A SECTORAL ANALYSIS OF THE FUTURE CHALLENGES FACING THE SPANISH ECONOMY

2021

BANCO DE ESPAÑA
Eurosistema

Documentos Ocasionales
N.º 2133

Alejandro Fernández Cerezo and José Manuel Montero

A SECTORAL ANALYSIS OF THE FUTURE CHALLENGES FACING THE SPANISH ECONOMY (*)

Alejandro Fernández Cerezo

BANCO DE ESPAÑA

José Manuel Montero

BANCO DE ESPAÑA

(*) The authors are grateful for the comments received in several internal seminars of the Banco de España, in particular, from Ángel Gavilán, José Manuel González-Mínguez, Mario Izquierdo, Enrique Moral-Benito and Josep Pijoan-Mas. They would also like to thank Beatriz González and Isabel Soler for their help in constructing sectoral efficiency indicators.

Documentos Ocasionales. N.º 2133

December 2021

The Occasional Paper Series seeks to disseminate work conducted at the Banco de España, in the performance of its functions, that may be of general interest.

The opinions and analyses in the Occasional Paper Series are the responsibility of the authors and, therefore, do not necessarily coincide with those of the Banco de España or the Eurosystem.

The Banco de España disseminates its main reports and most of its publications via the Internet on its website at: http://www.bde.es.

ISSN: 1696-2230 (on-line edition)

Abstract

This paper studies the relative position of various sectors of activity in the face of the main structural challenges for the Spanish economy. First, as regards the challenge of boosting medium-term growth, we review the sectoral developments on the productivity side, analysing human and technological capital and business dynamics within each sector. Second, the sectors are classified on the basis of their resilience to the different structural transformations currently in the pipeline for the main economies, such as technological and digital transformation, energy transition and population ageing. To this end, the information from a very broad set of sectoral indicators has been summarised in a narrow set of composite indicators in order to classify the productive sectors according to the relative degree of exposure to each of these challenges. Our results show that services relating to professional, scientific and technical activities, information and communication, and financial and insurance activities, as well as the manufacture of machinery, computer, electronics and pharmaceutical products, are well placed in terms of both productivity and resilience. However, in general these sectors have little weight in the Spanish economy. By contrast, accommodation and food service activities, the primary sector and transport services are the most vulnerable in the dimensions analysed.

Keywords: economic sectors, productive sectors, sectoral analysis, Spanish economy, productivity, digitalisation, climate change, population ageing.

JEL classification: D24, O4, O14, Q5.

Resumen

Este trabajo proporciona una visión acerca del posicionamiento relativo de los distintos sectores de actividad ante los principales retos que afronta la economía española. Por un lado, ante el desafío de impulsar el crecimiento a medio plazo, se examinan las perspectivas de evolución de la productividad por ramas, analizando el capital humano y tecnológico y las dinámicas empresariales dentro de cada sector. Por otro lado, se clasifican los sectores según la resiliencia frente a las diferentes transformaciones estructurales que han de afrontar las principales economías, como la tecnológica y digital, la transición energética y el envejecimiento poblacional. Para ello, se ha resumido la información procedente de un conjunto muy amplio de indicadores sectoriales, lo que permite clasificar las ramas productivas según el grado relativo de exposición frente a cada uno de estos retos. Los servicios de actividades profesionales, científicas y técnicas, información y comunicaciones, y actividades financieras y de seguros, así como la fabricación de maquinaria, productos informáticos, electrónicos y ópticos y la de productos farmacéuticos, se encuentran bien posicionados en términos tanto de productividad como de resiliencia, pero se trata de sectores, en general, con una reducida dimensión en la economía española. Por el contrario, la hostelería, el sector primario y los servicios de transporte presentan las mayores vulnerabilidades en las dimensiones analizadas.

Palabras clave: sectores económicos, ramas productivas, análisis sectorial, economía española, productividad, digitalización, cambio climático, envejecimiento.

Códigos JEL: D24, O4, O14, Q5.

Contents

1 Introduction

The sectoral dimension is key for understanding certain dynamic phenomena, such as productivity, innovation or the reallocation of factors of production in an economy. Among other factors, sectoral heterogeneity influences an economy's resilience to different types of disruptions. These may be more permanent, such as technological, climate or demographic change, or more exogenous, such as the response to a shock (e.g. a pandemic).

Indeed, the COVID-19 health crisis and the social distancing measures adopted to contain it have evidenced the importance of sectoral heterogeneity in understanding the economic impact of shocks. The pandemic triggered an unprecedented crisis in recent history, giving rise to a reduction in productive capacity, together with disruptions to supply chains and internal demand (Guerrieri et al., 2020). Also, the productive system in different countries has determined the intensity of the effects of the containment measures, whose impact has been highly uneven, depending on how essential a sector is and on its sensitivity to physical presence in terms of both employees and customers (Gómez and Del Río, 2021).

The shock caused by this pandemic has also occurred against a backdrop in which the Spanish economy, in step with the advanced economies as a whole, faces a series of structural challenges that are subject to various time horizons. It is reasonable to believe that the pandemic may accelerate some of the economic and social trends that had already been previously observed, such as digitalisation. In any event, highly differentiated impacts on the productive sectors are to be expected, driving growth in those better positioned relative to these structural changes and hampering the recovery of the more vulnerable sectors.

The Spanish economy's main future challenges are related to slow productivity growth (in turn, linked to shortcomings in human capital, innovation and reallocation of resources) and to its ability to implement the transformations required by the processes of technological change (particularly that associated with digitalisation), demographic ageing and climate change. These challenges are not independent of each other, but rather interact between themselves.

Spain has recorded very modest productivity growth (in terms of both total factor productivity (TFP) and labour productivity) in the last three decades. From a sectoral viewpoint, this lacklustre productivity is explained by low productivity growth sectors accounting for a larger share of the economy and by Spain's lower productivity compared with other European countries practically across all sectors (Cuadrado, Moral-Benito and Solera, 2020). Productivity growth is the key variable for sustained growth in the medium and long term and for social well-being. In a low growth economy, it is more difficult for economic policy to implement structural reforms that entail redistributive consequences, since it is harder to muster the resources required for adopting measures that cushion their impact on the affected groups. In turn, if there are no reforms, the outcome is lower economic growth.

According to the economic literature, two of the main factors limiting productivity growth are human capital (Schivardi and Schmitz, 2019) and business dynamics,[1] which affects the reallocation of resources within each sector. However, because these factors are ultimately subject to the law of diminishing returns, the true driver of growth is technological progress, i.e. the generation of ideas.[2] It is well known (Cotec, 2020) that Spain has a high and persistent deficit in terms of knowledge generation, which also makes it difficult to fully exploit ideas generated abroad.

The global economy is undergoing three major transformations. The first one is the digitalisation of the economy,[3] which has been under way for over 20 years and where Spain has made significant progress in some, albeit not all, areas.[4] Pressing ahead with digitalisation will be key for economic growth in the coming years. This process becomes even more significant if the concept of digital economy is expanded to include new trends, such as artificial intelligence and big data, or previous trends, such as robotisation of productive processes. In addition, the pandemic has accelerated the digitalisation process, highlighting the strengths and weaknesses of firms and the best and worst positioned sectors.

Second, climate change generates different kinds of risks that can be classified into two categories: physical risks and transition risks. Physical risks are associated with global warming and with more frequent and severe weather events that may harm physical assets or disrupt business operations. Transition risks are related to the process of moving towards a low-carbon economy, which requires reducing greenhouse gas emissions.[5] This paper will focus solely on transition risks. Transforming the current energy model to combat climate change will cast light on which economic sectors are better and worse equipped to tackle this energy transition.[6]

A good example of the importance of the challenges deriving from digitalisation and climate change is the design of the Next Generation EU programme. Its aim is for Europe to become greener and more digital (these are the two central pillars, together with social and territorial cohesion and gender equality), as well as resilient and prepared to tackle current and future challenges. The programme envelope amounts to €750 billion, in the form of grants and loans, of which up to €140 billion have been allocated to Spain

1 See Chapter 4 of the Banco de España *Annual Report* 2015.

2 Ideas are non-rivalrous goods that can be used by several agents at once; therefore, they are not subject to diminishing returns (Romer, 1990).

3 Strictly speaking, these technologies are understood as data transmission or processing systems where the information is represented by means of binary characters. Our use of "digitalisation" is broader, as explained in the main text.

4 According to the European Commission's Digital Economy and Society Index (DESI), Spain is the country that has most progressed in this sphere, together with Ireland and the Netherlands. However, it ranks 11th among the European Union (EU) Member States. Spain stands out for its good connectivity, thanks to the availability of fast and ultrafast fixed and mobile broadband networks, but has lower relative levels in basic digital skills and in the integration of digital technology in businesses.

5 The Law on Climate Change and Energy Transition, which sets out ambitious goals for the future, was approved in April 2021. The plan aims to reduce greenhouse gas emissions by at least 23% by 2030, as compared with 1990 levels. In the longer term, the goal is to achieve climate neutrality by 2050.

6 In addition, a greater concern for environmental sustainability may bring about numerous regulatory, technological and consumption habit changes with uneven effects across the different sectors of activity. However, this issue will not be addressed in this paper.

(12.5% of GDP in 2020) and will be disbursed between 2021 and 2026. The aim is to allocate 20% to digital transformation and 37% to the green transition. This is a great opportunity to address the weaknesses in innovation in Spain, which interact with the digital economy and climate change.

Finally, the population ageing process can be illustrated based on the substantial drop in the working-age population as a proportion of the total population. This is, in turn, the result of three trends: (i) the fertility rate dropping below the replacement level; (ii) longer life expectancy and (iii) the largest population cohorts beginning to reach retirement. This process is taking place at different speeds globally (with the exception of Africa), but in Spain, as in other European economies, it has been under way for approximately one decade, and it is expected to gain momentum over the coming years.

