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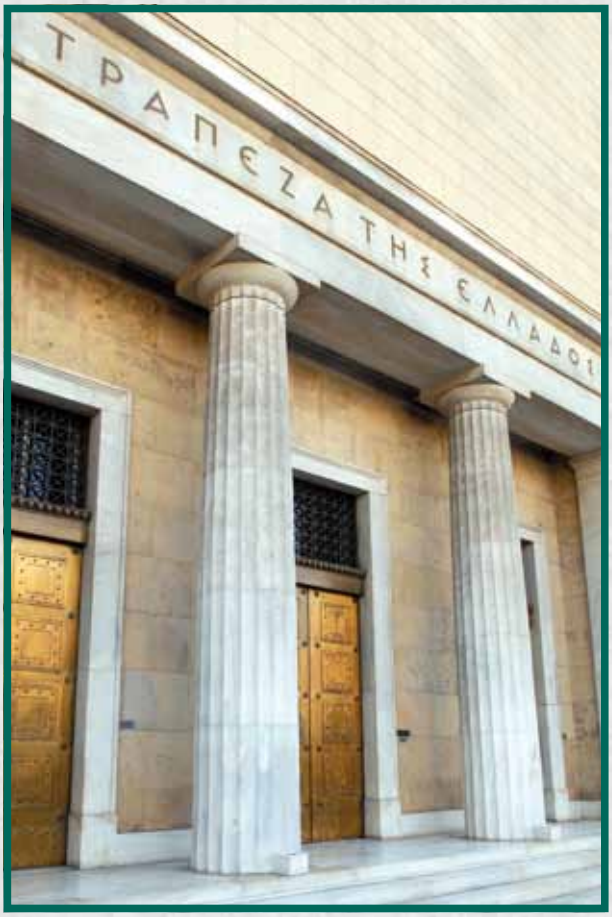

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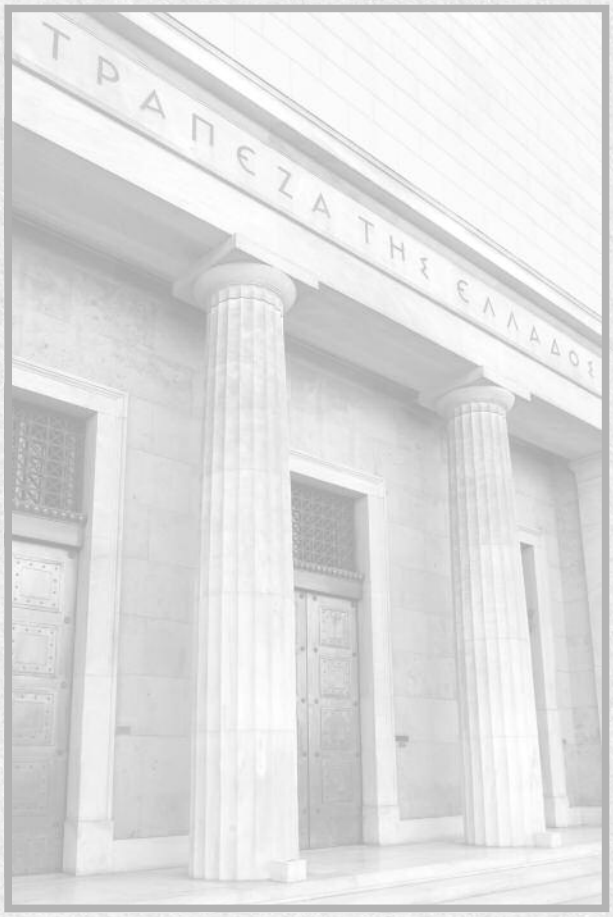

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CONTENTS

GREECE'S INTEGRATION INTO GLOBAL VALUE CHAINS

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ABSTRACT

This paper investigates Greece's involvement in GVCs using the decomposition suggested by Wang et al. (2013, 2018) and applied to the World Input-Output Database (WIOD). In general, we find that domestic value added is high in service sectors and much lower in manufacturing, in line with the results from the literature. However, we find evidence of both upstream and downstream activity in different sectors. In particular, upstreamness is found in crop and animal production, mining and quarrying, the manufacture of basic metals, and wholesale and retail trade. Downstreamness is common in accommodation and food services. Two sectors —manufacture of food products and manufacture of pharmaceuticals— have seen a rise in the importance of domestic value added in exports. That is, the products are increasingly being made from start to finish, providing high levels of domestic value added in exports. Finally, there are sectors which display the characteristics of both upstreamness and downstreamness. These include the manufacture of textiles, wood and wood products, paper and paper products and, most importantly, petroleum and chemicals, which exhibit the greatest degree of GVC integration of any sector in Greece. The consolidation of these trends towards greater integration —either in manufacturing or in services and distribution— is likely to be of benefit for the Greek economy, allowing it to improve the quality of its exports as well as lowering their price.

Keywords: global value chains, Greece, upstreamness, downstreamness

JEL classification: F23, L14

Η ΣΥΜΜΕΤΟΧΗ ΤΗΣ ΕΛΛΑΔΟΣ ΣΤΙΣ ΠΑΓΚΟΣΜΙΕΣ ΑΛΥΣΙΔΕΣ ΑΞΙΑΣ

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ΠΕΡΙΛΗΨΗ

Στην παρούσα μελέτη διερευνάται η συμμετοχή της Ελλάδος στις παγκόσμιες αλυσίδες αξίας σύμφωνα με την ανάλυση που προτείνουν οι Wang et al. (2013, 2018) και η οποία εφαρμόζεται στη βάση δεδομένων World Input-Output Database (WIOD). Το γενικό συμπέρασμα της μελέτης είναι ότι η εγχώρια προστιθέμενη αξία είναι υψηλή στους κλάδους των υπηρεσιών και πολύ χαμηλότερη στη μεταποίηση, συμβαδίζοντας με τα αποτελέσματα της βιβλιογραφίας. Ωστόσο, τα αποτελέσματα καταδεικνύουν συμμετοχή κλάδων οικονομικής δραστηριότητας τόσο στα αρχικά στάδια (upstreamness) όσο και στα τελικά στάδια (downstreamness) της παγκόσμιας παραγωγικής αλυσίδας. Συγκεκριμένα, οι κλάδοι της φυτικής και ζωικής παραγωγής, της παραγωγής ορυχείων-λατομείων, της παραγωγής βασικών μετάλλων και του χονδρικού και λιανικού εμπορίου συμμετέχουν στα αρχικά στάδια της παγκόσμιας παραγωγικής αλυσίδας. Η συμμετοχή στα τελικά στάδια της παγκόσμιας αλυσίδας παραγωγής παρατηρείται συνήθως στον κλάδο καταλυμάτων και δραστηριοτήτων υπηρεσιών εστίασης. Δύο κλάδοι —η βιομηχανία τροφίμων και η παραγωγή βασικών φαρμακευτικών προϊόντων και φαρμακευτικών παρασκευασμάτων— καταγράφουν αύξηση του ποσοστού της εγχώριας προστιθέμενης αξίας στις εξαγωγές. Αυτό σημαίνει ότι η παραγωγή των εν λόγω προϊόντων γίνεται σε αυξανόμενο βαθμό από την αρχή έως το τέλος, προσδίδοντας υψηλότερη εγχώρια προστιθέμενη αξία στις εξαγωγές. Τέλος, υπάρχουν κλάδοι που συμμετέχουν τόσο στα αρχικά όσο και στα τελικά στάδια της παγκόσμιας αλυσίδας παραγωγής. Σε αυτούς τους κλάδους περιλαμβάνονται η παραγωγή κλωστοϋφαντουργικών υλών, ειδών ενδυμασίας, δέρματος και δερμάτινων ειδών, η βιομηχανία ξύλου και κατασκευής προϊόντων από ξύλο, η βιομηχανία χαρτοποιίας και κατασκευής χάρτινων προϊόντων και κυρίως οι κλάδοι παραγωγής οπτάνθρακα και προϊόντων διύλισης πετρελαίου και παραγωγής χημικών ουσιών και προϊόντων, οι οποίοι έχουν στην Ελλάδα την υψηλότερη συμμετοχή στις παγκόσμιες αλυσίδες αξίας. Η ισχυροποίηση της τάσης μεγαλύτερης συμμετοχής στις παγκόσμιες αλυσίδες αξίας —είτε στη μεταποίηση είτε στους κλάδους υπηρεσιών και διανομής— ενδέχεται να αποφέρει οφέλη στην ελληνική οικονομία, καθιστώντας δυνατή τη βελτίωση της ποιότητας των εξαγωγών της, καθώς και τη μείωση των τιμών εξαγωγών.

GREECE'S INTEGRATION INTO GLOBAL VALUE CHAINS*

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1 INTRODUCTION

One salient feature of economic globalisation over the past decades has been the rise of global value chains (GVCs), where the different stages of production and distribution of goods and services have become increasingly fragmented and dispersed across countries. This has been made possible by advances in information, communication and transportation technologies, together with institutional and market reforms that have allowed countries to participate in global economic activity. The expansion of GVCs, through increased outsourcing and offshoring[1] of intermediate inputs to foreign suppliers, has fundamentally changed international trade, creating opportunities but also risks for both advanced and emerging market economies. The advent of the global financial crisis in 2008-09 halted this expansion, which had already been slowing, and triggered a streamlining of GVCs, with firms reducing the complexity and length of their supply chains (OECD 2013; ECB 2016).

In particular, GVCs have been undergoing a number of structural shifts, which are occurring against the backdrop of trade protectionism and policy uncertainty. First, GVCs are becoming less global and more regional around core advanced but also emerging market economies, while there is a shift towards onshoring of production to key export markets to better cater for rising domestic consumption. Second, GVCs, and the accompanying foreign direct investment, are increasingly less driven by considerations of labour cost minimisation (ECB 2016), a trend that is expected to be amplified in the future due to automation and artificial intelligence. Third, GVCs are growing more service-[2] and knowledge-intensive, with capitalised spending on R&D and intangible assets such as brands, software, and intellectual property making up a larger share of revenue (McKinsey 2019). This, in principle, would favour countries with high-skilled labour forces, innovation-oriented businesses, strong legal and regulatory frameworks, and good institutional governance.

An extensive body of literature has analysed the impact on countries and firms from their participation in GVCs, which can be beneficial in various ways. Evidence shows that greater GVC participation is typically associated with higher investment, productivity gains, economic growth and employment creation (Saito et al. 2013; Ignatenko et al. 2019). GVC integration increases competition, allocative efficiency and technological spillovers, facilitating the upgrading of products, processes and skills. The benefits can spread more widely in the economy, as technology and expertise are transferred from lead global firms to local

* The authors would like to thank T. Kosma and H. Balfoussia for their useful comments. The views expressed are those of the authors.

1 Outsourcing by a firm occurs when part of the production process (including perhaps services involved in the production process) is conducted by another firm. Offshoring is outsourcing conducted in another country.

