beta_{2}Path_{i} + \beta_{3}Governance_{i} + \beta_{4}Export_prop + + \psi Z_{i} + \varepsilon_{i}$$

where *Filière*_i is vector of production environment variables composed of:

- *Type_filière*_i a categorical variable based on a synthetic index revealing the type of production *filière* a firm belongs to;

cable transport infrastructure and services; Aerospace and defence; Aerospace and defence transport infrastructure and services; Electrical or electronic equipment for domestic use; Industrial electrical appliances, machinery and processed goods for non-dedicated use for specific industries; Non-electrical tools and small parts for domestic, industrial and professional use; Jewellery; Energy; Circular economy and waste management; Water service; Building; Finance; Tourism; Audio and audiovisual content; Telecommunications infrastructure and services; Education and vocational training; Other supply chain.

⁴ For each firm and for each employee, the level of education held is converted using the theoretical duration of the corresponding course of study and those required to access it: for example, an upper secondary school diploma corresponds to 13 years of schooling (5+3+5). By aggregation, enterprise data are obtained.

- > 1 *filières*_i is a dummy variable equal to 1 if a firm declares to belong to more than one filière;
- *Local_comp*_i is a dummy variable equal to 1 in case of exclusively local competition.

*Behaviour*_i is a vector of variables portraying innovation-related behaviours, computed starting from an array of elementary items, summarized by means of a two-step procedure: (i) a Multiple Correspondence Analysis (MCA) is performed on each group of items, and (ii) firm-level summarized values for the first component are then clustered (partitioned) in three groups on the basis of the intensity of the phenomenon (high, medium and low)⁵. This resulted in the following synthetic indicators:

- $Inno_i$, for innovation⁶;
- *Invest*_i, on the levels of investments in R&D, technologies and digitalization, human resources and training, internationalization, environmental and corporate responsibility, that we proxy for intensity of investments;
- AI_i, for artificial intelligence (AI) in business processes⁷;

⁵ A Multiple Correspondence Analysis (Benzécri, 1973) is performed on the association of the frequencies of each group of items in order to calculate the chi-square information and inertia explained by the first dimension. On such variable, a K-means procedure of clustering has grouped each dimension into three classes of values (high, medium, low) on the basis of uses Euclidean distances, therefore cluster centers are based on least-squares estimation.

⁶ Innovation takes into consideration the following activities: *intra muros* R&D, procurement of external R&D services, staff training on innovations adopted and/or planned, technical and aesthetic planning (design), acquisition of licences and/or patents, acquisition or development of software, databases and services for data analysis, acquisition of computer hardware, network and telecommunications equipment, acquisition of machinery, equipment and facilities for the innovations adopted or planned, marketing activities for new goods and/or services. Firms' individual coordinates for the

⁷ We consider: access control to locations, data or services (biometric recognition systems: face, fingerprints, voice, etc.), automation of production processes (using 'intelligent' software, which can automatically perform the repetitive tasks of operators, imitating their behaviour and interacting with computer applications), collaborative robotics (cobots, i.e. robots interacting with human operators), predictive (or preventive) maintenance of machinery (including vehicles), automation of sales functions in physical shops (in-store customer support, digital assistants, automated tills), automation of online sales functions for goods and services (navigation sup-

- *Tech*^{*i*} for digital technologies⁸;

Behavioural variables also include a dummy SW_i for the use of business management software⁹.

 $Path_i$ is a set of dummy variables related to pathways of firm's development as technological modernization of the business activity, diversification through the creation of a new area of activity beyond the core activity, transition to a new core business area, innovative transformation of economic activity involving the production of new goods and/or services not introduced to the market by competing enterprises.

 $HumanK_i$ is a vector of human capital related variables as Edu_i are the average years of education of persons employed (and its squared term Edu_i^2 to grasp the non-linearity of the phenomenon) and $Training_i$, a dummy variable equal to 1 if firm invested in (non-compulsory) training of its personnel over the year 2022.

Governance^{*i*} is a set of variables that distinguishes between: foreign MNCs, Italian MNCs, Italian group of firms, independent firms not belonging to

port, automated payment and invoicing, automated responders, etc.).