The economic implications of population ageing range from potential changes in the consumption basket to decreases in labour supply (including human capital quality), productivity, and savings and investment levels.[7] A priori it is difficult to anticipate these economic effects because they depend on the response of the economic authorities and the agents themselves (for example, they may save more, delay their decision to retire or invest more in human capital). As regards changes in consumption patterns, variations in the relative weights of consumer goods and services (both final and intermediate) are to be expected. For instance, increases in the weight of products related to health, food and household goods and services are likely, while transport and hospitality-related consumption can be expected to decline.[8] Moreover, the sectors most affected by having workers close to retirement may encounter more difficulties finding qualified and experienced labour. There is also evidence that older workers receive less training (both formal and in-house) and take longer to find a job once they become unemployed (Heywood and Siebert, 2009), making it less likely for them to change occupation or sector (Hurd, 1996). Also important are individual incentives to remain in the labour force, offering flexible forms of employment, such as part-time work.[9]

This paper analyses which sectors of the Spanish economy are better positioned and not so well positioned vis-à-vis the foregoing economic challenges, as a first step in determining what type of structural transformation each will have to face.[10] First, a simple conceptual and empirical framework will be developed to identify the variables that will help

7 See Chapter 4 of the Banco de España *Annual Report* 2018 "Economic consequences of demographic change".

8 In any event, this is likely to be a gradual process and, therefore, the different sectors will have time to adapt to the changes.

9 See *PES Strategies in Support of an Ageing Workforce. Study report* for an in-depth analysis of possible levers with which to address the challenge of demographic ageing in Europe.

10 Another important consideration is that both the COVID-19 crisis and the growing tensions between China and the United States have shown that it might be advisable to classify certain sectors as strategic. Indeed, the European Commission and the European Council consider Open Strategic Autonomy to be central to their efforts to strengthen the EU's economic resilience and global integration. For example, the authorities need to consider what degree of strategic autonomy countries should have in the production of certain goods, such as pharmaceutical and defence-related products, or semiconductors. Although this paper does not address these issues, this does not mean that they are not important or do not merit in-depth study in the future.

measure the exposure and position of the sectors with respect to each of the challenges analysed. This framework will serve as a reference to create a heat map reflecting the position of some sectors relative to others within each economic challenge. The results of the analysis indicate that the sectors that are relatively better positioned to tackle the various challenges analysed have relatively little weight in the Spanish economy's productive structure. These include professional, scientific and technical activities, information and communication services, and financial and insurance activities. By contrast, the relative position is worse in accommodation and food service activities, the primary sector and some transport services in terms of productivity and resilience.

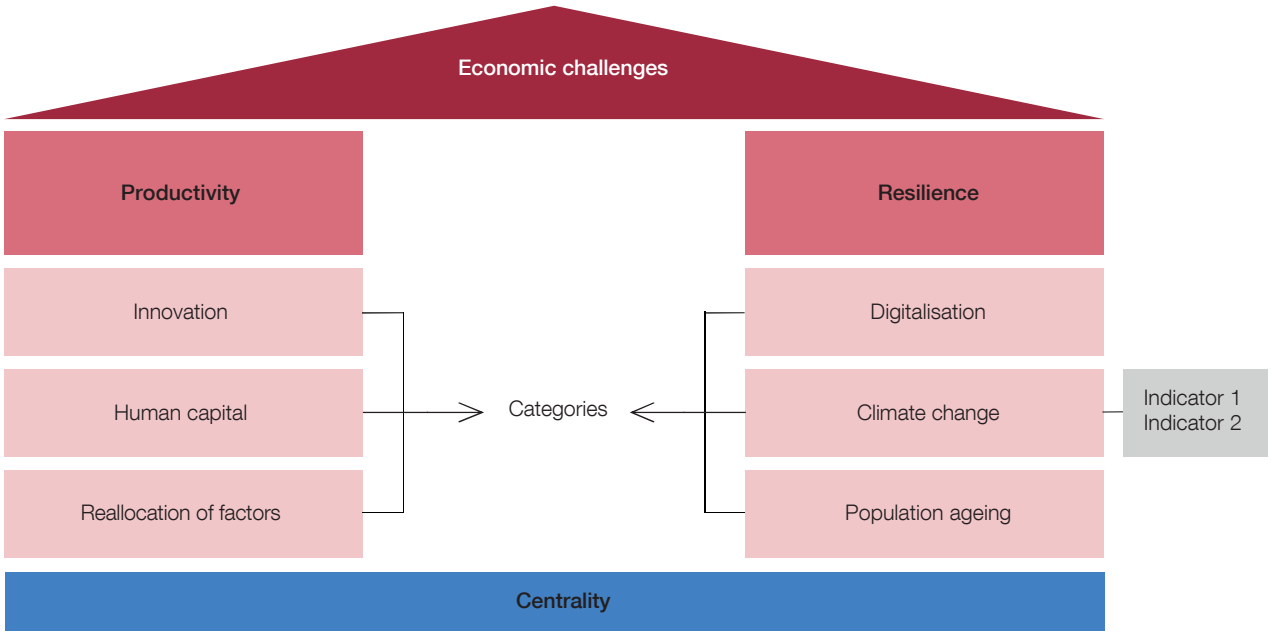
The rest of the paper is structured as follows. Sections 2 and 3 develop the conceptual and empirical frameworks that will serve as a basis for analysing the relative position of the sectors. Section 4 describes the data used to approximate the categories considered and Section 5 sets out the results. The final section presents the conclusions and outlines some economic policy recommendations.

2 Conceptual framework

The starting point of the analysis is a simple conceptual framework that classifies the challenges into two large areas: productivity and resilience.[11] Each area is in turn divided into three main categories: productivity divides into human capital, innovation and reallocation of factors, and resilience into digitalisation, population ageing and climate change (see Figure 1). It is important to note that this analysis gives a static view of the relative position of the industries analysed, since it is based on indicators that provide a snapshot of the situation of each industry. However, this position should actually be a dynamic concept, changing over time as firms and consumers adapt to the challenges and economic policy changes are introduced. Also, as noted above, it is obvious that these categories are not orthogonal to each other; rather, there are complex interactions that should be taken into account when interpreting the results.

Finally, the concept of economic centrality influences the considerations regarding the relative position of the different sectors. Regardless of the relative position of the sectors of activity with respect to the challenges, some sectors deserve special attention because, broadly speaking, they occupy a central position within the Spanish economy

Figure 1
MAIN ECONOMIC CHALLENGES



SOURCE: Banco de España.

11 In economics, resilience is a multi-dimensional concept that refers to the ability to recover quickly from a shock, to withstand a shock or to avoid its impact altogether.

and globally. These activities generate very significant spillovers and knock-on effects for the rest of the economy and provide an infrastructure or essential inputs for other firms in the same industry or in related industries. Firstly, in certain cases, such as electricity and water supply, there may be industries which, despite performing poorly as regards the aforementioned challenges, deserve attention because they are essential for the functioning of the country. Secondly, in other cases, the importance of a specific industry is related to its high share in the economy; therefore, any transformation may have deep effects on the rest of the economy. For instance, the accommodation and food service activities sector is usually characterised by its scant productivity and its sensitivity to changes in consumption patterns linked to ageing, but it accounted for 6.2% of GVA in 2019, one of the highest figures in Spain's economy and higher than that recorded in other countries for this sector. Lastly, it is also important to consider an "external centrality" dimension that takes into account the importance of the sector from the viewpoint of its contribution to the external sector's equilibrium.

Based on this simple conceptual framework, the next step is to identify a set of indicators that captures the main dimensions characterising each of the seven categories considered. These dimensions will reflect a combination of economic theory and data availability at sectoral level. In addition, indicators with high information content will be used. Once the set of indicators has been selected, they will be grouped into a composite index for each of the six categories considered, to facilitate their analysis. Based on the composite indices, heat maps will be prepared for each category, using cross-section variability at sector of activity level to obtain their relative position.

3 Construction of composite indices and heat maps

An established methodology for this type of analysis, developed and systematised by the Organisation for Economic Co-operation and Development (OECD) and the European Commission's Joint Research Centre, described in OECD (2008), is used for constructing the composite indices. Most individual indicators have different scales and measuring units. Therefore, in an initial stage, they are standardised in a (0, 1) range that preserves the observations ranking relating to the different sectors. Specifically, for a given indicator, the observations are modified in accordance with the formula:

$$\text{Standardised indicator} = \frac{\text{Indicator} - \text{min indicator}}{(\text{Max indicator} - \text{min indicator}) \times \text{direction}} + 0.5 \times (1 - \text{direction}) \quad [1]$$

where min indicator and max indicator are, for this specific indicator, the maximum and minimum values from all the sectors and direction is defined as -1 if the indicator improves with low values or +1 if the opposite occurs. This transformation has some advantages. For instance, all the indicators have the same range of variation (from 0 for the worst sector to 1 for the best) and they fulfil the invariance property, i.e. the original order of the observations is not modified. However, their main drawback is their sensitivity to outliers, which must be treated appropriately.[12]

Once the standardised indicators have been obtained for each of the six categories considered for each sector j ($I_{c,j}$, c=1,…,6; j=1,…,k), an aggregation method must be selected to draw up the composite index for each category (CI_c). In the case at hand, a simple average (equal weights) has been used owing to its interpretation advantages.