2 Ignatenko et al. (2019) note that the so-called servicification of manufacturing exports has been an important trend. More specifically, when measured in value added terms, the share of services exports in world exports is almost twice as large as what official statistics on gross exports show.

firms and workers, encouraging the latter's engagement in the supply network and exporting activity. Brumm et al. (2019) show that economies with greater participation in GVCs improve their current account balances in the form of higher external surpluses or lower external deficits. Their result is robust even after controlling for country size, trade openness or domestic manufacturing intensity.

There are multiple channels through which GVC participation increases productivity, including a finer division of labour across countries (Grossman and Rossi-Hansberg 2008), greater input variety (Halpern et al. 2015), learning externalities, and lower production costs which free up funds for R&D investment (Glass and Saggi 2001). A handful of studies at the industry level document that service offshoring positively affects productivity in advanced economies (see, for example, Crinò 2008; Amiti and Wei 2009; Winkler 2010). Other studies at the firm level in advanced and emerging market economies corroborate that international outsourcing increases productivity (see, for example, Görg et al. 2008; Kasahara and Rodrigue 2008; Fariñas and Martín-Marcos 2010; Jabbour 2010; Ito et al. 2011; Montalbano et al. 2018). Schwörer (2013), combining industry and firm data for a number of European countries, finds that offshoring of services and non-core manufacturing has led to productivity gains, which are driven particularly by multinational firms, whereas offshoring of core manufacturing activities have had no such effects.

In the presence of productivity gains, some papers show that GVC participation can have positive effects on the labour market, decreasing unemployment and increasing wages even of the unskilled workers under certain conditions (see, for example, Grossman and Rossi-Hansberg 2008; Mitra and Ranjan 2010; Kohler and Wrona 2010).

As regards investment, while involvement in GVCs may contribute to attracting investment, evidence is mixed, as investment crucially depends on broader policy and institutional frameworks (OECD, WTO and UNCTAD 2013).

The spread of GVCs could make it easier for SMEs to participate in trade, as the break-up of the production process makes it feasible for a specialised firm to find niche markets (*Global Value Chain Development Report 2019*). There is evidence that the internet reduces search costs, facilitating more exchanges of goods, services, know-how and technology, thus increasing firm productivity. Cross-border e-commerce platforms are also providing new opportunities for SMEs and even micro firms.

At the same time, GVC participation can generate economic and social costs that need to be carefully managed. These costs include an increase in income inequality, partly due to compositional changes in the labour market (Timmer et al. 2013, 2014; Farole 2016), as well as making a country more vulnerable to monetary policy spillovers and external shocks. Wang et al. (2017a) conclude that the deeper and more intense a country-sector's participation in GVCs the stronger the impact of a global economic shock, while Burstein at al. (2008) and Ng (2010) provide evidence of strong correlations between countries' GVC links and business cycle co-movement. An interesting finding in the literature is the critical role played by "global hub" sectors (i.e. large suppliers or users of inputs that tie otherwise unrelated sectors together) in propagating shocks through GVCs (Frohm and Gunnella 2017). Moreover, Criscuolo and Timmis (2017) argue that the position within a GVC determines a country's resilience to different types of shocks; for example, downstream industries are relatively more vulnerable to supply shocks, while upstream industries that are farther from final consumers are more exposed to demand shocks.

GVCs also make trade wars particularly expensive, amplifying the effects of tariffs (Blanchard 2019; Huidrom et al. 2019). Because tariffs are (typically) applied to the gross value of

a good, rather than just the value added, every border crossing increases the total tariff bill associated with production. In addition, through GVCs, the costs and benefits of higher tariffs may extend well beyond the direct "intentional" targets to countries and firms worldwide, including the country imposing the tariff. Finally, all else equal, higher tariffs give firms an incentive to consolidate their GVCs into fewer countries and border crossings, potentially excluding and thus harming smaller open economies.

Overall, the net gain or loss from GVC participation in terms of a country's GDP growth and employment depends on a host of factors, not least the stage of the country's development and its production structure, exchange rate regime and financial integration. The gains from GVC participation are not automatic and there is a large degree of heterogeneity. The findings of the literature suggest that countries that favourably position themselves in GVCs not only exploit their proximity to expected consumers, raw materials and critical input suppliers, but also implement the right domestic regulations and policies. Ignatenko et al. (2019) point out that "moving up" to more high-tech sectors and higher income as a result of GVC participation does take place but is not universal, suggesting that gains are likely conditional on other factors.

The extent of both outsourcing and offshoring varies by country and sector. There are differences in GVCs in terms of average production length, intensity of participation, and relative positions of countries or sectors in the value chain. Ignatenko et al. (2019) suggest that physical proximity as well as standard country-pair characteristics, such as common border, common language and colonial linkages, are important determinants of GVC participation, particularly for the manufacturing sector. Additional policy-related variables in the gravity equation specification, i.e. preferential trade agreements, lower exchange rate volatility, and common currency, also increase GVC participation.

In this paper we focus on the case of Greece. Over the crisis, Greece has become a more export-oriented country. The share of total exports in GDP rose from 19% in 2009 to 36% in 2018. Exports of goods and services (excluding shipping) have risen by 60% in real terms since their trough in 2009, much higher than euro area exports as a whole. At the same time, the Greek current account deficit as a percentage of GDP has declined by 17 percentage points since the beginning of the crisis, suggesting that increased GVC participation may have been behind part of this rebalancing. Indeed, results presented in the recent Occasional Paper produced by the ECB Working Group on GVCs (ECB 2019) suggest that the trade rebalancing of Greece may have been supported by changes in its GVC activities. In view of the recent protracted recession and timid recovery of the Greek economy, it makes sense to explore whether the Greek economy is making progress in terms of GVC participation and whether we can thus expect gains in terms of growth in the near future. As the Greek economy is small, it is necessary to understand where it is positioned within the various GVCs and what vulnerabilities this implies. Once its position and degree of participation in the various GVCs has been identified, the next step is to understand their underlying determinants and thus what policies may have an impact on the gains to be expected from GVC participation. The sectoral analysis presented in this paper aims to shed light on the above questions and guide policy choices.

The results suggest that Greece has become more integrated into GVCs along with its increased openness. This result is evident when we break down gross exports into value added in intermediate and final goods exports. Increased integration is evident not just in terms of manufacturing, but also in distribution and services. Moreover, different sectors reflect differing degrees of upstreamness and downstreamness.

The rest of the paper is organised as follows: In the next section, we briefly review the lit-

erature on decomposing gross exports into their various components and what this tells us about participation in GVCs. In the third section, we discuss issues of data and methodology. The fourth section presents some results and the final section concludes. Information on data sources and definitions are provided in Appendix A and B, respectively.

2 DECOMPOSING GROSS EXPORTS AND GVCs

Drawing on input-output tables, a number of studies have developed analytical methodologies and metrics to measure countries' and sectors' integration into GVCs. Goods and services now often get exported and reimported several times before being consumed by final users. Figures for gross exports thus involve more double counting. A truer picture of the value of exports to a specific country is rather given by measuring value-added exports. This observation has led to a large bibliography which seeks to divide gross exports into various components. An examination of these components allows value added to be assigned more accurately to each country. It also allows us to understand how countries fit into the chain – whether they produce the technology behind the product, whether they produce different parts, whether they are largely involved in assembling items, or whether they focus more on sales and the marketing of the final product.

Hummels et al. (1998, 2001) were among the first to explore the impact of what they termed vertical specialisation (VS) on trade. Vertical specialisation is defined as occurring when goods are produced in two or more countries with different countries specialising in different stages of the production process. They calculated the level and growth of VS-based trade, defined as the import content of exports. In Hummels et al. (1998), they focus on four case studies: the US-Canada trade agreement in 1965; US-Mexico trade and the role of maquiladoras, which are Mexican plants that are exempted from Mexican tariffs on inputs they use from the US; Japanese manufacturing companies outsourcing to Southeast Asian countries; and, finally, Opel's move into Spain. They find strong evidence of an increasing trend in the volume of imports embodied in exports. They then generalise this result using the OECD Input-Output Database for various years between 1968 and 1990. The results confirm that increased VS is a more general phenomenon. There are, however, wide differences between countries, with large countries generally having lower levels of VS than small ones, since they can more easily retain all stages of production. In the Hummels et al. (2001) paper, these results are confirmed, and they then go on to ask whether the increase in VS is due to VS increasing in the same sector or the sectoral composition of exports moving more towards sectors with higher VS. They find that the former is more important in explaining the overall rise.

Hummels et al. (2001) note that vertical specialisation is wider as a concept than the import content of exports. Exports produced in one country could go on to be used as inputs to another country's exports. This they call VS1. However, to calculate VS1, bilateral trade data are also required. Daudin et al. (2009) are able to calculate VS1 and also VS1* which is the part of VS1 that returns to the original country. If VS1 is higher than VS, this suggests that a country takes part more in exporting inputs for further exports. Such countries could be primary producers or manufacturers of industrial inputs for processing. By contrast, when VS is greater than VS1, a country is more focused on exporting final goods which have used significant import content (e.g. assembling countries). They also discuss the extent to which VS and VS1 will vary across sectors. They use data from the Global Trade Analysis Project (GTAP) covering up to 113 regions and 55 sectors in 1997, 2001 and 2004. Their results show that it is important to look at value-added exports rather than gross exports if we are to understand interconnectedness of global production. Moreover, they then explore what value-added export measures tell

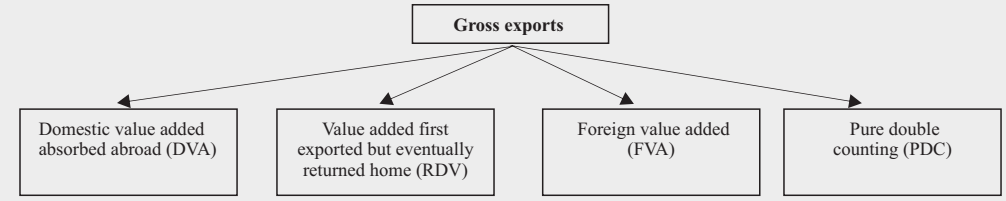
us about the regionalisation of trade compared to standard measures. If regional trade is measured using standard exports, one can conclude that all continents are regionalised. However, they are less regionalised when using value added data. Furthermore, standard trade statistics overestimate the importance of external demand for industrial products and underestimate it for services.