⁸ Two aspects of digital technologies are considered here: (i) the use of at least one type of cloud services as: database hosting and file storage, remote management software (finance, accounting, customer relations, etc.), remote business data analysis (Data Analytics, including Big Data analysis), office software such as Microsoft Office 365 (writing programs, spreadsheets, etc.), communication and collaboration services (e-mail, remote desktop applications, etc.), E-commerce services; (ii) the investment in the two-year period 2021-2022 or plans to invest in the three-year period 2023-2025 on digital technologies as: broadband connection, Mobile Internet connection (4G-5G), Internet of Things, Immersive technologies, Big Data processing and analysis, Advanced automation, collaborative robots and intelligent systems, 3D printers, Simulation between interconnected machines, Blockchain for product or process certification, Cyber-security. This variable is grouped into medium-high and low levels as, individually, medium- and high levels are not significantly different from each other in terms of effects productivity with respect to the low level.

⁹ This variable is set equal to one if the firm adopts at least one of the following enterprise management software: ERP, CRM for business management of company documentation management, industrial accounting, business management planning, production planning, production management, customer relations, supplier and warehouse management.

groups; *Export_prop* is the ratio of export over turnover. Finally, Z_i is a vector of control variables including the five NUTS-1 geographic locations, employment-size in logarithmic form (*log_emp*) and its squared term, to mimic the shape of its non-linear impact on productivity, herself log-smoothed. A vector of 3 digits (NACE Rev.2) economic activity dummies is also included, to proxy for capital intensity (not available) and other industry-level specificities. Finally, in order to show different effects on labour productivity on different subsamples of firms, we also run multiple regressions, one for each group (split sampling). Appendix 1 provides basic statistics of the explanatory variables.

The information on the 28 production *filières* is summarized in the four groups represented by the variable $Type_filière_i$, by means of a two steps procedure: (i) a Principal Component Analysis (PCA) run on microdata aggregated at *filière* level for a subset of interest variables¹⁰, and (ii) a k-means clustering procedure, applied on factor scores to identify homogeneous groups of supply chains¹¹ (see Section 4.3 for descriptive statistics).

¹⁰ We consider the above mentioned variables: training of personnel (*Training*); average years of education (*Edu*); artificial intelligence in business processes (*AI*); innovation (*Inno*); use of business management software (SW); use of digital technologies (*Tech*); levels of investments in R&D, technologies and digitalization, human resources and training, internationalization, environmental and corporate responsibility (*Invest*); path of development (*Path*). We also consider the share of employment in knowledge intensive services (KIS) and high tech (HT) manufacturing (*Employment KIS-HT*) in the group of economic activity (3 digit NACE Rev.2) of the supply chain. A principal component analysis (PCA) was performed on the correlation matrix of standardized aggregate data (each variable therefore has mean 0 and variance 1), then we extracted the principal (components to which an eigenvalue > 1 is associated) which reproduce a greater amount of information than that contained in a single standardized variable. Following this criterion, a two-dimensional subspace was identified. The first and second principal components reproduce 61.5 per cent and 19.6 per cent of the variance respectively, that is, over 81 per cent of the total variance (total information contained in the data matrix).

¹¹ For the determination of the optimal number of clusters (the objective function in this case is to minimize the internal variance within each group), the Elbow method was followed.

4. Descriptive statistics and multivariate analysis results

4.1. Background: structural changes in the Italian production system

As in other advanced economies, after the global financial crisis (2008) the Italian business system underwent a process of internal re-composition, with an increase in the weight of service activities and larger enterprises compared to manufacturing and smaller ones. Underlying these trends, however, with respect to France, Germany and Spain (that with Italy form the "E4 group"), Italy (i) presents a higher share of micro-enterprises, (ii) suffered a deeper impact of the Great Recession on manufacturing activities, and (iii) experienced a slower pace of development of advanced service activities and business creation in general (Figure 1).

Recent years, to which the analysis refer, were marked by the recovery of construction activities after a 15-years long decline, fostered by tax incentives, and by the selective impact of the pandemics shock on service activities (most notably, on tourism and personal services). Tendencies led to a net decrease in the number of service enterprises: overall, considering units with at least 3 persons employed, service firms represented 58.8% of the total economy in 2001, 65.6% in 2011, and reached 70.4% in 2021, and fell back to 69.6% in 2021. The slowdown in the service activities and the expansion of the construction sector occurs in a context in which the share of industrial firms keeps decreasing (20.7% in 2011, 18.9% in 2018, 18.4% in 2021). The contraction of industrial sector concerns exclusively small and very small industrial entities which, overall, recorded a loss of 46 thousand employees (-4.7% of employees among micro-enterprises).