The composite index for category c is calculated as follows:

$$IC_c = \sum_{j=1}^{k} \omega_{c,j} I_{c,j} \quad [2]$$

where ω_{cj} reflects the weights assigned to each individual indicator (in this case, 1/k).[13]

Lastly, heat maps are prepared for each category. This technique is very useful for large sets of data, since the density of the items or elements comprising a set of values can be represented in the map using different colours (Vacanti, 2019). These heat maps reflect the position of some sectors relative to others at a given point in time. In our case (see Annex 1), depending on the indicator, the analysis covers the period 2013-2019. To this end, the sectors are classified into six distinct groups, based on the following percentiles of the distribution of the indices' values: 10th, 25th, 50th and 90th percentiles. Each range is assigned a colour (from dark red if <10th percentile to dark green if >90th percentile). This

12 In this analysis a logarithmic transformation will be used in indicators with outliers on the upper or lower part of the distribution.

13 An alternative technique for describing a broad set of variables in the principal components analysis. As a robustness test, a synthesis technique has also been applied, the results of which provide a very similar sectoral ranking to that obtained using the above-mentioned standardisation (see Annex 2).

classification gives an idea of which sectors are more (red) or less (green) laggard in the different categories in relative terms. It also provides an indication of each sector's current potential in helping to address the Spanish economy's challenges. Obviously, this potential will evolve over time depending on how the different sectors progress or lose momentum in the different categories identified.

4 Selection of indicators and sectors of activity

4.1 Indicators

The selection and classification of indicators depend on the objective pursued and their availability. In this case, the goal is to capture the most significant dimensions of the economic challenges considered. These will be determined by the nature of the challenge and how it is interwoven with economic theory. In any event, it is best to avoid having too many indicators. Accordingly, their correlation matrices are analysed.[14] The indicators selected for each of the categories are described below, together with a brief justification of the underlying rationale. A more detailed description is included in Annex 1.

Productivity: Productivity is a multi-dimensional term that has been widely discussed in the literature. The growth of this variable is the main driver of sustained economic growth. Productivity can increase in many ways. However, the only one that is not subject to the law of diminishing returns is the build-up of ideas, because ideas are non-rivalrous goods which can be used simultaneously by several agents (Jones, 2019). This is why the first category considered is the innovative capacity of sectors, i.e. their potential for generating developments or new knowledge. Thus, in order to capture the different dimensions of this category, the indicators that are taken into account include spending in innovative activities, the weight of sales introducing innovative elements in the market, the percentage of firms with a strategy including the launch of new products or the improvement of existing ones, and the percentage of firms applying for patents. In addition, the average historical growth of labour productivity is included in order to reflect how each sector's innovative potential has translated into productivity gains in the past.

A second category that is important for productivity growth is human capital, owing to its twofold role as direct input in production and as a key element in the production and absorption of new ideas.[15] The term "human capital" is also multi-dimensional and encompasses aspects as diverse as health, quantity (and quality) of knowledge and people's innate abilities. Work experience and other kinds of social and emotional skills are also part of human capital. Owing to data availability considerations, the indicators selected focus on aspects more related to training, work experience and quality of labour (Annex 1). Thus, the percentage of employees with higher education who receive some type of on-the-job training, the average employee tenure[16] in firms in the sector, the wage premium in the sector (as a proxy of average job quality) and the rate of temporary employment are used. The latter variable is an indicator which the literature has linked to the quality of human capital in one way or another, owing to its negative impact on on-the-job training or health (Bentolila, Dolado and Jimeno, 2019).

14 The aim is to avoid introducing too many indicators that measure similar dimensions and have a very high correlation between sectors, i.e. indicator-rich, information-poor contexts.

15 See López-García and Montero (2012) and the references cited there.

16 This variable could capture factors other than degree of work experience with an opposite impact on productivity, such as, for instance, lack of labour mobility owing to labour market rigidity. However, the correlation with productivity per hour in the sector is positive, which would support our interpretation.

The third and last category is the potential for reallocation of resources within the sector. The reallocation of factors of production within a firm and between firms in the same sector contributes to improving economic efficiency, and hence economic growth (Banerjee and Duflo, 2005; Bartelsman, Haltiwanger and Scarpetta, 2013). There is ample literature on these issues pointing to a series of indicators that help calculate the extent to which the allocation of resources within a sector is adequate, and the extent of distortions. In our case, we use the wealth of information on firms from the Banco de España's Central Balance Sheet Data Office to construct some of these indicators. Specifically, (i) the covariance between the size and productivity of firms in the sector has been constructed using the methodology proposed by Olley and Pakes (1996), whereby it is expected that the most productive firms tend to be the ones that become larger, and (ii) the standard deviation of the marginal product of capital according to Hsieh and Klenow (2009),[17] whereby capital from less productive firms will, in theory, be reallocated to firms that are more productive until capital productivities are equalised, which would translate into minimal dispersion. The percentage of weak firms in a sector, defined as those which are financially vulnerable and with persistent stagnation in investment and business volume, has also been calculated.[18] McGowan, Andrews and Millot (2018) and Banerjee and Hofmann (2018) show that a greater incidence of these types of firms in a sector adversely affects both employment and aggregate productivity in the medium term, possibly because their survival may hamper the process of reallocating resources to other companies with greater growth and job creation potential.

Also, data from the Central Business Register (DIRCE) of the National Statistics Institute (INE) have been used to construct two additional indicators: the percentage of microfirms with long lifespans (those with fewer than ten employees and a lifespan exceeding ten years) and the firm turnover rate (the sum of enterprise birth and death rates). An excessive proportion of microfirms with extended lifespans may be negative due to their adverse impact on productivity growth, innovation and export capacity.[19] As regards firm turnover, business dynamism indicates the fluidity of the reallocation of resources among firms.

Resilience: This term is also multi-dimensional. It relates to the economic system's capacity to withstand the impact of shocks (static resilience) and recover rapidly (dynamic resilience). In the case at hand, this concept would be linked to the sector's sustainability or viability in the face of the transformations that the major trends of digitalisation, climate change and population ageing will require. But sectors of activity should not only be resilient to these well-known challenges; they should also be able to cope with unidentified shocks (unknown unknowns). This ability to adapt to the unknown is probably related to the position in the productivity category.

17 The standard deviation of the marginal product of capital (MPK) is calculated for each sector. In turn, the MPK for each firm is obtained as the logarithm of the ratio of value added to stock of capital.

18 A firm is deemed vulnerable if it meets these conditions: sales growth is lower than the median for the sector, investment is negative two years running and the ratio of net debt to maximum gross income in the last three years is greater than 12, provided net debt is positive.

19 Young microfirms tend to be more innovative and disruptive and usually harness this initial momentum to grow and gain in size. Failure to gain in size after a certain period of time is evidence that they are not particularly innovative.

It should be borne in mind that the dimension of geopolitical risks is being left out of the analysis. A current example of these risks is the US-China rivalry. This phenomenon is extremely important because of its potential as a global game changer, thereby increasing the risk of undermining the cross-country interdependence (mainly in trade, but also cultural and technological) which the pandemic has deepened. Particularly relevant is the debate on the strategic nature of certain sectors, since it could lead to restrictions on the free movement of products, investments and ideas between countries.[20]

The main challenges linked to resilience have been grouped into three large categories. The first one is digitalisation, or digital transformation, which goes beyond the application of digital technologies to productive and product marketing processes. Rather, it is understood as a broad process also encompassing other related technologies – such as artificial intelligence (specifically, machine learning) and task automation (the use of industrial robots) – whose development has received strong impetus in recent years. This process is linked to the adoption of what the economists call "general purpose technology". Such technology is characterised by its ubiquity, its potential for ongoing improvements and, above all, its ability to increase productivity across all economic sectors.[21]

It is therefore necessary to use a broad set of indicators that capture the multiple dimensions of this phenomenon. Thus, a digital intensity index developed by the OECD (Calvino et al., 2018) is used, which, in turn, comprises six sub-components: investment in information and communication technologies (ICT) as a percentage of total investment (separating investment in ICT equipment from investment in software and databases); share of ICT inputs[22] in total output; share of ICT specialists in total employment; stock of robots per employee; and share of turnover from online sales. Since this indicator shows little sectoral variability (it classifies sectors into four categories), ICT investment and ICT capital stock as a percentage of the total (calculated using the EU KLEMS database) have also been included, along with each sector's knock-on effect on the output of the ICT sector. Furthermore, all sectors of activity produce digital goods and services to a greater or lesser extent. To capture this broader concept of the digital economy, the weight of each sector in the digital economy's GVA (calculated using the digital economy satellite account estimated for the United States) has been taken into account.[23]

In addition, indicators have been included that seek to capture the degree of exposure to disruptive technologies, such as artificial intelligence and task automation.

---

20 By way of illustration of the strategic nature of certain sectors, Joe Biden, the President of the United States, requested a review of the supply chains of key products and industries to address vulnerabilities and risks. Meanwhile, the "Made in China 2025" plan is the Chinese Government's strategy to bolster and restructure the country's industry. The aim is to become a global powerhouse in technology.

21 Although there is no clear consensus, at least three previous technologies are widely considered to earn this distinction: the steam engine, the electricity generator and the printing press.

22 According to Eurostat, the main NACE two-digit sectors that make up the ICT sector are manufacture of computer, electronic and optical products (26), telecommunications (61), computer programming, consultancy and related activities (62), and repair of computers and personal and household goods (95).

23 The US Bureau of Economic Analysis includes three types of goods and services in its definition of the digital economy: ICT infrastructure, e-commerce and priced digital services. See Barefoot et al. (2018).

Lastly, a variable defined as the percentage of employees who are able to work from home is also added, which could be useful to measure the resilience of the sector to shocks that force a reorganisation of working methods (for instance, due to a health crisis or extreme weather event).

The second category of challenges is climate change, which generates different types of risks. However, as mentioned in the introduction, this paper focuses on transition risks, i.e. those relating to the process of shifting to a low-carbon economy. That is why the indicators focus primarily on gas emissions (mainly CO_2) by sector. Nevertheless, other relevant dimensions have been considered, such as the environmental tax burden, defined as the weight of environmental taxes in each sector's activity (see Annex 1).