Koopman et al. (2014) go further in decomposing gross exports. First, they identify domestic value added in a country's exports, which is further decomposed into domestic value added in final goods exports, domestic value added in intermediate exports, which then return home as imports of final goods, and domestic value added in intermediate exports, which return home as inputs to final goods that are then exported. The second and third cases are double counted in gross export statistics. This double counting is equivalent to the VS1 measure of Hummel et al. (2001). Second, there is the foreign value added in a country's exports (equivalent to VS). Foreign value added can be further decomposed into foreign value added in the country's final goods exports and intermediate goods exports. Using these conceptual breakdowns, they decompose gross exports for a number of countries. Comparing the cases of the US and Mexico is useful. The US has a large domestic value added in exports – in 2004, it stood at just under 75%. Its foreign value added is 13%. The amount of foreign value added and the amount of domestic value added which return back to the US is 11%, i.e. relatively large. Thus most of US exports are domestic value added; this fact is consistent with the fact that the US is a large country and that it heads GVCs. By contrast, Mexico has much lower domestic value added (52%) and a high foreign value added in final goods exports (48%), reflecting its high level of GVC integration and its role downstream in global production chains.

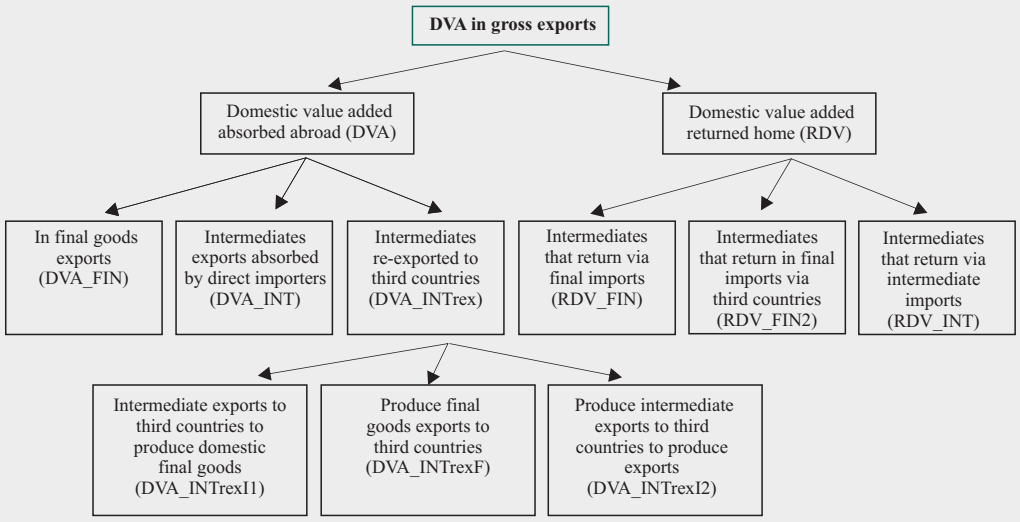
In a series of papers, Wang, Wei and Zhu (2013, 2018) and Wang, Wei, Yu and Zhu (2017a, 2017b) generalise the Koopman et al. (2014) framework to allow it to be applied at a sectoral/bilateral level. Chart 1, which is taken from Wang et al. (2013), illustrates the division of gross exports into 16 separate components. They are particularly critical of the literature that focuses on forward and backward linkages (Johnson and Noguera 2012; Johnson 2014) and proposes the so-called VAX ratio, based on either forward linkages or backward linkages. Indeed, they show that various VAX measures found in the literature cannot be used when looking at sectoral trade, bilateral trade, or sectoral-bilateral trade. By contrast, examining their 16 components allows for a comprehensive analysis of how a country is integrated into GVCs. Thus a high and rising level of pure double-counted (PDC) terms is indicative of greater integration into GVCs and reflects the toing and froing as goods pass repeatedly across borders before becoming final goods. Other elements can tell us whether countries are downstream —mainly assemblers— foreign value added in final goods (FVA_FIN) will be high and rising and pure double counting (PDC) falling. Additionally, domestic value added in final goods (DVA_FIN) will be high and rising. As countries move up the production chain —upstream integration— FVA_FIN will be falling, PDC rising and returned domestic value (RDV) high; domestic value added in intermediate goods (DVA_INT) and foreign value added in intermediate goods (FVA_INT) will be high and rising. They use these concepts to examine the automobile industry in the US, as well as electrical and optical equipment in Mexico and various Asian countries (Japan, Korea, Taiwan, China, India and Indonesia). Japan, Korea and Taiwan exhibit low and declining FVA_FIN, stable FVA_INT and rapidly expanding PDC in electrical and optical equipment exports, suggesting that they are quite upstream; the other three countries, by contrast, still have a large share of FVA_FIN, though in the case of China FVA_FIN has been declining and PDC rising as it moves up the production chain. Indonesia likewise has rapidly expanding FVA_INT and PDC. India, by contrast, has a high and rising level of

Chart 1 Gross exports accounting

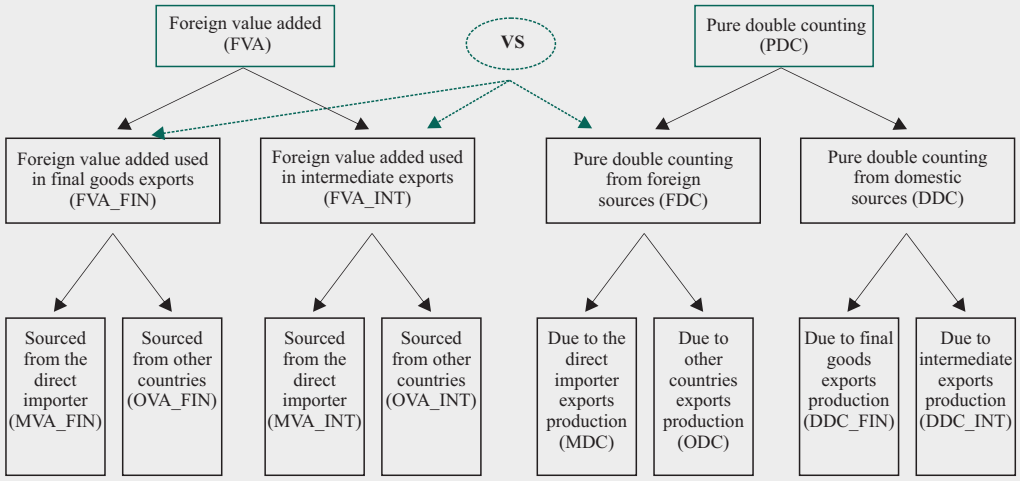
A. Major categories



B. Domestic value added



C. Foreign value added



Source: Wang et al. (2013).

FVA_FIN, whilst FVA_INT has been declining, reflecting its integration into GVCs at a later date.[3]

Borin and Mancini (2015, 2017) refine the original decomposition of Koopman et al. (2014) and Wang et al. (2013). Koopman et al. consider only aggregate trade and not bilateral trade. Moreover, while Wang et al. consider bilateral trade, their approach is not internally consistent, since they mix up two different ways to account for value added in exports: the source-based approach, which calculates value added from the perspective of the country generating the value added; and the sink-based approach, which takes the perspective of the country of final demand. Borin and Mancini explore the case of Italy and show that Italy is strongly integrated into "Factory Europe". In some sectors (basic metals, chemicals, and coke and refined petroleum products), Italy is relatively downstream; in others (textiles, wearing apparel, leather products), it is upstream.

The strong regional component of GVCs has been investigated by Los et al. (2013). This relates to the so-called "Factory Europe", "Factory America" and "Factory Asia" (Santoni and Taglioni 2015). Los et al. find that whilst regionalism is still present in 2011, it has weakened relative to 1995. Others use network analysis to illustrate the regional aspect. Large countries are at the centre, with small countries at the edge engaged in either providing raw materials or assembling final goods. In 1995, they find the US and Germany to be core countries. They remain so in 2011 but are also joined by China (Amador and Cabral 2015, 2016).

Damjanovic and Banerjee (2017) focus on Slovenia and show that the economy has become ever more integrated into production chains. Increasingly, it is specialising in manufactured intermediate goods, which have high value added in exports (fabricated metals, wood production, and mineral products). It also has downstream integration involving assembly-line businesses (transport, motor vehicles, pharmaceuticals), which generate much lower domestic value added.

Kummritz (2014) and Kummritz and Quast (2016) focus on forward and backward linkages for a large group of countries and sectors. Kummritz (2014) examines the link between participation in GVCs and development (where development is measured by domestic value added) and finds a positive effect. Kummritz and Quast (2016) focus on sectoral differences in the degree of fragmentation of production. Sectors such as motor vehicles, other transport equipment, metals, and computers and electronics have high foreign value added. By contrast, agriculture, mining and quarrying, R&D, and business services are upstream in supply chains and far from final demand. They generate higher domestic value added.

Wang et al. (2017a) examine four aggregated sectors, namely agriculture, mining, manufacturing and services. They find that mining has a strong upstream position in global production networks, manufacturing is the industry that has been most deeply integrated into GVCs and services have the lowest GVC participation intensity, but their participation rate has grown faster than agriculture in recent years.

3 Wang et al. (2017a) have also provided a methodology to decompose production activities at the country, sector, or country-sector level into different types depending on whether they are for domestic demand without involving trade, "traditional" trade (without involving trade in intermediate goods), simple GVC activities, or complex GVC activities. GVCs are basically "trade in intermediate products". The distinction between simple and complex GVC activities is determined by the number of national border crossings, so they can be phrased as "value-added activities cross one or more than one national border". Applying their tools to the most up-to-date inter-country input-output database (WIOD 2016), they show that complex GVC was the most important driving force for globalisation and co-moves strongly with the growth of global GDP, both in booms and in recessions. Wang et al. also provide a pair of GVC participation indices based on whether the production factor content crosses national borders for production and taking into account both forward and backward industrial linkages. The first GVC participation index describes the domestic value added generated from a country-sector's GVC activities through downstream firms as a share of that country-sector's total value added. The second participation index measures the percentage of a country-sector's total production of final goods and services that represent the value added that is involved in GVC activities through upstream firms. The relative values of the two indices indicate a country-sector's position in the global production network. For instance, a higher degree of forward participation than backward participation implies that the country/sector is more actively engaged in upstream production activities in GVCs.

Breaking down manufacturing into sub-sectors, the authors find that "transportation equipment" (mainly represented by automotives) is a typical GVC industry. Due to the complexity of its production process, input demand and cost structure vary widely in different production stages and locations. Furthermore, as it is a dynamic process, the comparative advantage of each production location constantly changes, and along with it the intensity of GVC participation of each country.

For the utility and service industries, a large proportion of their value added is exported indirectly (e.g. "electricity, gas and water" and "retail trade"), in contrast to, for example, "leather and footwear," which is a typical "direct" exporting sector.

The construction sector is less integrated into GVCs, partly because it may be difficult to export directly due to the limitation of cross-border factor mobility. Its factor content, however, is often embodied in other sectors' exports involving international production sharing indirectly. Similar phenomena exist in many services sectors, such as transportation and public services.

Ignatenko et al. (2019) also document that the manufacturing and services sectors participate differently in GVCs. Services, including business and financial services and wholesale trade, have very high forward linkages, reflecting the fact that they are intermediate inputs in their export destinations, and limited backward linkages, reflecting the fact that the production of business and financial services uses limited foreign inputs. By contrast, the largest manufacturing sectors tend to have sizeable foreign inputs (backward linkages).