Figure 1. Number of enterprises in E4 countries' non-financial business economy in 2020 vs. 2008 (left: total, manufacturing, high-tech services) and share of high-tech services in value added of the non-financial business sector in 2019 (right: percentage values) (*)



Source: Eurostat, Structural Business Statistics.

(*) Business economy: NACE B to N and S95, excluding K; High Technology service activities: NACE 59 to 63 and 72. Number of enterprises in High tech services: 2012=100, instead of 2008.

Note - The dynamics of enterprise stocks can be influenced by changes in the definition of statistical units, which came into effect in 2017 (see Faramondi, 2019)¹².

¹² In recent years European Countries (Italy in 2019, reference year 2017) has implemented the correct definition of statistical unit "Enterprise", as defined in EU Regulation 696/93. The Enterprise is the smallest combination of legal units that is an organisational unit producing goods or services, which benefits from a certain degree of autonomy in decision-making, especially for the allocation of its current resources. An enterprise carries out one or more activities at one or more locations. An enterprise may be a sole legal unit or one group of legal units under common control". The correct application provides rules to group several legal units under common control when they do not have sufficient autonomy in the decision-making process. This paradigm shifts the impact on the observation of the production system significantly, leading to a reduction in the number of companies, an increase in their average size and a decrease in several economic variables, due to intra-group flows consolidation. There is also a reshaping of value added and therefore of productivity per economic activity accordingly.

4.2. Structural and behavioural characteristics of Italian enterprises

Below, we briefly illustrate the prevalence of structural and behavioural characteristics in the Italian business system referring to the variables used as explanatory in the regression analysis. These include governance, as portrayed by the type of ownership, the education of the workforce, the implementation and types of survival or development strategies undertaken, the usage of business software, and the three synthetic variables mimicking the adoption of specific ICT technologies, the presence of innovative activity, and the intensity of investment in R&D, human resources, internationalisation, and corporate responsibility. Production *filières* and their treatment are presented in next Section 4.3.

The type of ownership reveals several elements that were not (and very often could not be) considered in the analysis, such as management practices, access to finance, linkages with other companies and foreign markets, etc. To this respect, the analysis distinguishes single (i.e. independent) enterprises from enterprises belonging to a group, and these latter are further disentangled into domestic and multinationals companies (national or foreign owned) (MNCs). In 2022, just about 30% of the population of enterprises with at least 10 persons employed consisted of single enterprises, and about 27% were part of domestic groups, while the remaining 43,5% was roughly equally split between Italian and foreign multinational enterprises. This pattern varies with size: almost 90% of large enterprises with at least 250 persons employed were labelled as MNCs, half of them being subsidiaries of foreign MNCs and 40% with Italian ownership; single enterprises represent only 2% in this segment. The territorial pattern (intertwined with employment size and industry) is also very relevant: in the North-west about 62% of enterprises are

part of MNCs (most of them being foreign owned), while in the Islands (Sicily and Sardinia) MNCs sum-up to less than 20% of units. Conversely, single enterprises are 17.6% in the North-west and more than 40% in both the South and the Islands (Figure 2).





Source: Istat, Frame SBS

The education of the workforce is another constituent feature of the enterprise that, besides its definitional linkage to productivity via its relationship with wages and value added, has an explanatory power of its own as a driver of innovation and a complementary element for the effective adoption of technologies and innovation.



Figure 3 Distribution of Italian enterprises with 10 persons employed and more, by education of the workforce, overall (left) and by industry (right) (school-years). Year 2022

Source: calculations based on Istat LEED Register (Asia Occupazione) and Business census survey data

As recalled in Section two, this can also hint at managerial practices and, for smaller-sized units, given the strict relationship between the educational attainment of owners and workers, to the capability of following any innovation-related path. In our analysis, education is measured in years required to obtain the highest diploma possessed by each person employed in the enterprise. On average, it stands at close to 13 years per p.e. (i.e. slightly less than the legal requirement for a secondary school diploma in the Italian education system). Its distribution, as expected, is slightly skewed to the right. It is interesting to note that most of variability stays within industries, even when comparing the circa 800 economic activities at the 5th digit level of NACE (in Figure 3 hereunder, portrayed at 2 digits).