The third category is population ageing, which poses significant challenges in multiple areas at the sectoral level, although this paper focuses on the two considered most important. First, firms will have to face the progressive ageing of the labour supply. Second, they are also seeing a transformation in demand for their products, with changes not only in the goods and services consumed but also in consumption habits. Product design, marketing strategies and payment methods, for example, will have to be adapted to an older population.

On the labour supply side, a set of variables from the INE's Labour Force Survey (LFS) is used, reflecting: (i) the exposure of each sector to labour supply shortages (percentage of employees older than 50);[24] (ii) employment flexibility, measured by the percentage of employees on part-time contracts, which is interpreted in our context as an approximation to the ability to retain older workers; and (iii) investment in training, which is key to prolonging working life (measured as the percentage of employees receiving in-company training). On the demand side, first, there is the degree of exposure to the silver economy, defined as the knock-on effect of the health (NACE code 86) and residential care (code 87) sectors on other sectors' demand, calculated using input-output tables and, second, the sectoral distribution of the consumption basket of the over-65s compared with the rest of the population, drawing on the INE's Household Budget Survey.

Lastly, the main dimensions used to measure each sector's economic centrality are proxied using a series of indicators reflecting both the importance of the different sectors as customers and suppliers in the production chain, calculated using input-output tables (see Annex 1), and their share in terms of employment, number of firms and exports, among others, in the economy as a whole. For "external" centrality, two variables are considered: the share of the sector's exports in the country's total exports and the difference between the share of output exported and the share of materials imported to manufacture one unit of output in each sector.

24 A sector with a high share of older workers is deemed to face a more complex renewal of its labour force in a low labour supply environment, and will therefore be considered less resilient.

4.2 Sectoral coverage of the analysis

One aspect to bear very much in mind when selecting the sectors is the trade-off between the level of granularity and the capacity to distil overall messages. In any event, the starting point must be NACE Rev. 2. In our view, a sector classification to two digits of NACE (amounting to 88 sectors) provides a reasonable balance between granularity and manageability. Further, this level of disaggregation provides for a suitable level of data availability. Ultimately, the empirical methodology rests on the relative position within the distribution of the indicators, meaning a lower level of disaggregation would yield less reliable results.

However, it may make sense to refrain from analysing the relative position of some sectors, such as certain non-market services (specifically activities of membership organisations (94), of households as employers (97 and 98) and of extraterritorial organisations (99)), along with public administration, defence and compulsory social security (84), education (85) and human health activities (86), which have the idiosyncrasy of a very large public sector presence. The analysis will therefore encompass a total of 81 sectors, which in 2019 accounted for 82% of the Spanish economy's total GVA.

5 Results

The results of the sectoral positioning vis-à-vis the economic challenges are shown using a heat map that classifies the sectors by the above-mentioned categories. Table 1 shows the relative position of the NACE Rev. 2 two-digit sectors, revealing the strengths and weaknesses of each.

From the standpoint of **productivity,**[25] the best positioned services sectors are information and communication (particularly computer programming, consultancy and related activities), research and development services, financial and insurance activities, and other professional, scientific and technical activities (which stand out for their innovation indicators and include specialised design and photographic activities). On the industrial side, manufacturing related to the production of high value-added goods stands out, such as the chemical and pharmaceutical industries and manufacture of computer, electronic and optical products, manufacture of machinery and equipment n.e.c.,[26] manufacture of electrical equipment, manufacture of motor vehicles and other transport equipment[27] and manufacture of refined petroleum products. By contrast, the services sectors with the worst productivity figures are accommodation and food service activities and some administrative and support service activities (such as rental and leasing activities and services to buildings and landscape activities), along with the primary sector activities and construction-related sectors, which perform poorly due to unfavourable human capital and innovation indicators.

The services sectors are, broadly speaking, better positioned vis-à-vis the **technological and digital transformation** challenge, in particular information and communication services (since these are the sectors with the closest ties to information technology), financial and insurance activities, and professional, scientific and technical activities (ranging from specialised services to firms through to veterinary and research and development activities). By contrast, the least favourably placed services sectors in relative terms are accommodation and food service activities, real estate activities and warehousing and support activities for transportation. Among the industrial sectors with the highest levels of digitalisation are manufacture of computer, electronic and optical products, manufacture of motor vehicles and manufacture of other transport equipment. Conversely, the worst positioned activities in technological and digital terms are those related to the primary sector, mining and quarrying, construction and waste and remediation activities

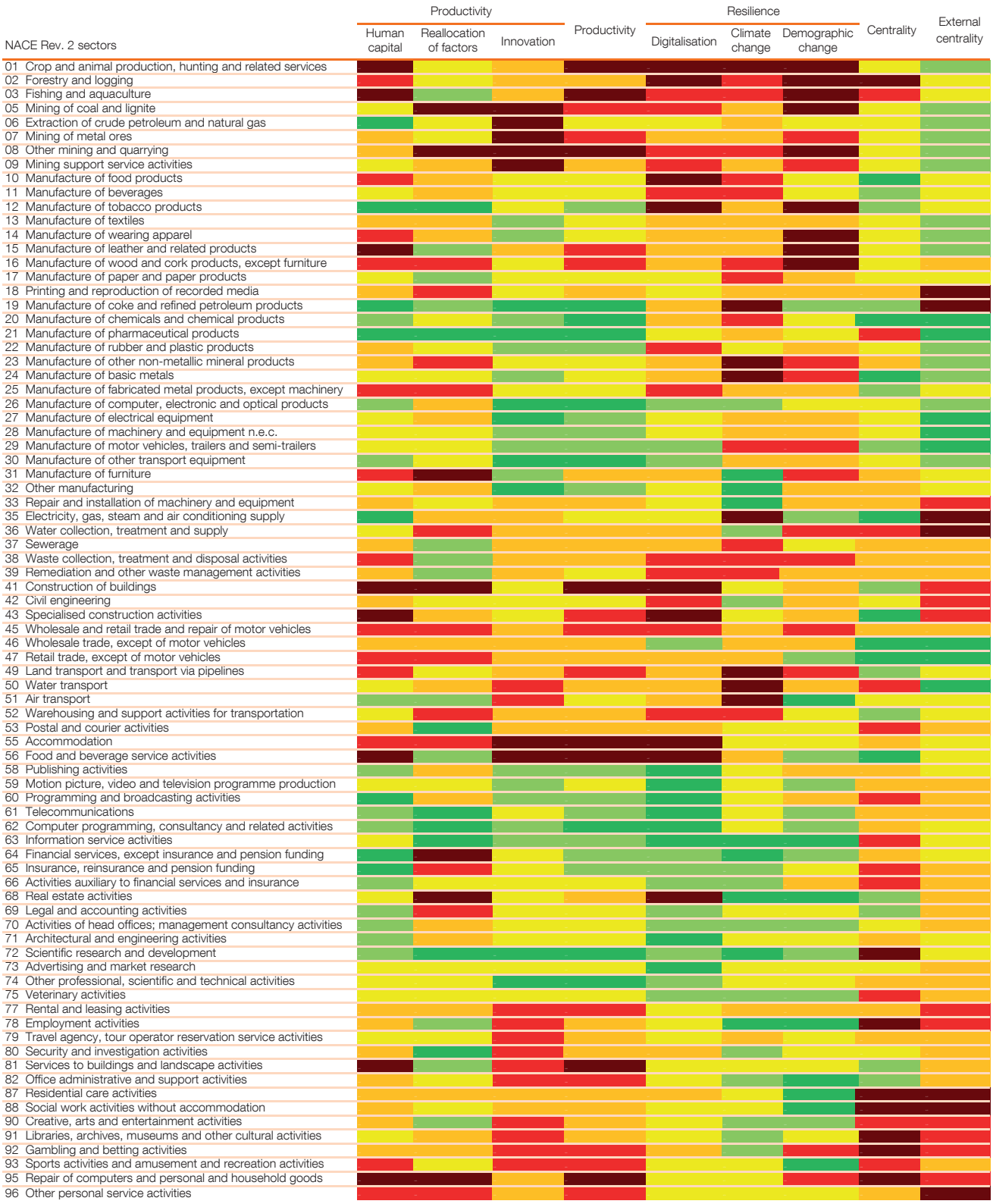
25 Certain messages can be distilled by analysing the three productivity categories. For instance, financial activities and information and communication services stand out for their high levels of human capital, as do certain industrial sectors, such as electricity supply and the chemical and pharmaceutical industries. By contrast, accommodation and food service activities, construction and the primary sector, among others, have the lowest relative levels of human capital. With regard to the fluidity of the reallocation of resources among firms, the best figures are to be found in information and communication services, research and development and postal and courier activities, while construction, financial and real estate services and some mining and quarrying industries show the worst relative indicators. The most innovative activities identified are manufacture of computer products, of pharmaceutical products, of electrical equipment and of transport equipment, along with research and development services and other professional and scientific activities. At the other extreme are accommodation and food service activities and mining and quarrying.

26 N.e.c.: not elsewhere classified.

27 Includes the building of ships and boats, aircraft, railway equipment and military vehicles.

Table 1

SECTORAL POSITIONING VIS-À-VIS THE ECONOMIC CHALLENGES. NACE Rev. 2 TWO-DIGIT SECTOR HEAT MAP



SOURCE: Banco de España.
NOTE: Dark green: 90th percentile. Dark red: 10th percentile.

(NACE codes 38 and 39), while the worst positioned manufacturing sectors are manufacture of food products, beverages and tobacco and manufacture of metal products.