In short, the degree of participation in or integration into GVCs differs significantly across sectors. Manufacturing enterprises have higher average GVC participation intensity than mining and services. In manufacturing, higher R&D and knowledge intensities are associated with higher GVC participation. In services, GVC participation is also heterogeneous across industries, with communication, financial and business services as well as trade and transportation services having much higher GVC participation than other domestic services (education, health care, personal services).

2.1 AGGREGATE DATA AND EXISTING EMPIRICAL WORK FOR GREECE

Kalyvitis et al. (2018) estimate the domestic value added of Greek exports for the year 2010 using input-output tables and find significant differences in terms of domestic value added between sectors ranging from 38.3% in "coke and refined petroleum" to 88.1% in "fishing and aquaculture".

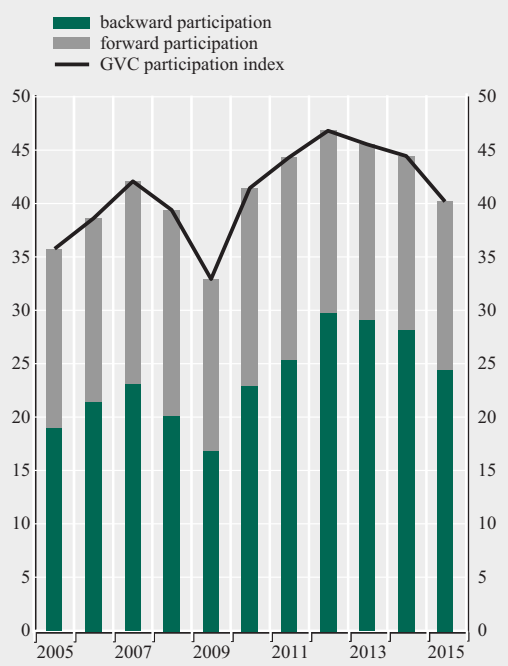
The OECD[4] provides a comprehensive analysis of trade in value added and GVCs. On the basis of the latest OECD data, Greece is found to have increased its levels of integration into GVCs up until 2007, before slowing down at the onset of the financial crisis. A quick recovery followed, with the GVC participation index rising from 33.0% in 2009 to 46.8% in 2012 and subsequently decelerating to reach 40.3% in 2015 (see Chart 2). The rise in the GVC participation index is attributed to higher backward participation, while forward participation has remained rather stable. This finding is in line with the results presented in the recent ECB Occasional Paper on GVCs (2019). The ECB finds that Greece has moved downstream since 2008. For Greece, they argue that this is largely a composition effect, arising from downstream sectors having gained export share from upstream ones. Looking specifically at the medium-to-high-tech and high-tech sectors, Greece stands out for having a relatively low participation but a more upstream position than for its economy as a whole.

Between 2009 and 2018, the openness of the Greek economy, as defined by the share of exports in GDP, increased significantly from 19% of GDP to 36%. This resulted from the

4 OECD, Trade in Value-Added (TiVA) database, December 2018.

Chart 2 Greece's participation in GVCs

(% of total exports)



Source: OECD TiVA database, December 2018.

rebalancing of the Greek economy towards tradable sectors of economic activity observed since 2008.[5] Between 2008 and 2014, there was a significant rise in the exporting performance of sectors in both manufacturing (such as "manufacture of basic pharmaceutical products", "manufacture of computer, electronic and optical products", "manufacture of textiles, wearing apparel and leather products") and services (such as "accommodation and food service activities" and "water transport"). It is therefore of interest to examine the decomposition of gross exports for the recent period. This is our aim in this paper. Additionally, we focus on the sectoral level, since aggregate numbers hide significant differences across sectors.

3 DATA AND METHODOLOGY

To calculate value added in trade and perform the decomposition of gross exports, access to world input-output tables and bilateral trade data is required. Two sources exist: the World Input-Output Database (WIOD; www.wiod.org/home) and the OECD Trade in Value-Added (TiVA) database. We use the former in this paper (see Appendix A). As noted by Timmer et al. (2015), the WIOD is based on official data using the International System of National Accounts. It is also freely available. By contrast, the OECD publishes only derived indicators and not the underlying data. WIOD data are available from 2000 until 2014. The database contains 43 countries (plus the rest of the world) and 56 sectors.

Calculations are done in R using the "decompr" package (Quast and Kummritz 2015), which generate the decomposition provided by Wang et al. (2013). Since our focus is on Greek exports by sector to all trading partners (that is, we do not focus here on bilateral-sectoral trade of Greece with each of its individual trading partners), the Wang et al. decomposition is sufficient for our analysis and there is no need to use the even more complex decomposition found in Borin and Mancini (2015, 2017).

In what follows, we focus on some of the more interesting sectoral developments based on criteria such as the importance of the sector in terms of exports as well as sectors exhibiting significant changes. There are many metrics that we could use from the literature. We begin with one of the simplest measures of integration – vertical specialisation (VS) technically defined as the sum of FVA_FIN, FVA_INT and PDC. VS shows us the extent to which different sectors depend on imported foreign value added in producing their exports. We then move on directly to look at the decomposition found in Wang et al. (2013, 2017, 2018). We do not look at back-

5 Bank of Greece (2014), *Annual Report 2013*, Box V.1 "The crisis favours a shift of productive activities to tradable goods and services". Bank of Greece (2015), *Monetary Policy – Interim Report*, Special Feature IV.2 "Sectoral productivity and export activity", December.

ward and forward linkages for the reasons noted above.

4 RESULTS

A general conclusion that emerges is that domestic value added is lowest in Greek manufacturing and more dispersed and highest in services. This is in line with the stylised fact that GVCs dominate manufacturing because of the ability to divide production in manufacturing up into various steps. There is some evidence that between 2000 and 2014, for the economy as a whole, total FVA has been rising whilst total DVA has been falling, pointing to greater integration into GVCs. The correlation coefficient between DVA and FVA is strongly negative (-0.97). With the rise in FVA, there has also been a rise in double counting (correlation coefficient 0.67) as would be expected.

Turning now to some specific sectors, Chart 3 shows "crop and animal production", which accounts for 6.2% of gross value added (GVA) in the Greek economy (average 2000-2014) and 3.8% of exports. Exports are mainly domestic value added (DVA = DVA_FIN+DVA_INT+DVA_INTrex was on average 86%). FVA is likely to take the form of inputs to crop production (fertilisers, seeds, etc.). Interestingly, however, DVA in exports is half in intermediate goods, which will act as inputs to intermediate/final goods in other countries, and half in final goods being exported. While the sector is clearly not that integrated, there is evidence of quite strong changes over the period 2000-2014. DVA has been falling as FVA is rising. Additionally, double counting (PDC) has been rising as has returning domestic value added (RDV). All these developments point to rising GVC integration.

Chart 4 presents the breakdown for "mining and quarrying". The high proportion of DVA (88% on average) reflects the fact that this sector deals with natural resources. It is an upstream activity in that the natural resources are extracted only to be exported as intermediate goods (note that DVA_INT+DVA_INTrex = 86%) to be finalised elsewhere. Over time, in spite of the fall in DVA and the rise in FVA and PDC, the changes are small, as would be expected for a sector that is a natural upstream activity.

These results are consistent with IOBE (2016). A characteristic of the domestic mining industry is its openness; the share of exports of mining products in total Greek exports of goods had been rising over the period 2008-2014 and picked up to 12% in 2014. The internationalisation of the mining industry is also evidenced by the fact that some domestic enterprises are subsidiaries of multinational corporations,[6] while others have joint ventures, mining activities and export trade networks in many foreign destinations.

A sector that is closely related to mining and quarrying is the "manufacture of basic metals" (see Chart 5). Domestic value added (DVA = DVA_FIN + DVA_INT + DVA_INTrex) accounts for 70.4% of total gross exports. This industry stems, in part, from natural reserves of basic metals which Greece has. VS averaged 29.1% over the period, suggesting downstream activities. In addition, domestic value added is overwhelmingly in intermediate goods which are then exported as inputs to production in other countries (see DVA_INT and DVA_INTrex). Toing and froing is also evident, with double counting coming in on average at almost 15%. Double counting has also been increasing since around 2005 (the large drop in 2009 is connected with the global slowdown in trade associated with the financial crisis). Thus, another important export sector appears to have been showing signs of increased integration into global production.

6 In 2012, Kerneos acquired a 54% stake in the Greek mining company, Elmin, the leading European exporter of monohydrate bauxite. In 2014, Imerys acquired S&B. Imerys Greece is the world's largest producer of pre-treated perlite and the world's largest exporter of bentonite, exploiting the excellent quality mineral resources and the processing plants in Milos. Almost all the company's products are exported.

Chart 3 Crop and animal production, hunting and related service activities

Source: Authors' own calculations using WIOD data (see Appendix A).

Chart 4 Mining and quarrying

Source: Authors' own calculations using WIOD data (see Appendix A).

Chart 5 Manufacture of basic metals

Source: Authors' own calculations using WIOD data (see Appendix A).

Looking in more detail at the products exported in this sector, aluminum and nickel take up about 20% of gross exports. Alumina comes next with about 10%, while magnesium products (refractories, dead-burned magnesia and caustic calcined magnesia) also have a significant share in exports. IOBE (2019) notes that Greece is among the largest exporting countries of aluminum as a raw material, 4th in Europe and 12th globally. Moreover, the manufacture of aluminum, which mainly involves the manufacture of raw materials and semi-final products, is among the fastest growing sectors of Greek manufacturing, having increased by 21% between 2010 and 2017.

The "manufacture of food products, beverages and tobacco products" averaged 7.1% of Greek exports between 2000 and 2014 (see Chart 6). This sector illustrates some interesting changes over time. It is a high domestic value added sector, as might be expected (Greece processes and exports its own produce). However, until the crisis the allocation between the export of intermediate goods and final goods was fairly stable (at just below 60% for final goods, just under 20% for intermediate goods and some 8% in the form of DVA_INTrex). Thereafter, there is a sharp decline in domestic value added in intermediate exports and a rise in value added in final exports. In particular, between 2000 and 2014, DVA_INT falls by 11 percentage points and DVA_FIN rises by 16 percentage points, and, as is clear from the chart, these movements occurred from the late 2000s onwards. The implication is that Greece now takes its agricultural produce right through all processing stages to ultimately export branded final goods often covered by the European scheme of protected designation of origin.

These developments are consistent with sectoral studies of the manufacturing of food products. The National Bank of Greece (2015a) notes that while the food supply chain still has a relatively small manufacturing component (adding just 40% to the agricultural production versus 70% in Western Europe), around 25% of Greek food exports have exploited Greece's comparative advantages and gained significant shares in the international market (e.g. olives, yogurt and honey). The common strategy of producers is to target high-income countries (such as the euro area, the UK, the US, Japan) with branded products in packaged forms.