The analysis also tests the relevance of the implementation of strategic behaviours regarding (a) the pursue of a technological modernisation of the activity, (b), the diversification of products and customers, that possibly contributed to (c) a transformation of the activity, or the most radical change, i.e. (d) the transition to another activity (Figure 4, left). Whereas 43% of the (10+) enterprises declared to have invested in modernisation (and up to 61% of large enterprises), the other patterns were followed by far less companies. Diversification stood at about 15%, with no significant differences by employment size, while the transformation of the activity had been pursued by 15% of large firms and 10% or less of smaller units. Finally, the transition to another activity, which can be regarded rather equally as both a good and a bad signal, was declared by about 5% of firms across all sizes. Some companies followed more than one of the above strategies (on average, 1.3).







Our analysis also considers the uptake of specific ICT technologies, that often require the complementary endowment of human capital, or a specific attitude of the enterprise and/or of the business (Figure 4, right). In decreasing order of diffusion, these include: the simulation of interconnected machines, performed by close to 12% of the population, and up to 20% for the case of larger units; IoT, Data analytics (Big Data), and advanced automation, all performed by less than 10% of firms, but by a three or fourfold share of larger units; 3D printing and blockchain technologies, which have even lower overall rates of adoption (6.3 and 4.6% respectively), which roughly doubles for larger companies; lastly, the usage of immersive technologies, which is still growing up from a niche status.







The use of enterprise management software is also included in the analysis: overall, about half of firms with at least 10 persons employed declared to use at least one application of this type (see above, Section 3). By industry adoption rates reflect the sophistication of economic activities, which often goes hand in hand with their average business size, and range from just above one third of enterprises in low-tech service activities, to two out of three in ICT and Financial services, and Energy; correspondingly, by-size rates span from little less than 50% for smaller units to above 80% for the larger ones with at least 250 p.e. (Figure 5).

As outlined in Section 3 above, some behavioural elements are treated by means of synthetic variables. These include (a) innovative activity – comprising the performance of R&D, and innovation related purchases of ICT and other equipment – and (b) the intensity of investment in R&D, ICTs, human resources, internationalisation, and corporate responsibility. These features – as portrayed in dichotomous variables – are overall widely diffused (rates ranging from 51% to about 60% of firms), with a significant by-size extent across large industry aggregates (Figure 6).





Source: Istat, Business census survey

4.3. Production filières: typologies and characteristics

Overall, the 28 production *filières* surveyed in the questionnaire embrace the Italian production landscape while investigating its systemic dimension, that is, through firms' interactions of mutual exchange of goods, services, technology. Its usefulness is well known in the applied economic research which emphasizes the role of external economies to firm but internal to its local productive context.¹³ The most numerous *filiére* in terms of persons employed and enterprises is Agribusiness, followed by Road transport, Building, Clothing, footwear, clothing accessories, also for sports use, and Tourism, with a very high variance in terms of average dimension, ranging from 26 and 28 persons employed in Jewellery and Construction *filières* to the 156 and 127 of Aerospace and defence, Transport infrastructure and services *filières* (Figure 7). In general terms, about four firms out of five participate to only one supply chain, such share increases to two thirds in the case of large enterprises.

¹³ On a national basis, a renewed and remarkable attention in policymaking is now increasing in the light of recent policy re-orientation approach which identifies *filières* as a tool to provide financial resources within the Italian National Plan of Recovery and Resilience (*Piano Nazionale di Ripresa e Resilienza - PNRR henceforth*), particularly the Decree 13 January 2022 *Attuazione dell'Investimento 5.2 «Competitivita' e resilienza delle* filiere produttive».

Figure 7 Persons employed, enterprises and productivity levels by production filières. Year 2022. Percentage shares and



Source: Istat, Business census survey

animal and household care and cleaning products; 6=Health and social care; 7=Road transport; 8=Road transport; nfrastructure and services; 9=Water transport; 10=Water transport infrastructure and services; 11=Transport by rail and cable; 12=Rail and cable transport infrastructure and services; 13=Aerospace and defense; 14= transport infrastructure and services; 15=Electrical or electronic equipment for domestic use; 16=Industrial electrical appliances, machinery and processed goods for non-dedicated use for specific industries; 17=Non-electrical tools and small parts for domestic, industrial and professional use; 18=Jewelry; 19=Energy; 20=Circular economy and waste management; 21=Water service; 22=Building; 24=Tourism; 25=Audio and audiovisual content; 26=Telecommunications infra-Note: 1=Agribusiness; 2=Home and office furnishings; 3=Clothing, footwear, clothing accessories, also for sports use; 4=Publishing; 5=Pharmaceuticals, personal, structure and services; 27=Education and vocational training; 28=Other supply chains. Our analysis groups the 28 production *filières* into 4 main typologies, ranging from the highest to the lowest intensity in terms of technological trajectories and innovation actions implemented by enterprises, that is, behaviors leading to competitiveness (Figure 8).