As mentioned earlier, sectoral exposure to **climate change** reflects the sensitivity to transition risks associated with the need to cut greenhouse gas emissions. As Table 1 shows, two very distinct groups can be distinguished. First, the sectors with the highest emissions, such as those in the primary sector and mining and quarrying, the bulk of manufacturing (notably manufacture of coke and refined petroleum products, manufacture of other non-metallic mineral products[28] and basic metals), electricity generation and supply and sewerage and waste collection and treatment, along with transportation and storage services. Relatively larger investment and adaptation efforts will have to be made in these sectors to contribute to national emission reduction targets. Second, the services sectors are, broadly speaking, less vulnerable to the energy transition challenge owing to their lower emissions intensity. The same is true of some manufacturing sectors, such as manufacture of computer, electronic and optical products, manufacture of furniture and repair and installation of machinery and equipment.[29]

As explained earlier, this analysis leaves out "climate change-related physical risks", i.e. disruptions caused by temperature changes and extreme weather events, such as floods, droughts, tornadoes, etc. However, a portion of these risks cannot be entirely eliminated, since the disruptions to the functioning of firms and sectors caused by such events remain. According to various studies,[30] the main industrial groupings affected by these risks are agriculture, manufacture of food and beverages, energy, tourism, insurance, the real estate sector and infrastructure-related construction. Some sectors are doubly affected (from the standpoint of emissions reductions and physical risks), such as agriculture and energy.

The impact of **population ageing** will also vary across the sectors, with a clear divide, in general terms, between the services sectors and the others, as can be seen in Table 1. The sectors with the least favourable relative position are the primary sector, mining and quarrying and numerous manufacturing divisions, such as manufacture of tobacco products, textiles, furniture and vehicles. On the services side, the worst placed sectors are those related to land and water transport, to gambling activities and to the sale and repair of motor vehicles. Meanwhile, the best positioned activities in relation to population ageing are concentrated in the services sectors, notably residential care activities and social work activities (without accommodation), along with retail trade, information service activities and real estate activities.[31] Among non-service sectors, energy supply stands out.

28 For instance, glass, ceramic products, cement and concrete.

29 This sectoral hierarchy is in line with the findings of the *Final report of the High-Level Expert Group on Sustainable Finance*, which defines the high climate impact sectors as those that are key to the transition to a low-carbon economy (e.g. the primary and secondary sectors and transportation).

30 See, for example, the sectors affected by adaptation to climate change according to the European Commission.

31 Real estate activities include imputed rents of owner-occupied housing. The proportion of the population living in owner-occupied housing rises with age.

Notwithstanding the foregoing, the results show some heterogeneity if a distinction is drawn between consumer demand indicators and labour supply indicators. For instance, comparing the distribution of the spending of people over the age of 65 with the rest of the population, based on INE data, the sectors likely to benefit include food, health and healthcare goods and services and housing-related services. By contrast, the sectors that will probably see demand decline include tobacco, clothing and footwear, manufacture of vehicles and accommodation and food service activities.[32] In terms of labour supply, the most exposed sectors are concentrated in the primary sector, the industrial sector, construction and land transport. The services sectors with a greater technological component are positioned favourably, since workers are highly skilled and a low proportion of them are close to retirement age.

Each sector's relative position and centrality in the economy

Analysis is also required of each sector's centrality within the Spanish economy's productive system (see the last two columns of Table 1). In terms of internal centrality, the sectors accounting for a larger relative share of the productive system are, first, energy and gas supply, followed by wholesale and retail trade, food service activities (owing to their share of employment and the number of firms), manufacture of food products, chemicals and specialised construction activities. At the other extreme are social work, arts and recreation services and other services, research and development and employment activities. Nor are professional, scientific and technical activities or information and communication particularly central. In terms of external centrality, the sectors contributing most positively to the external sector are manufacture of electrical equipment, manufacture of machinery and equipment n.e.c. and manufacture of motor vehicles, along with wholesale and retail trade, the chemical industry and manufacture of pharmaceutical products.

Combining the centrality analysis with the challenges identified provides a clearer picture of the Spanish economy's sectoral outlook. Chart 1.1 provides a visual representation of the sectors' relative position in the dimensions of productivity (vertical axis) and resilience (horizontal axis) vis-à-vis the three structural transformations (technological change and digitalisation, energy transition and demographic change),[33] taking into account the degree of internal centrality (represented by the size of the bubbles).

The main conclusion that can be drawn is that the most productive and challenge-resilient sectors have low levels of centrality in the Spanish economy.[34] Among services, professional, scientific and technical activities (69-75), information and communication activities (58-63) and financial and insurance activities (64-65) are well positioned in

32 It is important to note that this is a static analysis and does not take into account possible behavioural changes among future generations of agents.

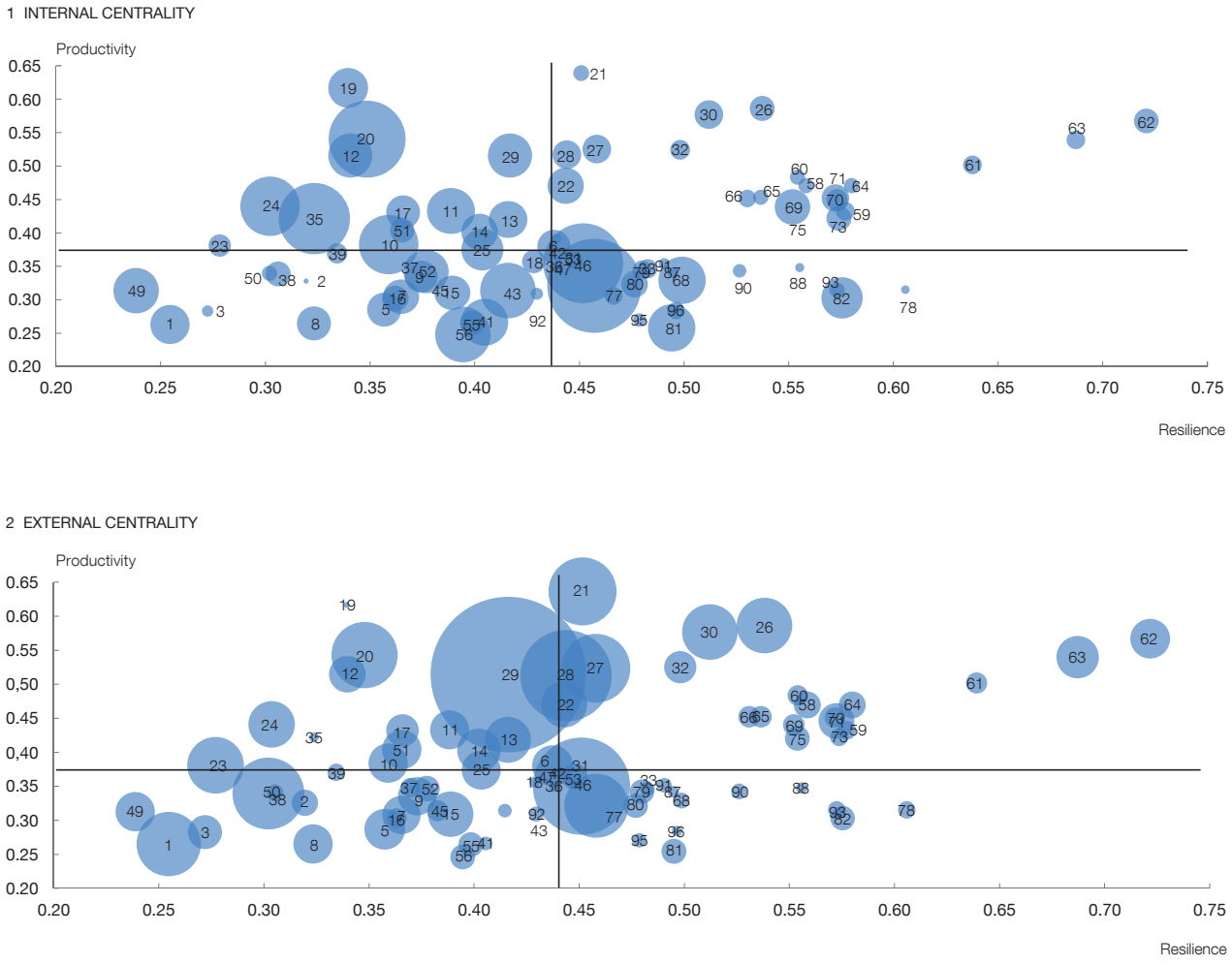
33 The resilience dimension is obtained giving equal weightings to the digitalisation, energy transition and demographic change categories.

34 There is also a clearly positive and significant correlation between productivity and resilience (0.26 weighted by centrality, 0.34 unweighted), evidencing the crucial role played by productivity.

Chart 1

POSITIONING OF THE NACE REV. 2 TWO-DIGIT SECTORS VIS-À-VIS THE MAIN ECONOMIC CHALLENGES

Services relating to professional, scientific and technical activities, information and communication, and financial and insurance activities, as well as the manufacture of machinery and of computer, electronic, optical and pharmaceutical products, are well positioned both in terms of productivity and resilience, but these are sectors, in general, with little weight in the Spanish economy. By contrast, accommodation and food service activities, the primary sector and transport services have the most vulnerabilities in the dimensions analysed.



SOURCE: Banco de España.
NOTE: The size of the bubbles indicates the degree of centrality.

terms of both productivity and resilience. On the manufacturing side, manufacture of computer, electronic and optical products (26), electrical equipment (27) and machinery and equipment (28), along with manufacture of other transport equipment (30) and other manufacturing (32), also exhibit high figures in both dimensions, as do manufacture of basic pharmaceutical products and pharmaceutical preparations (22) and manufacture of rubber and plastic products (21). However, each of these sectors accounts for a relatively low share of the Spanish economy. Meanwhile, manufacture of chemicals and chemical

products (20) and manufacture of motor vehicles (29) are very central sectors and have high levels of productivity, but are somewhat more vulnerable to the structural changes discussed, particularly those relating to emissions reductions. Conversely, social work activities (87-88), employment activities (78) and recreation activities (93) are better positioned with respect to the challenges, particularly population ageing, but perform worse in terms of productivity.