The authors of the National Bank of Greece (2015b) provide the indicative example of Greek olive oil. Olive oil is mainly exported in bulk form to Italy, where —after being blended with olive oil of different origins— it is marketed as Italian branded olive oil, leaving most of the value added to Italian companies. As a result, only 27% of Greek olive oil production reaches the stage of labelling/branding, compared with 50% in Spain and 80% in Italy. Nevertheless, a gradual change in strategy has been observed, resulting in an increase in exports of branded olive oil in the period 2010-2014. This has brought about higher domestic value in final exports of olive oil, one of the top exporting Greek products, which is what our results show.

Kalyvitis et al. (2018) also note that since 2003 olive oil has been exported to more countries. While Italy remains the top exporting destination, it now has a lower share in total Greek exports. They interpret this diversification as signalling a gradual change in strategy of Greek exporters from exports of olive oil in intermediate form to Italy to exporting olive oil to final high-income destination countries, such as Germany and the US.

The "apparel and textile" industry is one of the most important manufacturing industries in Greece, accounting for 11% of total exports in manufacturing over the period 2000-2014. This industry has undergone significant changes over the past decade caused by systemic changes on the international stage, through globalisation, the liberalisation of textile trade and the resulting increase in competition. The liberalisation of textile trade, i.e. the abolition

Chart 6 Manufacture of food products, beverages and tobacco products

Source: Authors' own calculations using WIOD data (see Appendix A).

of import restrictions in Europe in 2005, led to a rapid restructuring process in all southern European countries. Restructuring was exacerbated by the financial crisis of 2008-09 and was visible in the reduction in the number of companies, a downsizing of surviving firms and their consolidation through a change in their business model. The Greek apparel sector has focused on products with higher value added offering design services in addition to quality manufacturing and has delocalised production activities to neighbouring Southeast European countries. In particular, Northern Greece has the advantage of geographical proximity to possible delocalisation areas in South Bulgaria, the Republic of North Macedonia and Albania. Vertical integration has been a successful strategy in the textile industry, as vertically integrated textile companies have been more resistant in the financial crisis than single-stage firms (EC 2012).

Chart 7 looks at the "manufacture of textiles, wearing apparel and leather products". The results again suggest rising GVC integration – Greece appears to be making more cloth from its cotton/wool which it exports directly as an input to textile firms downstream, which then turn it into clothes and other products. This is reflected in a rising DVA_INT and a falling DVA_FIN, along with a rise in PDC and a rise in FVA_INT. Double counting now stands at 6% of gross exports. This rise in double counting suggests increased toing and froing of products. To put that number into perspective, PDC is around 5-7% in the US automobile industry, which involves a lot of cross-border transactions that double count value added (Wang et al. 2013).

Charts 8 and 9 look at the manufacturing of products which are often inputs to other activities – wood and cork products, and paper and paper products. In the early 2000s, domestic value added was rising while that of foreign origin was falling. Similarly, double counting fell and then rose again. In the case of wood and its products, the turning point occurred at the crisis and by 2014 double counting was above 7%, up from its trough of just over 3%. VS, which indicates some downstream activity, reached 25% in 2014. Finally, most domestic value added is in intermediate goods, indicating some upstream activity as well. The story for paper and paper products is similar; this time, the turning points occur earlier (around 2005), but double counting is higher on average (6.4%) and there is more downstream activity (VS is 24% on average and, in the post-crisis period, fluctuates between 25% and 30%).

The petroleum refining industry is a vital link in the supply chain of petroleum products. It imports and processes crude oil, producing intermediate and finished petroleum products. The products are then directed for final consumption (domestic demand and exports), mainly through the network and infrastructure of oil trading (marketing) companies.[7] With continuous investment in modernisation and upgrading, the Greek refineries have achieved a high Nelson complexity factor.[8] For comparison, the average capacity of European refineries is about 144,000 barrels per day, while the average Nelson complexity factor is 7.63 (IHS 2013). In Greece, the average capacity is slightly smaller, 131,000 barrels per day, but the average complexity factor is well above the European average (9.57). It is worth noting that the most complex refineries have the capability of producing petroleum products with high market value and can process most types of crude oil and thus exploit variations in price and availability. Moreover, they can adapt more easily to changing market and geopolitical conditions and local fuel specifications. These factors contribute to better profitability, but the greater complexity requires significant investments and implies an increased need for inputs and energy use.

7 Two groups of companies (Hellenic Petroleum SA and Motor Oil Hellas SA) operate four refineries with a total refining capacity of 526,000 barrels per day, or 26.3 million tons per year.

8 The Nelson Complexity Index (NCI) is a measure of the sophistication of an oil refinery, where more complex refineries are able to produce lighter, more heavily refined and valuable products from a barrel of oil.

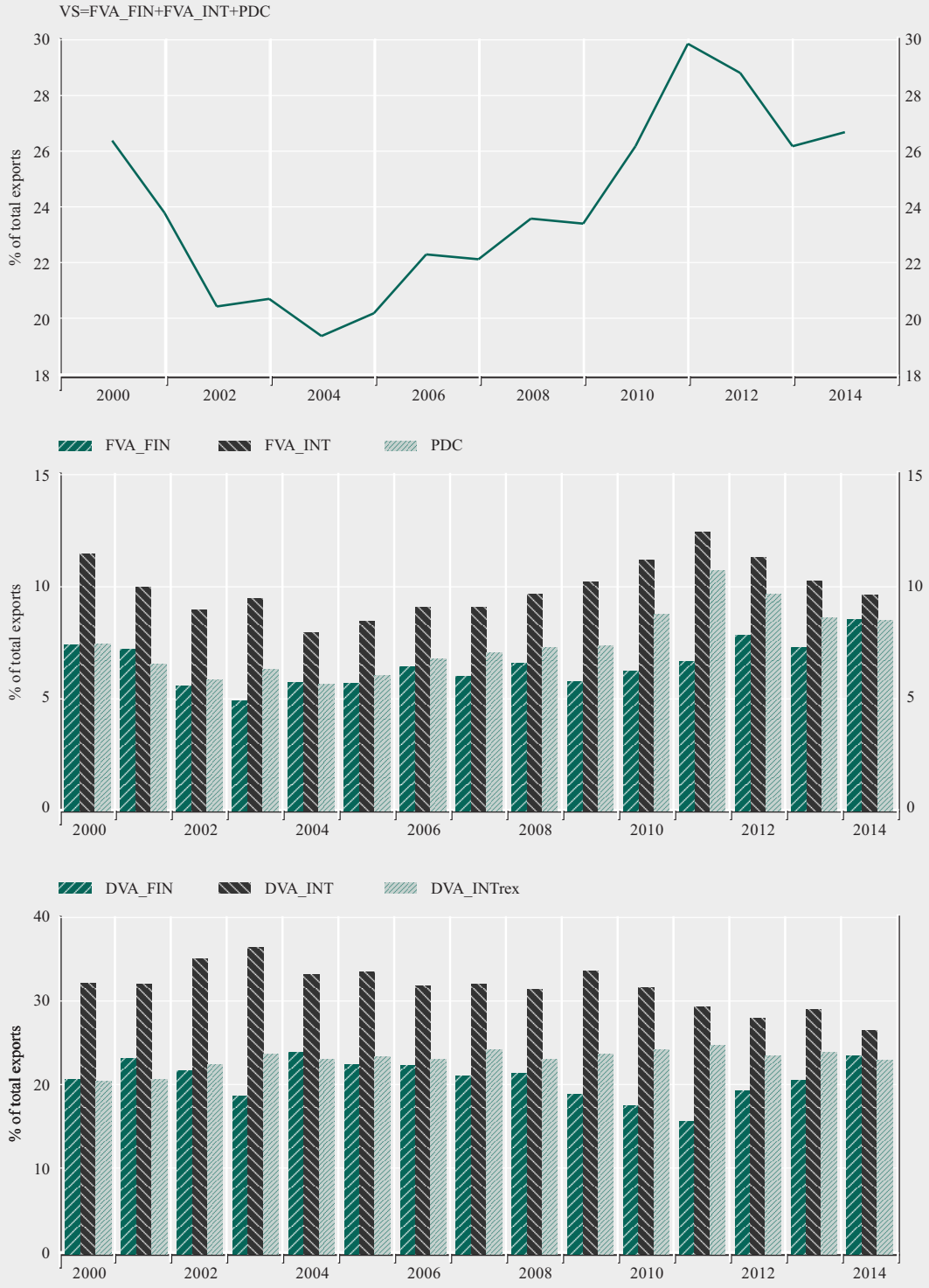
Chart 7 Manufacture of textiles, wearing apparel and leather products

Source: Authors' own calculations using WIOD data (see Appendix A).

Chart 8 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials

Source: Authors' own calculations using WIOD data (see Appendix A).

Chart 9 Manufacture of paper and paper products



Source: Authors' own calculations using WIOD data (see Appendix A).

The crisis of the Greek economy, together with the recession in Europe, has had catalytic effects on the refining sector in Greece, significantly changing the environment in which the Greek refineries operate. The turn to exports provided an outlet for the Greek refineries, which following the contraction in the domestic market faced the risks of low capacity utilisation and of falling below the minimum efficient scale of production threshold that would have worsened further their financial results. Thus, after a period of significant investments to modernise and upgrade their capacity and under the pressure from low domestic demand and its weak outlook, the Greek refineries have sought new markets and have expanded in existing markets abroad, mainly in countries outside the EU.

The activity of the Greek refineries contributed to the reduction of the trade deficit. With the exports of petroleum products reaching EUR 10.3 billion in 2012, most of which (86%) goes to non-EU countries, the Greek refineries contributed 37.5% to the total exports of the country, up from 8.4% a decade earlier. Meanwhile, imports remained relatively stable. As a result, according to Bank of Greece data, the import coverage ratio of crude oil and petroleum products with exports increased from 25% in 2005 to 42% in 2012.

Chart 10 depicts the results of our analysis for this sector ("manufacture of coke and refined petroleum products"). It has the lowest domestic value added of any sector in Greece and the highest foreign value added (averaging 41% and 45%, respectively, over the period). Double counting also averaged 14% and VS 59%. This indicates a very high degree of downstream activity, associated with the importing of crude oil and its refining into various products which are then re-exported. However, the fact that the majority of these exports are intermediate goods and not final consumption goods, because refined oil and other products are usually used as inputs into other activities, suggests that along with increased downstream activity, there has also been increased upstream activity.

A similar picture is found in the "manufacture of chemicals and chemical products" (see Chart 11), albeit to a lesser extent. Both upstream and downstream linkages are present. VS averages 23.1%, indicating downstream activity. Value added in intermediate goods —whether domestic or foreign— is higher than that in final goods, indicating integration into GVCs. Double counting is also high at 7.6% and has been increasing. IOBE (2018) notes that the sector's production is focused on special chemicals and consumer chemicals and is highly dependent on imported chemical raw materials. The most important exports are polymers and consumer chemicals, representing 32% and 25% of total exports of chemicals, respectively. About a quarter of exports of chemicals are special chemicals, followed by basic inorganic compounds (mainly fertilisers) and petrochemicals, which are intermediate inputs into other sectors.