Specifically, the first type of *filières*, labelled 'Top performing', is the most dynamic and performing in terms of such behaviors, includes the most technologically mature *filières* and represent only 0.4% of enterprises, but 18% of persons employed and 25.8% of value added. About 0.4% of personnel is employed in high-tech manufacturing sectors and knowledge intensive business sectors. It includes the *filières* with the highest average productivity level and average dimension (above 99thousand euros and 61 persons employed respectively)¹⁴. Consistently with average size class (and vertical integration), this type of *filières* includes both segments featured by natural monopolies as those originating by public utilities, and top performing (technologically advanced) manufacturing *filières*. The second type stands out for its 'Human capital' and performs medium high intensity of behaviours leading to competitiveness, while presenting the highest average years of education of persons employed, the highest average dimension (63 persons employed) but a below national average use of AI. They represent 11% of enterprises, 9% of persons employed and 7.9% of value added.¹⁵ In further descending order, the third type is 'Third tier'; these *filières* represent about one fifth of enterprises, persons employed and value added.¹⁶ The fourth type of *filières* called

¹⁴ The first cluster includes the following *filières*: Pharmaceuticals, personal, animal and household care and cleaning products; Transport by rail and cable; Air and rail transport infrastructure and services; Electrical and electronic equipment for domestic use; Industrial electrical appliances, machinery, and processed goods for non-dedicated use for specific industries; Energy; Telecommunications infrastructure and services.

¹⁵ The second cluster includes the following *filières*: Publishing; Health and social care; Aerospace and defence; Audio and audio-visual content; Education and vocational training.

¹⁶ The third cluster includes the following *filières*: Home and office furnishings; Road transport; Road transport infrastructure and services; Water transport; Non-electrical tools and small parts for domestic, industrial and

'Laggard' performs the lowest level along all the dimensions of analysis, yet involves 65% of enterprises, 53,5% of persons employed and 45,9% of value added.¹⁷



Figure 8 Main indicators by type of production filières. Year 2022. Percentage values.

5. Regression results

Estimates in Table 1 suggest that – other things being equal –the engagement in specific production *filières* impacts on firm productivity. We interpret this result as the relevance of advantages generated by production linkages within the production *filière*, which arise within a division of labour organized either locally or on an international scale, within a web of business-to-business transactions which lead to productivity gains.

Source: Istat, Business census survey Note: Finance *filière* excluded

professional use; Circular economy and waste management; Water services.

¹⁷ The last cluster includes the following *filières*: Agribusiness; Clothing, footwear, clothing accessories, also for sports use; Water transport infrastructure and services; Jewellery; Building; Tourism; Other supply chain.

In addition, even when controlling for the role of (3rd digit NACE) economic activity, itself proxying capital intensity and other latent sector-specific variables (column A), other things being equal:

- Belonging to any of the *filières* in the 'top performing' cluster increases productivity by 3.3% on average with respect to the (*laggards*) baseline; in addition, participation to more than one *filière* positively affects productivity;
- The presence of local competitors as main competitors shows negative effects.
- The impact on productivity of specific investments and behaviours can be summarised as follows:
- The higher the intensity of investments, innovation actions and the use of AI technologies, the higher the productivity gains;
- The use of enterprise management software and digital technologies have a positive impact;
- In terms of development trajectories, technological modernization has a positive and significant impact, while transformation and diversification *per se* have significant negative effects (this could also reflect longer time lags for returns to surface);
- Human capital has a positive and significant role: on average, one additional year of education of workforce provides a 6.7% increase in productivity (as explained in Section 2 above, this relationship is also non-linear); training activities also increase productivity, by an additional 2.3%.
- With respect to governance, being a foreign-controlled MNC (against being a single enterprise) provides the highest productivity returns re-

spect to Italian MNC and Italian group. Export propensity is confirmed highly relevant in determining productivity gains (by over 17%);

The above results are robust to different measures of NACE, that is, to different metrics of capital intensity. ¹⁸

By class-size results (columns B, C, and D) show differential behaviours and effects on productivity.