By contrast, the sectors that exhibit weaknesses in terms of productivity and resilience are the primary sector (1-3), transportation services (49-53) and accommodation and food service activities (55-56), all of which account for a mid-level relative share of the economy. It is worth noting that the wholesale and retail trade sectors (46-47) are the most central in the Spanish economy since they account for a large proportion of firms and employment. However, their productivity and resilience levels are below average.

Chart 1.2 shows the relative position of the different sectors based on the degree of external centrality. The results are similar to those set out in Chart 1.1, but the bubble sizes differ. Manufacture of motor vehicles (29), manufacture of computer products (26) and manufacture of electrical equipment (27) have a higher significance owing to their sizeable contribution to the external sector, while other sectors, namely manufacture of other mineral products (23), electricity supply (35) and accommodation and food services (55 and 56), are much less significant.

At the one-digit level of disaggregation, sectors such as agriculture, retail and wholesale trade and accommodation and food service activities represent a substantially larger share of the productive system in Spain than in other countries such as France, Germany and the United States (see Table 2). As discussed earlier, these sectors are worse placed in terms of both productivity and resilience. By contrast, some of the sectors with better relative positions vis-à-vis the main challenges analysed, such as professional, scientific and technical activities, information and communication, and financial and insurance activities, make up a lower share of the Spanish economy than in the three reference economies.

Moving to a higher level of disaggregation, Tables 3.1 and 3.2 show the share of GVA accounted for by the ten best and ten worst scoring sectors in terms of productivity and resilience in Spain, France, Germany and the United States.[35] Generally speaking, the results at the two-digit level confirm that the Spanish economy's productive system relies more heavily on the least productive and least resilient sectors compared with the reference countries, and that the better placed sectors in both dimensions account for a smaller share of the system. Indeed, the primary sector, accommodation and food service activities and wholesale and retail trade make up a substantially larger share of aggregate GVA than in the three reference countries, partly owing to Spain's greater

35 The best (worst) positioned sectors are those in the top right (bottom left) quadrant of Chart 1.1.

Table 2

SHARE OF 2018 NATIONAL TOTAL GVA BY SECTOR

NACE	Sector	Spain (%)	France (%)	Germany (%)	United States (%)
A	Agriculture, forestry and fishing	3.1	1.9	0.7	0.9
B	Mining and quarrying	0.2	0.1	0.1	1.7
C	Manufacturing	12.3	11.1	22.3	11.7
D	Electricity, gas, steam and air conditioning supply	2.5	1.7	1.9	1.4
E	Water supply	1.1	0.7	1.1	0.3
F	Construction	6.1	5.6	4.9	4.2
G	Wholesale and retail trade	12.8	10.3	10.0	9.9
H	Transportation and storage	4.6	4.5	4.4	3.4
I	Accommodation and food service activities	6.2	2.9	1.6	2.8
J	Information and communication	3.8	5.3	4.8	6.9
K	Financial and insurance activities	4.1	4.1	3.8	7.7
L	Real estate activities	11.5	12.8	10.5	12.7
M	Professional, scientific and technical activities	4.7	8.1	6.4	7.9
N	Administrative and support service activities	4.2	5.9	5.2	4.0
Q	Human health and social work activities	6.7	7.8	6.1	7.7
R	Arts, entertainment and recreation	2.1	5.3	4.5	1.1
S	Other service activities	1.9	9.1	7.7	1.5

SOURCE: OECD.

reliance on tourism. Conversely, the best positioned services (professional, scientific and technical activities, information and communication activities and financial and insurance activities) represent a lower share. The importance of the ten best positioned sectors in terms of productivity and resilience can be illustrated with a few figures: despite representing around 12% of gross value added and 10% of employment, they account for 32% of spending on innovative activities and their average wage is 24% higher than the national average.

Table 3

GVA SHARE OF THE 10 BEST (WORST) POSITIONED SECTORS IN TERMS OF PRODUCTIVITY AND RESILIENCE IN THE NATIONAL TOTAL

Best positioned sectors

NACE	Sector	Spain (%)	France (%)	Germany (%)	United States (%)
26	Manufacture of computer, electronic and optical products	0.2	0.6	1.4	1.5
58	Publishing activities	0.2	0.7	0.5	1.4
59-60	Video and television programme activities and broadcasting	0.5	0.6	0.5	1.0
61	Telecommunications	1.4	1,2	0.9	1.6
62-63	Computer programming, information and related activities	1.7	2.8	2.9	3.0
64-65	Financial and insurance activities	4.1	4.1	3.8	7.7
69-70	Legal, accounting, head office and other activities	2.2	3.9	3.2	4.9
71	Architectural and engineering activities	1.1	1,7	1,4	1.1
72	Scientific research and development	0.5	1.7	0.8	0.6
74-75	Other professional, scientific, technical and veterinary activities	0.5	0.4	0.5	0.8

Worst positioned sectors

NACE	Sector	Spain (%)	France (%)	Germany (%)	United States (%)
1-3	Agriculture, forestry and fishing	3.1	1.9	0.7	0.9
5-9	Mining and quarrying	0.2	0.1	0.1	1.7
13-15	Manufacture of textiles, wearing apparel, leather and other	0.8	0.2	0.3	0.1
16	Manufacture of wood and cork products, except furniture	0.2	0.2	0.2	0.2
37-39	Waste collection and remediation	0.7	0.6	0.9	0.3
45-47	Wholesale and retail trade	12.9	10.3	10.0	10.0
49	Land transport and transport via pipelines	2.2	2.2	1.7	1.5
50	Water transport	0.1	0.1	0.2	0.1
52	Warehousing and support activities for transportation	1.8	1.5	1.7	0.7
55-56	Accommodation and food service activities	6.3	2.9	1.6	2.8

SOURCE: OECD.

6 Concluding remarks

The health crisis prompted by COVID-19 has evidenced the importance of sectoral heterogeneity in understanding the economic impact of shocks that affect an economy. Further, this crisis has materialised at a time when the Spanish economy, like other developed economies, faces a series of structural challenges, most notably low productivity growth, the process of technological change (particularly that related to digitalisation), climate change and population ageing. The impact of these challenges will differ across sectors depending on the capacity of the firms in each to address them and on the response of economic authorities.

This paper's main message is that the sectors with a better relative position to address the different challenges analysed account for a relatively small share of the Spanish economy's productive system, less than observed in other advanced economies. Manufacture of computer, electronic and optical products; professional, scientific and technical activities; research and development activities and financial and insurance activities, inter-alia, are well positioned in terms of both productivity and resilience. However, these top sectors accounted for 12.6% of total GVA in Spain compared to 15.1%, 17.4% and 22.5% in Germany, France and the United States, respectively.

Meanwhile, some of the economy's most central sectors are more vulnerable vis-à-vis future challenges. Specifically, many manufacturing and energy supply sectors are very central owing to their knock-on effects on other sectors and have high relative productivity levels, but are more vulnerable to challenges such as climate change due to their higher level of emissions. Conversely, real estate and social work activities are better placed vis-à-vis the challenges, particularly population ageing, but perform worse in terms of productivity. Lastly, some sectors have shortcomings in terms of both productivity and resilience, such as accommodation and food service activities, the primary sector and transport services.

Consequently, and given the goal of achieving sustained and sustainable productivity growth (which is key to ensuring rising levels of economic well-being in the long term), these results indicate the need to focus particularly on the cross-sector reallocation of factors of production. This may be a complex and costly process, but is essential to improve the Spanish economy's capacity to contend with the future challenges analysed. From this standpoint, improving the mechanisms that smooth the reallocation of productive resources (particularly labour) across sectors and firms appears to stand as a primary objective. Given that, a priori, skills do not seem particularly transferable between the sectors identified as potential winners and potential losers (Anghel, Lacuesta and Regil, 2020), strengthening continuous learning systems is key. More generally, restructuring processes typically entail transition costs that are predominantly borne by certain groups in the potentially contracting sectors. To ensure the success of such processes, the existing social safety nets should also be assessed to identify any aspects that need to be bolstered.

Lastly, this paper adopts just one of the possible approaches to broaching the complex issue of determining whether the different sectors of the Spanish economy are adequately positioned to address the long-term challenges. Therefore, any answer to such a complex question will necessarily be imperfect and alternative methodologies to that used here could result in a different relative position.

References

Anghel, B., A. Lacuesta and A. V. Regil (2020). "Transferability of workers' skills in sectors potentially affected by COVID-19", *Analytical Articles,* Banco de España.

Banco de España (2019). "Economic consequences of demographic change", Chap. 4, 2018 *Annual Report.*

Banerjee, A. V., and E. Duflo (2005). "Growth Theory through the Lens of Development Economics", in P. Aghion and S. Durlauf (eds.), *Handbook of Economic Growth,* 1st edition, Vol. 1, Chap. 7, Elsevier, pp. 473-552.

Banerjee, R., and B. Hofmann (2018). "The rise of zombie firms: causes and consequences", *BIS Quarterly Review,* September, Bank for International Settlements.

Barefoot, K., D. Curtis, W. A. Jolliff, J. R. Nicholson and R. Omohundro (2018). "Defining and Measuring the Digital Economy", *Working Paper* No 15, Bureau of Economic Analysis, US Department of Commerce, Washington D.C.

Bartelsman, E, J. Haltiwanger and S. Scarpetta (2013). "Cross-Country Differences in Productivity: The Role of Allocation and Selection", *American Economic Review* No. 103, pp. 304-334.

Bentolila, S., J. J. Dolado and J. F. Jimeno (2019). "Dual Labour Markets Revisited", *IZA Discussion Paper* No 12126.