The "manufacture of basic pharmaceuticals and pharmaceutical preparations" (see Chart 12) has likewise been growing in importance as an export industry over the past years. The exporting performance of the sector, as defined by the share of exports in gross output, rose from 31% in 1995-2007 to 68% in 2008-2014. The sector is characterised by high domestic value added (84.9%), which is overwhelmingly domestic value added in final products (79%). In other words, products are made almost from start to finish.

Greek pharmaceutical companies have the expertise and produce branded pharmaceuticals, mainly generics. Over the last decade, pharmaceutical companies in Greece have invested in high-tech equipment and quality control systems; as a result, they have increased their competitiveness, both in domestic and

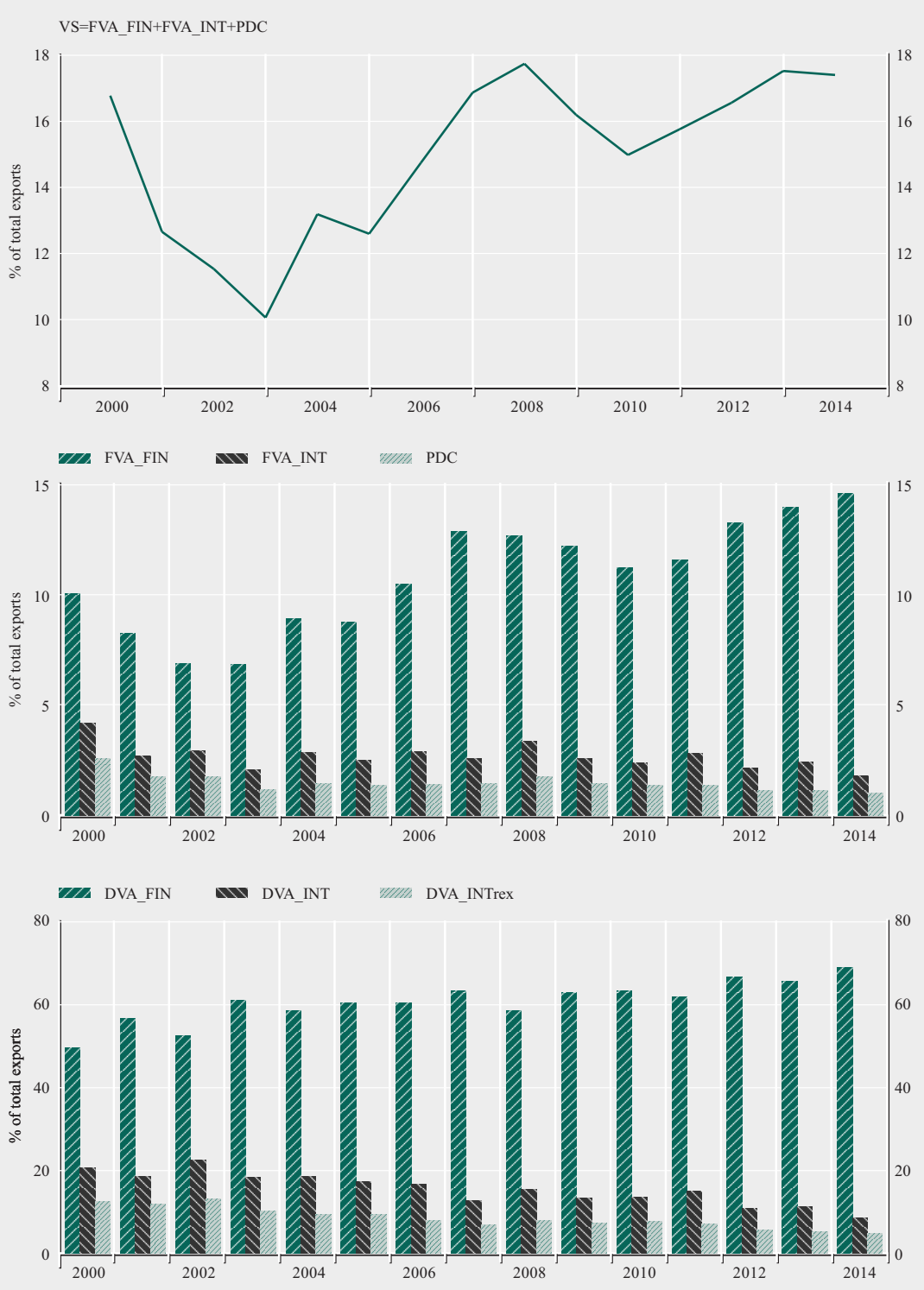
Chart 10 Manufacture of coke and refined petroleum products

Source: Authors' own calculations using WIOD data (see Appendix A).

Chart 11 Manufacture of chemicals and chemical products

Source: Authors' own calculations using WIOD data (see Appendix A).

Chart 12 Manufacture of basic pharmaceutical products and pharmaceutical preparations



Source: Authors' own calculations using WIOD data (see Appendix A).

international markets.[9] Multinational pharmaceutical companies have also been investing in research programmes in Greece. According to a report of the Panhellenic Exporters Association (March 2015), six modern units of production were created over the period 2011-2014, while participation in 85 research programmes was recorded. At the same time, investment in R&D led to the registration of 90 patents. As a result, the pharmaceutical industry has been considered a driver of the restructuring of the Greek economy towards tradable and competitive sectors.[10]

Turning now to utilities: unsurprisingly, utilities industries are dominated by domestic value added (Chart 13 provides the example of "electricity, gas, steam and air conditioning supply"). In the case of "water" and "sewage, waste, etc.", domestic value added is over 90% of gross exports. Exports are almost in their entirety intermediate goods. With respect to "electricity, etc.", foreign value added is slightly higher than for the other two, probably reflecting the import of primary materials to make electricity. Moreover, as would be expected, domestic value added in intermediate utilities (DVA_INT) and value added of intermediate utilities for re-export (DVA_INTrex) are high, reflecting the upstreamness of this industry.

The largest exporting sector in the Greek economy is "water transport" (see Chart 14). A share of 78% of gross exports (including both intermediate and final goods) represents domestic value added. VS is 21.8% of gross exports, indicating that foreign value added in the sector is important and double counting accounts for 5.5%. These results suggest some degree of GVC integration.

The sector of "accommodation and food services" (see Chart 15), clearly associated with the tourism industry, also has high domestic value added, 87.8% of gross exports. Integration appears low, with VS at 12% and double counting at 2.2%. Interestingly, the bulk of domestic value added in gross exports represents intermediate services rather than final services (DVA_INT + DVA_INTrex = 56.3%). The high share of exports in intermediate services is attributed to the presence of GVCs in tourism. Tourism is a highly fragmented industry, with many small firms located at tourist destinations that are geographically dispersed (Tejada and Liñán 2009; Nowak et al. 2010; Daly and Gereffi 2017). Therefore, mediation has had a crucial role in tourism. Travel agents, tour operators and the introduction of Information and Communications Technology have been the "intermediary" responsible for joining, building and advertising the tourism product and making it available to consumers. According to Bank of Greece data, the share of travel receipts attributed to "package tours"[11] has been on average 34% in the period 2010-2018. Independent travellers also extensively use electronic platforms to book their holidays.

Finally, we can look at "wholesale and retail trade" (see Chart 16). DVA_INT and DVA_INTrex are high, at around 81%, reflecting upstreamness. Domestic value added in these trade services is exported as inputs into other activities. This perhaps reflects the fact that Greece is a Balkan hub exporting utility services to countries in the region.

Policy implications

Our results show that several sectors in Greece have seen a dynamic integration into GVCs since the global financial crisis of 2008-09, exploiting cyclical and conjunctural

9 See the speech by the Governor of the Bank of Greece, Yannis Stournaras, at the Hellenic Association of Pharmaceutical Companies (SFEE): "Macroeconomic developments and the contribution of investment, research and innovation in the pharmaceutical sector to the new growth model" (15.3.2017, in Greek).

10 According to estimates by Kalyvitis et al. (2018), the share of total domestic value added in exports of Greek pharmaceutical products came to 86.6% for the year 2010. The value of "parallel exports" from Greece has also been declining since 2007, according to National Organisation for Medicines (EOF) data, and this provides additional evidence in favour of the high domestic value added in Greek exports of pharmaceuticals.

11 The category of "package tours" comprises any combination of travel services for tickets, accommodation and other services, provided by travel agencies. Cruise packages are also included.

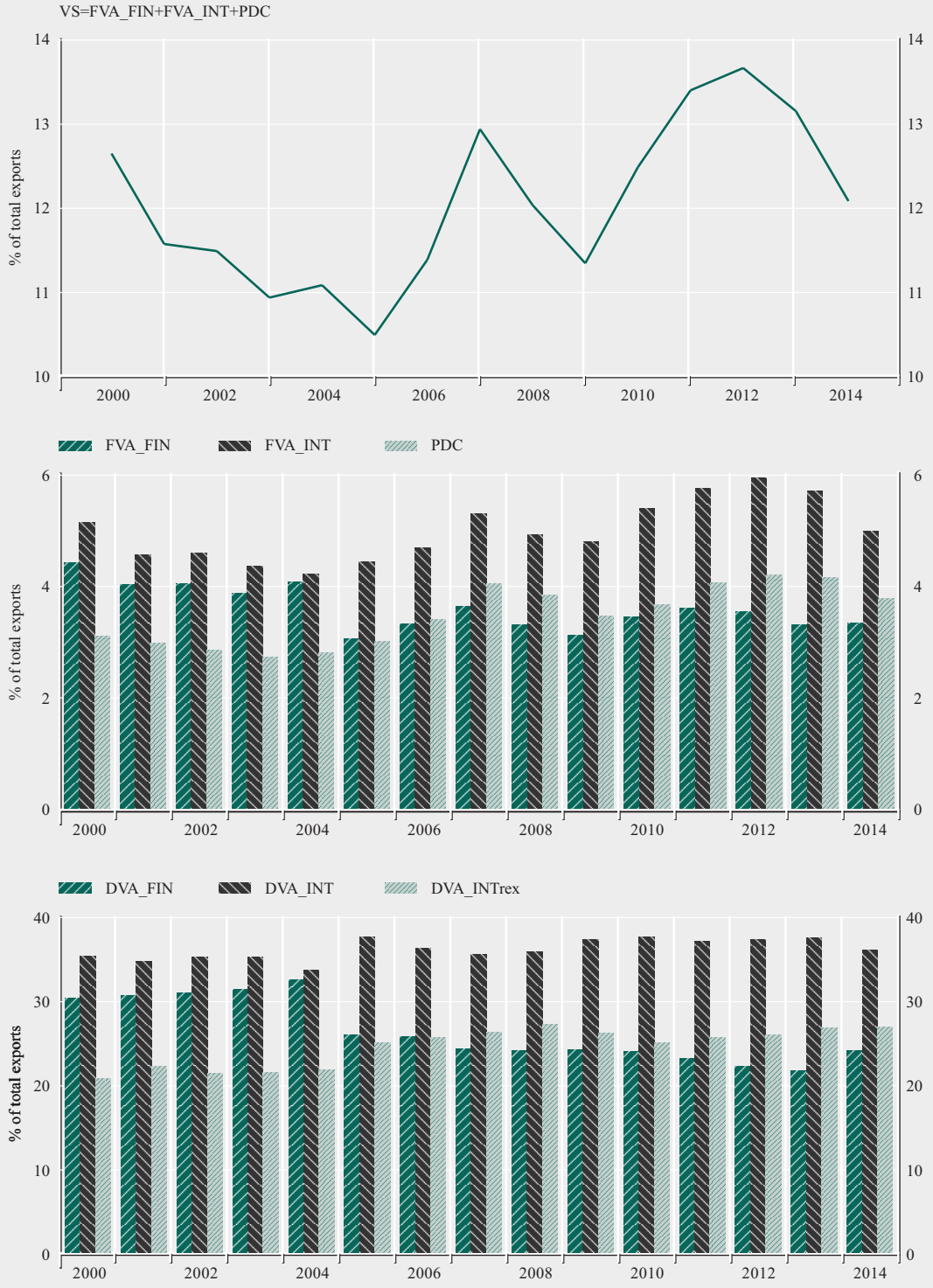
Chart 13 Electricity, gas, steam and air conditioning supply