Firstly, the role of *filière* is positive and significant only for small and medium- sized firms, and negative for large ones. Results for small firms point out the positive impact of 'Top performing' *filières* (+3.9% in terms of productivity with respect to being in the laggard *filières*), as well as their connection within more than one *filières*, while among medium sized firms the 'Human capital' *filières* stands out (+3.1%). Only smaller units are sensitive to being engaged in more than one *filière*. In addition, smaller units are significantly more impacted than medium-sized units by innovative actions, use of AI and digital technologies and business development trajectories.

By contrast, productivity outcome of investment intensity, use of business management software, education and training significantly increases with size across all samples¹⁹ (with the only exception of training activities, which are not significant for large firms), meaning that large firms are more affected. In fact, for large firms, regression results show that their behaviours greatly differ from the rest of the economy, as expected: the productive context does not have positive effects (as in the case of 'Top performing') or is not significant, as in the case of local competition. Since the 'Top performing' *filières* are

¹⁸ Relaxing controls for sector effects to the first digit of NACE classification, all variables increase their significance and impact (beta coefficient magnitude).

¹⁹ One additional year of education of the workforce increases productivity by 5.9% for small firms, 11.2% for medium firms and 15.9% for large firms. Results are obtained by calculating partial derivatives of EDU variable for each subsample and by using average sample-specific values of the variable.

composed not only of technology-intensive manufacturing *filières* but also of natural monopoly segment (public utilities), we interpret this result as the distortion (inefficient allocation of resources) induced by natural monopolies due to high barriers to entry and start-up costs hard to face also for large enterprises. In addition, for large firms the use of digital technologies payoffs is highest, while other behaviours proved to be not significant (namely, innovation, the use of AI, development paths).

	(A	7)	(B	5)	(C)	(D)	
	WHOLE SAMPLE (10+)		SMALL (10 to 49)		MEDIUM (50 to 249)		LARGE (250+)	
VARIABLES	coeff	(s.e.)	coeff	(s.e.)	coeff	(s.e.)	coeff	(s.e.)
Top performers	0.0326***	(0,006)	0.0388***	(0,007)	0.0009	(0,012)	-0.0683**	(0,032)
Human capital	0.0031	(0,009)	-0.0039	(0,011)	0.031*	(0,018)	0.0278	(0,045)
Third tier	-0.0028	(0,006)	-0.0008	(0,007)	-0.0144	(0,012)	-0.0289	(0,033)
Laggards (baseline)								
> 1 filières	0.0083*	(0,005)	0.0101*	(0,005)	-0.0121	(0,009)	0.0324	(0,023)
Local competition	-0.0741***	(0,005)	-0.0754***	(0,005)	-0.064***	(0,010)	0.0173	(0,032)
Investments H	0.0235***	(0,006)	0.0124*	(0,007)	0.0835***	(0,012)	0.1496***	(0,037)
Investments M	0.0213***	(0,005)	0.017***	(0,006)	0.0498***	(0,011)	0.0945***	(0,034)
Investments L (baseline)								
Innovation H	0.0501***	(0,008)	0.0476***	(0,010)	0.0388***	(0,013)	0.0198	(0,032)
Innovation M	0.0425***	(0,005)	0.0455***	(0,006)	0.0289***	(0,010)	-0.0176	(0,027)
Innovation L (baseline)								
AI H	0.04***	(0,013)	0.0371**	(0,017)	0.0364*	(0,020)	0.0387	(0,039)
AIM	0.0155**	(0,007)	0.0066	(0,008)	0.0461***	(0,012)	0.0372	(0,027)
AI L (baseline)								
Digital tech M, H	0.0547***	(0,005)	0.0565***	(0,006)	0.0264***	(0,009)	0.0621**	(0,025)
Digital tech L (baseline)								
Enterprise mng. software	0.0484***	(0,004)	0.0463***	(0,005)	0.0469***	(0,009)	0.0972***	(0,029)
Tech modernisation	0.0647***	(0,005)	0.0688***	(0,005)	0.0379***	(0,009)	-0.0036	(0,025)
Diversification	-0.0327***	(0,006)	-0.031***	(0,007)	-0.0348***	(0,012)	-0.0571*	(0,030)