Brindusa, A., M. Cozzolino and A. Lacuesta (2020). "Teleworking in Spain", *Economic Bulletin* 2/2020, Banco de España, pp. 1-20.

Calvino, F., et al. (2018). "A taxonomy of digital intensive sectors", *OECD Science, Technology and Industry Working Papers* 2018/14, OECD Publishing.

Cotec (2020). *Informe Cotec 2020,* Cotec Foundation for Innovation.

Cuadrado, P., E. Moral-Benito and I. Solera (2020). "A sectoral anatomy of the Spanish productivity puzzle", *Occasional Papers* No 2006, Banco de España.

Delgado, M. (2019). "Energy transition and financial stability. Implications for the Spanish deposit-taking institutions", *Financial Stability Review* No 37, Banco de España, pp 11-43.

Dingel, J., and B. Neiman (2020). "How many jobs can be done at home?", *Journal of Public Economics,* 189, 104235.

Estrada, Á., and D. Santabárbara (2021). "Recycling carbon tax revenues in Spain. Environmental and economic assessment of selected green reforms", *Working Papers* No 2119, Banco de España.

Frey, C. B., and M. A. Osborne (2017). "The future of employment: how susceptible are jobs to computerisation?", *Technological Forecasting and Social Change* 114, pp. 254-280.

Gómez, Á. L., and A. del Río (2021). "The uneven impact of the health crisis on the euro area economies in 2020", *Occasional Papers* No 2115, Banco de España.

Guerrieri, V., G. Lorenzoni, L. Straub and I. Werning (2020). "Macroeconomic implications of COVID-19: can negative supply shocks cause demand shortages", *Working Paper* No 26918, National Bureau of Economic Research.

Heywood, J. S., and S. W. Siebert (2009). "Understanding the labour market for older workers: a survey", *IZA Discussion Paper* No 4033.

Hsieh, C., and P. Klenow (2009). "Misallocation and Manufacturing TFP in China and India", *Quarterly Journal of Economics* 124(4), pp. 1403-1448.

Hurd, M. D. (1996). "The effect of labor market rigidities on the labor force behaviour of older workers", in D. Wise (ed.), *Advances in the economics of aging,* Chicago, IL, University of Chicago Press, pp. 11-60.

Jones, Ch. I. (2019). "Paul Romer: Ideas, Nonrivalry, and Endogenous Growth", *Scandinavian Journal of Economics* No 121 (3), pp. 859-883.

López-García, P., and J. M. Montero (2012). "Spillovers and absorptive capacity in the decision to innovate of Spanish firms: the role of human capital", *Economics of Innovation and New Technology,* Vol. 21(7), pp. 589-612.

Lucas, R. (1988). "On the Mechanism of Economic Development", *Journal of Monetary Economics* No 22, pp. 3-42.

McGowan, M., D. Andrews and V. Millot (2018). "The walking dead? Zombie firms and productivity performance in OECD countries", *Economic Policy,* Vol. 33, Issue 96, October, pp. 685-736.

Nelson, R., and E. Phelps (1966). "Investment in humans, technological diffusion, and economic growth", *American Economic Review* No 56, pp. 69-75.

Olley, G. S., and A. Pakes (1996). "The Dynamics of Productivity in the Telecommunications Equipment Industry", *Econometrica* No 64(6), pp. 1263-1297.

Organisation for Economic Co-operation and Development (OECD) (2008). *Handbook on the Construction of Composite Indicators. Methodology and User Guide,* Paris.

Romer, P. (1990). "Endogenous Technological Change", *Journal of Political Economy,* Vol. 98, No 5.

Schivardi, F., and T. Schmitz (2019). "The IT Revolution and Southern Europe's Two Lost Decades", *Journal of the European Economic Association,* Vol. 18, Issue 5, October, pp. 2441-2486.

Vacanti, N. M. (2019). "The Fundamentals of Constructing and Interpreting Heat Maps", in S. M. Fendt and S. Lunt (eds.), Metabolic Signaling. *Methods in Molecular Biology,* Vol. 1862, New York, NY, Humana Press.

Webb, M. (2020). *The Impact of Artificial Intelligence on the Labor Market,* mimeo, Stanford.

Annex 1 Indicators

Table A1.1
LIST OF INDICATORS

Indicator	Definition	Source	Sign
Productivity - Human capital			
Higher education	% of employees with a university degree	LFS (INE, microdata); 2019 average	+
Temporary employment ratio	% of employees with a temporary contract	LFS (INE, microdata); 2019 average	–
Job tenure	Average length of service of employees at the firm (months)	LFS (INE, microdata); 2019 average	+
Average wage	Nominal average wage of employees	Annual labour costs survey (INE); 2013-19 average	+
On-the-job training	% of employees receiving in-company training	LFS (INE, microdata); 2019 average	+
Productivity - Reallocation of factors			
Business entry-exit rate	Sum of firm births and deaths	Central Business Register (INE); 2013-2018 average	+
Non-viable firms ratio	% of firms meeting these conditions: (sales growth <P50 of sales growth + negative investment) for two years in a row & (net debt)/(maximum gross profit in the past 3 years)>12 & net debt>0	Banco de España Central Balance Sheet Data Office, 2010-2019 average	–
Dispersion of the marginal product of capital	Standard deviation of the marginal product of capital according to Hsieh-Klenow (2009), obtained as the logarithm of the value added-to-capital stock ratio	Banco de España Central Balance Sheet Data Office, 2010-2019 average	–
Size-productivity covariance	Covariance between the share of a firm's GVA in its sector and its productivity according to Olley-Pakes (1996)	Banco de España Central Balance Sheet Data Office, 2010-2019 average	+
Share of small firms	% of firms with <10 employees in each sector and >10 years of age	Central Business Register	–
Productivity - Innovation			
Spending on innovation	Spending on innovative activities / sales	Community Innovation Survey; 2017-2019	+
Innovation output	% of firms with innovative sales	Community Innovation Survey; 2017-2019	+
New product strategy	% of firms focusing on launching new products	Community Innovation Survey; 2017-2019	+
Higher quality strategy	% of firms focusing on product quality	Community Innovation Survey; 2017-2019	+
Patents	% of firms applying for patents	Community Innovation Survey; 2017-2019	+
GVA per hour	Average rate of change of GVA per hour for 2010-2017	EU KLEMS	+
Resilence - Technological change			
Work from home	% of employees who are able to work from home	Brindusa, Cozzolino and Lacuesta (2020); drawing on Dingel and Neiman (2020)	+
Digital intensity	Degree of digitalisation	Calvino et al. (2018), OECD; 2013-2015	+
ICT content	Column-by-column sum of the inverse matrix coefficients for the ICT sectors according to Eurostat: 26, 61, 62 and 95	Input-output tables	+
Share of investment in ICT	Investment in information and communication equipment, software and databases as a share of total investment	EU KLEMS	+
Share of capital stock in ICT	Capital stock in information and communication equipment, software and databases as a share of the total	EU KLEMS	+
Share of digital economy	% of digital economy GVA generated in each sector	Based on the digital economy satellite account of the BEA; data for the United States, 2013-2018 average	+
Automation	Likelihood of automation of the occupations in each sector	Based on the Frey and Osborne (2017) methodology, using LFS microdata	–
Impact of artificial intelligence	AI exposure index	Based on Webb (2020)	–

Table A1.1

LIST OF INDICATORS (cont.)

Indicator	Definition	Source	Sign
Resilience. Climate change			
Tonnes of CO2 divided by output	Thousands of tonnes of CO2 per €1 billion of production	Estrada and Santabárbara (2021); CN by sector (INE)	–
CO2 per unit of GVA	CO2 emissions included in each final product (taking into account intermediate goods purchased by each sector from other sectors), per unit of GVA	Delgado (2019)	–
Emission intensity	Greenhouse gas emissions divided by GVA	Eurostat	–
Total gas emissions	Greenhouse gas emissions	Eurostat	–
Environmental taxes	Revenue from environmental taxes (energy, transport, pollution and resource use)	Eurostat	–
Emissions growth	Average annual change in emissions 2008-2018	Eurostat	–
Resilience. Ageing			
Part-time employees	% of employees working part time	LFS (INE, microdata); 2019 average	+
On-the-job training	% of employees receiving in-company training	LFS (INE, microdata); 2019 average	+
Employees aged 50+	% of employees over the age of 50	LFS (INE, microdata); 2019 average	–
Exposure to the silver economy	Spillover capacity of health (86) and residential care activities (87) on other sectors	Input-output tables	+
Consumption of over-65s	Difference between the distribution of the average consumption of the over-65s and the rest of the population	Household Budget Survey (HBS)	+
Internal centrality			
Upstream centrality	Katz-Bonacich centrality index. Importance as a supplier to other sectors	Input-output tables	+
Downstream centrality	Katz-Bonacich centrality index. Importance as a consumer for other sectors	Input-output tables	+
Employment / Total employment	Employment as a % of total employment	LFS (INE); 2013-2019 average	+
Number of firms / total firms	Number of firms as a % of total firms	Central Business Register (INE); 2013-2018 average	+
Change in (firms / total firms)	Change in the share of firms in each sector between 2013 and 2018	Central Business Register (INE)	+
External centrality			
Domestic content in exports – import content in output	Share of output exported (including intermediate and final goods) – Share of materials imported to manufacture one unit of output in the sector	Input-output tables	+
Exports / total exports	Exports as a % of total exports	Input-output tables	+

Annex 2 Principal components analysis

To test the robustness of the analysis conducted using the indicator normalisation and aggregation methodology described in Section 3, a principal components analysis (PCA) is performed to draw together the information for each of the categories considered.

Each composite indicator is built using PCA by taking the weighted average of the principal components whose eigenvalues are greater than one, using those eigenvalues as weighting factors among the components.