Source: Authors' own calculations using WIOD data (see Appendix A).

Chart 14 Water transport

Source: Authors' own calculations using WIOD data (see Appendix A).

Chart 15 Accommodation and food service activities



Source: Authors' own calculations using WIOD data (see Appendix A).

Chart 16 Wholesale and retail trade and repair of motor vehicles and motorcycles

Source: Authors' own calculations using WIOD data (see Appendix A).

developments as well as some structural changes. Yet, both theory and experience suggest that there are a number of policies and institutional factors that, if developed, could further promote the participation of a country in GVCs. Such policies would enhance and propagate the net gains in terms of economic growth, exports, competitiveness, productivity and employment.

The quality of institutions, including the business environment, the rule of law and contract enforcement, and the quality of infrastructure and connectivity are important determinants of GVC participation. Trade and investment policy reforms as well as improvements in logistics networks and customs' administration also play a key role. This is particularly important for the Greek economy as a whole and for a number of its more extrovert sectors operating both upstream and downstream.

Domestic policies targeting knowledge creation and diffusion as well as capital investment, such as strengthening protection of intellectual property rights and investor rights, could enhance a country's GVC integration and its repositioning towards the upstream.

Adopting policies that facilitate innovation and reduce protectionist barriers may also help to improve the economy's competitiveness and narrow current account imbalances by fostering its GVC participation (ECB 2017). Similarly, multilateral initiatives aimed at trade and financial liberalisation may foster greater GVC participation and help reduce an economy's external imbalances.

Upstream sectors and services are more sensitive to trade barriers. Thus, given the gradual rise of services in GVC trade, it is also important to better understand barriers to services trade and the type of reforms and trade agreements that could potentially facilitate it (Ignatenko et al. 2019). Emerging evidence also reveals how the liberalisation of service markets, particularly the entry of new foreign service providers, can lead to substantial productivity gains in downstream manufacturing firms (Arnold et al. 2011, 2016).

Meanwhile, Greek governments need to develop a comprehensive and long-term digital strategy. Economies increasingly require a digital foundation, one that generates high-speed growth and navigates through disruptive change. The employment and investment of tomorrow will be data-intensive, and value in a knowledge economy is increasingly created by innovative ideas and data. Embracing digital technologies is not only good for the economy but for society as well. The digitally-powered, knowledge-intensive GVCs that are emerging and are likely to dominate in the coming years have a strong potential for inclusion.

Finally, the participation in GVCs might entail a trade-off between economic efficiency and income (or job opportunity) distribution, calling for proper domestic labour market adjustment policies and wider social safety nets.

5 CONCLUSIONS

This paper investigated Greece's involvement in GVCs using the decomposition suggested by Wang et al. (2013, 2018) and applied to WIOD data. In general, we find that domestic value added is high in service sectors and much lower in manufacturing, in line with the results from the literature.

However, we find evidence of both upstream and downstream activity in different sectors. In particular, upstreamness is found in crop and animal production, mining and quarrying, the manufacture of basic metals, and wholesale and retail trade. Downstreamness is common in accommodation and food services. Two sectors —manufacture of food products and manufacture of pharmaceuticals— have seen a rise in the importance of domestic value added in exports. That is, the products are increasingly being made from start to finish, providing high levels of domestic value added in exports. Finally, there are sectors which display the characteris-

tics of both upstreamness and downstreamness. These include the manufacture of textiles, wood and wood products, paper and paper products and, most importantly, petroleum and chemicals, which exhibit the greatest degree of GVC integration of any sector in Greece.

The consolidation of these trends towards greater integration —either in manufacturing or in services and distribution— is likely to be of benefit for the Greek economy, allowing it to improve the quality of its exports as well as lowering their price.

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APPENDIX A

GROSS EXPORTS DECOMPOSITION

Source: Own calculations using the World Input-Output Database (WIOD) 2016 Release.

The 2016 release of the WIOD covers 43 countries (and the rest of the world) for the period 2000-14. Data are produced for 56 sectors (roughly at the two-digit level with some service sectors being combined). A user guide to the database is provided by:

> Timmer, M.P., E. Dietzenbacher, B. Los, R. Stehrer and G.J. de Vries (2015), "An illustrated user guide to the World Input-Output Database: the case of global automotive production", *Review of International Economics*, 23, 575-605.

The results are derived from R, after modifying programmes originally written by:

> Quast, B. and V. Kummritz (2015), "DECOMPR: global value chain decomposition in R", *CTEI Working Papers*, 2015-01.

Sectors by NACE Rev. 2

NACE code	
01	Crop and animal production, hunting and related service activities
05-09	Mining and quarrying
24	Manufacture of basic metals
10-12	Manufacture of food products, beverages and tobacco products
13-15	Manufacture of textiles, wearing apparel and leather products
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17	Manufacture of paper and paper products
19	Manufacture of coke and refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
35	Electricity, gas, steam and air conditioning supply
50	Water transport
55-56	Accommodation and food service activities
45	Wholesale and retail trade and repair of motor vehicles and motorcycles

APPENDIX B

SOME DEFINITIONS

Value added is the value added by industries in producing goods and services for exports (OECD).

Global value chain (GVC) is the fragmentation and dispersion of the different stages of production and distribution of goods and services across countries.

GVC integration or GVC participation is defined as the use of foreign intermediates and integration into international production networks (OECD).

Vertical specialisation (VS) is defined as the sum of foreign value added in final goods, foreign value added in intermediate goods and pure double counting (FVA_FIN+FVA_INT+PDC). Vertical specialisation shows the extent to which different sectors depend on imported foreign value added in producing their exports.

Upstreamness reflects the starting stages of global production. Industries that are located at the most upstream end provide natural resource-based intermediate inputs and more manufactured intermediate inputs. Upstream industries are more integrated into GVCs. Indication of the industries' position at the head of GVCs is high and increasing FVA_INT, DVA_INT, PDC and RDV.

Downstreamness reflects the ending stages of global production. Industries that are located at the most downstream end specialise in assembling and processing activities, as they are placed at the final stage of the production chain. Downstream industries are less integrated into GVCs. Indication of the industries' position at the tail of GVCs is high and increasing FVA_FIN and DVA_FIN, and low and decreasing PDC and RDV.

Foreign value added (FVA) is the sum of foreign value added in final goods and foreign value added in intermediate goods (FVA_FIN+FVA_INT).

Domestic value added (DVA) is the sum of domestic value added in final goods, domestic value added in intermediate goods and domestic value added re-exported to third countries (DVA_FIN+DVA_INT+DVA_INTrex).

Gross exports are the sum of domestic value added, foreign value added, domestic value added returned home and pure double counting (DVA+FVA+RDV+PDC).

GREEK EXPORT PERFORMANCE: A CONSTANT MARKET SHARE ANALYSIS

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ABSTRACT

Following the gains of Greek non-fuel goods export market shares in the period 2005-2008, a continuous decline was recorded in the period 2009-2015, with their recovery starting in 2016. In this paper, we decompose the changes in the Greek export market shares during the pre- and post-crisis periods by employing the constant market share analysis framework. Our results indicate that the pre-crisis market share gains can be attributed to the strong positive effect stemming from the geographical distribution of exports, fuelled by the strong trade growth in Greece's main export markets (i.e. the euro area and Southeast Europe). The effect of the product composition of exports was almost neutral, while the competitiveness effect eroded more than half of the gains in the structure effect. In 2009-2018, the Greek export market share posted a decline that was mainly driven by the adverse competitiveness effect. The analysis of the last period (2016-2018) indicates a number of important findings. The adverse competitiveness effect is diminishing; the structure effect turns from negative in 2009-2012 to positive in 2016-2018, driven mainly by the geographical distribution effect and secondarily by the product composition effect. However, despite the recent recovery, the market shares have not yet reached their 2008 levels.