Table 1 Regression results

Dependent variable: log of productivity

	(A)	(В)	(C)	(D)	
	WHOLE SAMPLE (10+)		SMALL (10 to 49)		MEDIUM (50 to 249)		LARGE (250+)	
VARIABLES	coeff	(s.e.)	coeff	(s.e.)	coeff	(s.e.)	coeff	(s.e.)
New activity	-0.0168*	(0,010)	-0.0101	(0,011)	-0.0553***	(0,018)	-0.0492	(0,046)
Transformation	-0.046***	(0,007)	-0.0474***	(0,008)	-0.0382***	(0,013)	-0.0221	(0,031)
Training	0.0217***	(0,004)	0.0205***	(0,005)	0.0264***	(0,009)	0.0016	(0,028)
Education	-0.0909***	(0,009)	-0.0734***	(0,010)	-0.1092***	(0,026)	-0.1452*	(0,084)
Education (sqrt)	0.0064***	(0,000)	0.0054***	(0,000)	0.0088***	(0,001)	0.0116***	(0,003)
Foreign owned MNC	0.3163***	(0,011)	0.3365***	(0,015)	0.1951***	(0,015)	0.1959***	(0,042)
Italian MNC	0.2878***	(0,009)	0.3178***	(0,012)	0.1701***	(0,012)	0.2334***	(0,039)
Italian group	0.2026***	(0,005)	0.2108***	(0,006)	0.1291***	(0,010)	0.148***	(0,036)
No group								
Export propensity	0.1766***	(0,013)	0.1805***	(0,016)	0.1344***	(0,021)	0.2341***	(0,058)
log_employment	0.1415***	(0,013)	0.6343***	(0,075)	-0.3586*	(0,198)	-0.0011	(0,140)
log_employm (sqr)	-0.0177***	(0,002)	-0.0971***	(0,013)	0.0377*	(0,022)	-0.001	(0,010)
Constant	9.8642***	(0,062)	9.0422***	(0,129)	10.9933***	(0,485)	10.3982***	(0,756)
GEOGRAPHIC AREA	YES		YES		YES		YES	
NACE 3	YES		YES		YES		YES	
Observations	104,514		77,994		22,559		3,961	
R-squared	0.4186		0.4071		0.4571		0.5580	
Pr > F	<.0001		<.0001		<.0001		<.0001	
Rooted MSE	0.8173		0.8812		0.5613		0.5931	

Section K excluded; *** p-value<0.01, ** p-value <0.05, * p-value <0.1

6. Discussion and conclusions

This paper addressed the general topic of the recovery and revive of firm's productivity after the long period of stagnation which featured Italy before the pandemic, with the focus on the role of structural and organizational behaviours within a context of modernisation and digitalisation. We considered firm-level information available from the Business census survey for the year 2022 on behavioural patterns, on the level of workforce formal educa-

tion and the presence of training activities, on firms' business management models, on the use of a bundle of technologies, on the presence and intensity of investment in intangible assets, and on firms' engagement within specific production *filières*.

Results firstly shed new light on the role of production *filières* overall, relevant in the perspective of the Italian National Recovery and Resilience Plan (PNRR) and, most importantly, across all sectors (not only within manufacturing sectors), which renews the attention to their role in policy making. In fact, ceteris paribus engagement in specific production filières does make the difference on firm productivity as the production environment, be it localized or not (as in the case of services or public utilities), reduces transaction costs and increases external economies which lead to productivity gains. This holds true for firms engaged in high valued production *filières* ('Top performing' type), either manufacturing and technology-intensive or public utilities-centered - with respect to the (laggards) baseline. Our results confirm the positive net effect on productivity of the increase in the level of education, intensity of investments, innovation actions and the use of AI technologies, whose robustness is confirmed by the highly detailed controls included in the regressions. Technological modernization also proved to be significantly effective, as well as the use of bundles of digital technologies and enterprise management software.

The intensity and relevant of the above relationships, however, is also dependent on the employment size of enterprises: small firms are positively affected by their engagement in 'Top performing' *filières* and from being in more than one, confirming the returns from specialization. Medium sized firms are sensitive to the 'Human capital' *filières*. Differential development path also suggests the need to rethink industrial policies. Smaller units are the most affected by technological modernisation, as well as by innovation as well as by the adoption of more advanced technologies, including AI.

By contrast, training has a higher impact on medium sized firms, highlighting the role of organizational issues. Large firms greatly differ from the rest of the economy, as expected. Here, investments payoffs are the highest among all sub-samples, as well as the use of digital technologies and use of enterprise management software, while other behaviours proved to be not significant.

These findings could be further qualified in future research, as new sources become available. For instance, the use of data on electronic invoicing would allow for an objective definition of *filières* (rather than the subjective and predefined one from the Business census survey), based on factual relationships between customers and suppliers. In this way, it will also be possible to identify finer supply chains and localized clusters, made up that determine a single vertically integrated production process.