Next, the correlation coefficient is calculated for the rankings obtained through PCA and the min-max methodology described in Section 3. As can be seen, the correlations between the methodologies are very high, exceeding 90% in technological change and population ageing.

In addition, the ten best sectors under each methodology are compared, confirming that the two methodologies yield very similar results.

Table A2.1
CORRELATION BETWEEN RANKINGS

Minimum	Productivity	Technological change	Climate change	Ageing
Correlation coefficient between the PCA rankings and the rankings according to the Section 3 methodology	45.7 %	98.6 %	59 %	94.3 %

SOURCE: Banco de España.

Table A2.2
COMPARISON OF THE TOP 10 SECTORS ACCORDING TO THE PCA METHODOLOGY WITH THE RANKING USING THE MIN-MAX METHODOLOGY

Productivity		Technological change		Climate change		Ageing	
PCA	Min-max	PCA	Min-max	PCA	Min-max	PCA	Min-max
1	1	1	1	1	1	1	2
2	2	2	2	2	3	2	1
3	4	3	3	3	2	3	6
4	9	4	4	4	4	4	3
5	7	5	5	5	5	5	7
6	3	6	7	6	8	6	5
7	5	7	6	7	6	7	10
8	61	8	10	8	7	8	4
9	15	9	9	9	9	9	8
10	6	10	8	10	10	10	9

SOURCE: Banco de España.

BANCO DE ESPAÑA PUBLICATIONS

OCCASIONAL PAPERS

2030 ÁNGEL GÓMEZ-CARREÑO GARCÍA-MORENO: Juan Sebastián Elcano – 500 años de la Primera vuelta al mundo en los billetes del Banco de España. Historia y tecnología del billete.

2031 OLYMPIA BOVER, NATALIA FABRA, SANDRA GARCÍA-URIBE, AITOR LACUESTA and ROBERTO RAMOS: Firms and households during the pandemic: what do we learn from their electricity consumption?

2032 JÚLIA BRUNET, LUCÍA CUADRO-SÁEZ and JAVIER J. PÉREZ: Contingency public funds for emergencies: the lessons from the international experience. (There is a Spanish version of this edition with the same number).

2033 CRISTINA BARCELÓ, LAURA CRESPO, SANDRA GARCÍA-URIBE, CARLOS GENTO, MARINA GÓMEZ and ALICIA DE QUINTO: The Spanish Survey of Household Finances (EFF): description and methods of the 2017 wave.

2101 LUNA AZAHARA ROMO GONZÁLEZ: Una taxonomía de actividades sostenibles para Europa.

2102 FRUCTUOSO BORRALLO, SUSANA PÁRRAGA-RODRÍGUEZ and JAVIER J. PÉREZ: Taxation challenges of population ageing: comparative evidence from the European Union, the United States and Japan. (There is a Spanish version of this edition with the same number).

2103 LUIS J. ÁLVAREZ, M.ª DOLORES GADEA and ANA GÓMEZ LOSCOS: Cyclical patterns of the Spanish economy in Europe. (There is a Spanish version of this edition with the same number).

2104 PABLO HERNÁNDEZ DE COS: Draft State Budget for 2021. Testimony before the Parliamentary Budget Committee, 4 November 2020. (There is a Spanish version of this edition with the same number).

2105 PABLO HERNÁNDEZ DE COS: The independence of economic authorities and supervisors. The case of the Banco de España. Testimony by the Governor of the Banco de España before the Audit Committee on Democratic Quality / Congress of Deputies, 22 December 2020. (There is a Spanish version of this edition with the same number).

2106 PABLO HERNÁNDEZ DE COS: The Spanish pension system: an update in the wake of the pandemic. Banco de España contribution to the Committee on the Monitoring and Assessment of the Toledo Pact Agreements. 2 September 2020. (There is a Spanish version of this edition with the same number).

2107 EDUARDO BANDRÉS, MARÍA-DOLORES GADEA and ANA GÓMEZ-LOSCOS: Dating and synchronisation of regional business cycles in Spain. (There is a Spanish version of this edition with the same number).

2108 PABLO BURRIEL, VÍCTOR GONZÁLEZ-DÍEZ, JORGE MARTÍNEZ-PAGÉS and ENRIQUE MORAL-BENITO: Real-time analysis of the revisions to the structural position of public finances.

2109 CORINNA GHIRELLI, MARÍA GIL, SAMUEL HURTADO and ALBERTO URTASUN: The relationship between pandemic containment measures, mobility and economic activity. (There is a Spanish version of this edition with the same number).

2110 DMITRY KHAMETSHIN: High-yield bond markets during the COVID-19 crisis: the role of monetary policy.

2111 IRMA ALONSO and LUIS MOLINA: A GPS navigator to monitor risks in emerging economies: the vulnerability dashboard.

2112 JOSÉ MANUEL CARBÓ and ESTHER DIEZ GARCÍA: El interés por la innovación financiera en España. Un análisis con Google Trends.

2113 CRISTINA BARCELÓ, MARIO IZQUIERDO, AITOR LACUESTA, SERGIO PUENTE, ANA REGIL and ERNESTO VILLANUEVA: Los efectos del salario mínimo interprofesional en el empleo: nueva evidencia para España.

2114 ERIK ANDRES-ESCAYOLA, JUAN CARLOS BERGANZA, RODOLFO CAMPOS and LUIS MOLINA: A BVAR toolkit to assess macrofinancial risks in Brazil and Mexico.

2115 ÁNGEL LUIS GÓMEZ and ANA DEL RÍO: The uneven impact of the health crisis on the euro area economies in 2020. (There is a Spanish version of this edition with the same number).

2116 FRUCTUOSO BORRALLO EGEA and PEDRO DEL RÍO LÓPEZ: Monetary policy strategy and inflation in Japan. (There is a Spanish version of this edition with the same number).

2117 MARÍA J. NIETO and DALVINDER SINGH: Incentive compatible relationship between the ERM II and close cooperation in the Banking Union: the cases of Bulgaria and Croatia.

2118 DANIEL ALONSO, ALEJANDRO BUESA, CARLOS MORENO, SUSANA PÁRRAGA and FRANCESCA VIANI: Fiscal policy measures adopted since the second wave of the health crisis: the euro area, the United States and the United Kingdom. (There is a Spanish version of this edition with the same number).

2119 ROBERTO BLANCO, SERGIO MAYORDOMO, ÁLVARO MENÉNDEZ and MARISTELA MULINO: Impact of the COVID-19 crisis on Spanish firms' financial vulnerability. (There is a Spanish version of this edition with the same number).

2120 MATÍAS PACCE, ISABEL SÁNCHEZ and MARTA SUÁREZ-VARELA: Recent developments in Spanish retail electricity prices: the role played by the cost of CO_2 emission allowances and higher gas prices. (There is a Spanish version of this edition with the same number).

2121 MARIO ALLOZA, JAVIER ANDRÉS, PABLO BURRIEL, IVÁN KATARYNIUK, JAVIER J. PÉREZ and JUAN LUIS VEGA: The reform of the European Union's fiscal governance framework in a new macroeconomic environment. (There is a Spanish version of this edition with the same number).

2122 MARIO ALLOZA, VÍCTOR GONZÁLEZ-DÍEZ, ENRIQUE MORAL-BENITO and PATROCINIO TELLO-CASAS: Access to services in rural Spain. (There is a Spanish version of this edition with the same number).

2123 CARLOS GONZÁLEZ PEDRAZ and ADRIAN VAN RIXTEL: The role of derivatives in market strains during the COVID-19 crisis. (There is a Spanish version of this edition with the same number).

2124 IVÁN KATARYNIUK, JAVIER PÉREZ and FRANCESCA VIANI: (De-)Globalisation of trade and regionalisation: a survey of the facts and arguments.

2125 BANCO DE ESPAÑA STRATEGIC PLAN 2024: RISK IDENTIFICATION FOR THE FINANCIAL AND MACROECONOMIC STABILITY: How do central banks identify risks? A survey of indicators.

2126 CLARA I. GONZÁLEZ and SOLEDAD NÚÑEZ: Markets, financial institutions and central banks in the face of climate change: challenges and opportunities.

2127 ISABEL GARRIDO: The International Monetary Fund's view of social equity throughout its 75 years of existence. (There is a Spanish version of this edition with the same number).

2128 JORGE ESCOLAR and JOSÉ RAMÓN YRIBARREN: European Central Bank and Banco de España measures against the effects of COVID-19 on the monetary policy collateral framework, and their impact on Spanish counterparties. (There is a Spanish version of this edition with the same number).

2129 BRINDUSA ANGHEL, AITOR LACUESTA and FEDERICO TAGLIATI: 2021 Survey of Small Enterprises' Financial Literacy: Main Results. (There is a Spanish version of this edition with the same number).

2130 PABLO HERNÁNDEZ DE COS: Testimony before the Congress of Deputies Budget Committee on 25 October 2021 and before the Senate Budget Committee on 30 November 2021 in relation to the Draft State Budget for 2022. (There is a Spanish version of this edition with the same number).

2131 LAURA AURIA, MARKUS BINGMER, CARLOS MATEO CAICEDO GRACIANO, CLÉMENCE CHARAVEL, SERGIO GAVILÁ, ALESSANDRA IANNAMORELLI, AVIRAM LEVY, ALFREDO MALDONADO, FLORIAN RESCH, ANNA MARIA ROSSI and STEPHAN SAUER: Overview of central banks' in-house credit assessment systems in the euro area.

2132 JORGE E. GALÁN: CREWS: a CAMELS-based early warning system of systemic risk in the banking sector.

2133 ALEJANDRO FERNÁNDEZ CEREZO and JOSÉ MANUEL MONTERO: A sectoral analysis of the future challenges facing the spanish economy. (There is a Spanish version of this edition with the same number).