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Variable	Mean	St. Dev.	Min.	Max.
Al	3.3209846	11.2407467	0	100
SW	19.1981760	34.5689887	0	100
Digital Tech	11.5824957	22.5176632	0	100
Invest	33.0603735	39.0987662	0	100
Inno	13.7916793	24.4056744	0	100
>1_filière	0.2582943	0.6078635	0	1
Local comp	0.4600257	0.6921663	0	1
Path -Techmoder	0.4090783	0.6828119	0	1
Path -Diversif	0.1379538	0.4789222	0	1
Path -Newateco	0.0488846	0.2994577	0	1
Path -Trasform	0.0932156	0.4037655	0	1
Governance	2.541258	1.1007491	0	3
Export_prop	0.0642387	0.2545306	0	1
Training	0.3992153	0.6801362	0	1
Edu	12.1931914	2.8769956	0	20.1600000
Ln_add	3.0792341	1.1332658	2.3035846	11.6970447

Appendix 1 – Statistics for explanatory variables

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ECONOMIA ITALIANA 2024/1

Resilienza alla (nuova) doppia crisi: persistenze e cambiamenti negli assetti e nelle strategie delle imprese italiane

Le vicende economiche italiane dopo la fase acuta della pandemia sono state caratterizzate - in un contesto perturbato da ulteriori shock globali - da una ripresa economica più rapida rispetto ai principali paesi europei, sostenuta da politiche fiscali espansive e da una rilevante performance dell'export. In questo numero gli **editor, Giovanni Dosi** (Scuola Superiore Sant'Anna) e **Roberto Monducci** (Osservatorio Imprese Estere), assieme a un folto gruppo di ricercatori, si propongono di dare una prima risposta all'individuazione dei fattori microeconomici e settoriali sottostanti tali dinamiche, attraverso un intenso utilizzo di nuove fonti statistiche realizzate dall'Istat, in particolare la nuova edizione del Censimento permanente sulle imprese.

I primi due contributi di **Costa et al.** (*Ristrutturazioni del tessuto produttivo tra pandemia e inflazione: comportamenti, persistenze e transizioni d'impresa*) e di **Castelli et al.** (*Competitività, performance e partecipazione alle reti produttive internazionali del sistema esportatore italiano*) forniscono il quadro delle persistenze e dei cambiamenti intervenuti tra la fase pre e post Covid-19 all'interno del sistema produttivo e in quello esportatore.

Il contributo di **de Panizza et al.** (*The Italian production system in the aftermath of the pandemic: firms'behavior, production* filières *and productivity*) esamina il tema della produttività attraverso un'ampia gamma di comportamenti d'impresa, con particolare riferimento alla partecipazione alle filiere produttive. L'ultimo lavoro, a cura di **Bacchini et. al.** (*Italian's economy recovery: factors of resilience and future challenges*), propone un quadro di sintesi settoriale, evidenziando le diverse velocità di recupero dei comparti industriali ed alcuni fattori che potrebbero averne influenzato la ripresa.

Complessivamente, i contributi forniscono importanti elementi interpretativi sulle caratteristiche strutturali e le dinamiche delle imprese italiane degli ultimi anni. Il quadro che emerge è in chiaroscuro. Sicuramente gli shocks aggregati non hanno indotto quegli effetti di 'cleansing' generalizzato attesi da molti economisti; allo stesso tempo, una frazione delle imprese (variabile tra i diversi settori) ha mostrato una notevole vitalità, tentando upgrading nelle proprie strategie mediante innovazione organizzativa, nuove tecnologie, penetrazione dei mercati esteri, partecipazione alle reti produttive internazionali.

Completano il volume l'intervento di **Stefano Micossi**, Understanding the Italian economy's growth crisis e la rubrica di **Francesco Minotti**, dedicata al Fondo di garanzia per le PMI.

ECONOMIA ITALIANA nasce nel 1979 per approfondire e allargare il dibattito sui nodi strutturali e i problemi dell'economia italiana, anche al fine di elaborare adeguate proposte strategiche e di *policy*. L'Editrice Minerva Bancaria è impegnata a portare avanti questa sfida e a fare di Economia Italiana il più vivace e aperto strumento di dialogo e riflessione tra accademici, *policy makers* ed esponenti di rilievo dei diversi settori produttivi del Paese.