Keywords: constant market share, Greek exports, export performance, competitiveness effect, structure effect

JEL classification: F14, L60, O52, C60

ΕΞΑΓΩΓΙΚΗ ΕΠΙΔΟΣΗ ΤΗΣ ΕΛΛΑΔΟΣ: ΜΙΑ ΑΝΑΛΥΣΗ ΣΤΑΘΕΡΩΝ ΜΕΡΙΔΙΩΝ ΑΓΟΡΑΣ ΤΩΝ ΕΞΑΓΩΓΩΝ ΑΓΑΘΩΝ

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ΠΕΡΙΛΗΨΗ

Μετά την άνοδο των μεριδίων αγοράς των ελληνικών εξαγωγών αγαθών (χωρίς καύσιμα) κατά την περίοδο 2005-2008, παρατηρήθηκε συνεχής υποχώρησή τους την περίοδο 2009-2015, ενώ η ανάκαμψή τους ξεκίνησε το 2016. Στην παρούσα εργασία αναλύουμε τις μεταβολές στα μερίδια αγοράς των ελληνικών εξαγωγών κατά τις περιόδους πριν και μετά την κρίση, χρησιμοποιώντας τη μεθοδολογία της "ανάλυσης σταθερών μεριδίων αγοράς". Η ανάλυσή μας δείχνει ότι η άνοδος των μεριδίων αγοράς πριν από την κρίση μπορεί να αποδοθεί στο έντονο θετικό αποτέλεσμα που προκύπτει από τη γεωγραφική κατανομή των εξαγωγών, το οποίο τροφοδοτείται από τη μεγάλη αύξηση των εμπορικών συναλλαγών στις κύριες εξαγωγικές αγορές της Ελλάδος (δηλ. τη ζώνη του ευρώ και τη Νοτιοανατολική Ευρώπη). Το αποτέλεσμα της σύνθεσης των εξαγωγών κατά προϊόν ήταν σχεδόν ουδέτερο, ενώ το αποτέλεσμα ανταγωνιστικότητας αντιστάθμισε περισσότερο από το ήμισυ του θετικού αποτελέσματος σύνθεσης των εξαγωγών. Κατά την περίοδο 2009-2018, το μερίδιο αγοράς των ελληνικών εξαγωγών σημείωσε πτώση, που οφειλόταν κυρίως στο αρνητικό αποτέλεσμα ανταγωνιστικότητας. Από την ανάλυση της τελευταίας περιόδου (2016-2018) προκύπτουν ορισμένα σημαντικά συμπεράσματα. Το αρνητικό αποτέλεσμα ανταγωνιστικότητας μειώνεται, ενώ το αποτέλεσμα σύνθεσης μετατρέπεται από αρνητικό το 2009-2012 σε θετικό το 2016-2018, κυρίως λόγω της γεωγραφικής κατανομής και δευτερευόντως λόγω της κατά προϊόν σύνθεσης. Ωστόσο, παρά την πρόσφατη ανάκαμψη, τα μερίδια αγοράς δεν έχουν ακόμη φθάσει στα επίπεδα του 2008.

GREEK EXPORT PERFORMANCE: A CONSTANT MARKET SHARE ANALYSIS[1]

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1 INTRODUCTION

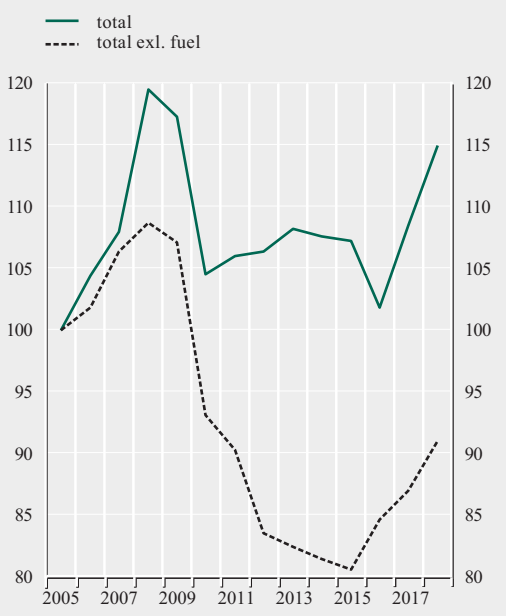
The positive developments in the external sector of the Greek economy, which materialised despite the significant contraction of economic activity that followed the outbreak of the crisis, are largely the result of the exceptional performance of Greek exports of goods, which have increased by more than 50% at constant prices since 2009 (from 7.5% of GDP in 2009 to 17.5% of GDP in 2018). This process reflects the dynamic shift of Greek firms towards foreign markets, as a result of the collapse of domestic demand, and was primarily based on both the recovery of global demand and the improvement of cost and price competitiveness through the gradual recouping of the losses of the previous decade (2000-2010). This paper evaluates the export performance of the Greek economy in comparison with the performance of the rest of the world, by analysing the evolution of Greece's export market shares. Changes in a country's market shares depend on its competitiveness as well as on the sectoral and geographical structure of its exports. In order to assess the impact of these factors on Greek exports, the commonly used "Constant Market Share Analysis" (CMSA) is conducted for the period 2005-2018, with particular emphasis on the period after the global economic crisis of 2008, which mostly coincides with the years of the Greek economic crisis. The analysis focuses on exports of goods, chiefly due to data availability issues. Besides, the adjustment of the external sector relied mainly on the favourable developments in goods exports. The analysis also excludes fuel exports, in order to avoid a distortion of the results for the rest of the exporting sectors as a consequence of the extensive adjustment of the market share of fuel exports, which represent almost one-third of total exports of goods. An additional reason for this exclusion is the fact that exports of fuels are strongly influenced by the volatility of international oil prices.

Underlying the CMSA approach is the idea that the product and destination structure of exports can affect the position of a country in foreign markets. If the country specialises in products and markets where demand is growing faster in comparison with other markets, then its exports will outgrow world exports and thus its aggregate market share will increase, even if individual product and destination market shares remain constant. This is defined as the "structure effect". The difference between the actual change in market shares and the structure effect is the "competitiveness effect", which is a "pure" market effect and incorporates the impact of all factors, besides structure, that determine the market share of the exporting country. This methodology enables us to evaluate the contribution of key products and destinations to the evolution of export performance, as well as the impact of other factors that affect market shares, such as price and non-price competitiveness. The CMSA was initially used by Tyszynski (1951). Since then, several refinements have taken place, aimed at addressing its limitations. The CMSA method used in this analysis follows the

1 The authors would like to thank C. Papazoglou and T. Kosma for their useful comments and invaluable insights into the issues discussed in this article. The views expressed are those of the authors and do not necessarily reflect those of the Bank of Greece. The authors are responsible for any errors or omissions.

Chart 1 Greek export market shares (2005-2018)

(Greek exports as % of world exports, current prices, 2005=100)



Source: United Nations, COMTRADE database; authors' own calculations.

refined formulation suggested by Nyssens and Poullet (1990), according to which the change in the market share is approximated by the difference between a country's export growth and the export growth of the "world". This methodology has been employed in the analysis of the market share evolution in a number of countries/areas such as the euro area, Portugal, Spain, Ireland, and Canada (see Task Force of the MPC of the ESCB 2005; Amador and Cabral 2008; Jiménez and Martin 2010; Pina 2011; de Munnik, Jacob and Sze 2012; Pandiella 2015).

The contribution of this study is twofold. First, it applies a refined CMSA methodology for the period before and after the sovereign debt crisis; second, it investigates the key drivers of the Greek export market shares in major geographical destinations and major exporting sectors, attempting to point out any idiosyncrasies of these markets. Specifically, the CMSA methodology is applied separately to (a) four destination markets, i.e. the euro area, South-east Europe (SEE), advanced economies outside the euro area, and the rest of the world; and (b) four product sectors, namely food, beverages and tobacco (including all processed and unprocessed products); chemicals and plastics (including pharmaceuticals); machinery and transportation equipment; and other manufactured products (which includes all manufactured products not classified in the other three sectors).

The paper is organised as follows: the next section provides an overview of recent developments in the Greek and world export markets, while Section 3 contains a literature review and a presentation of the methodology used. The description of the data follows in Section 4. The analysis of the CMSA results is presented in Section 5. Finally, Section 6 summarises the conclusions and policy implications of the study.

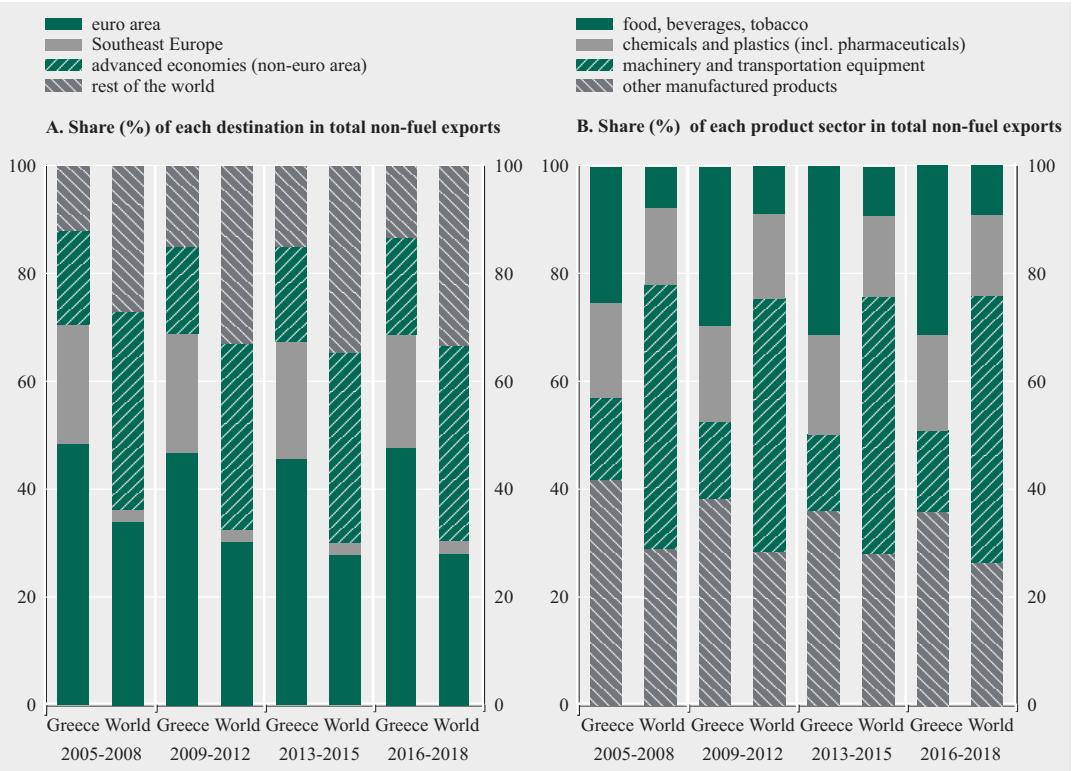
2 DEVELOPMENTS IN THE GREEK EXPORT MARKET SHARES AND THE STRUCTURE OF GREEK AND WORLD EXPORTS BY PRODUCT AND GEOGRAPHICAL DESTINATION

The market share of Greek exports showed a considerable improvement until 2008 (see Chart 1), despite the continued losses of cost/price competitiveness since 2000.[2] After an initial decline due to the outbreak of the 2008 crisis, it followed an upward trend, which, with the exception of 2015-2016, continued through 2018. However, this picture is significantly affected by the increase in the market share of fuel exports, which kept rising during the period under consideration and had more than tripled by the end of 2018. This can be attributed only partially to price increases, given that at the same time fuel exports, at constant prices, increased at an average annual rate of 16% and their share in total Greek

2 According to the Harmonised Competitiveness Indicators published by the ECB (Statistical Data Warehouse), Greece's competitiveness in terms of cost and prices declined by 29% and 19%, respectively, between 2000 and 2009. However, a significant recovery took place in 2010-2015, with cost and price competitiveness improving by 24% and 13%, respectively.

Chart 2 Breakdown of Greek exports by geographical destination and product sector (excluding fuel)

(current prices)



Source: United Nations, COMTRADE database; authors' own calculations.

exports rose from 11% in 2005 to 35% in 2018. This exceptional export performance of the fuel sector is to a great extent the result of the significant growth of investment in the sector.[3] The market share of non-fuel goods increased during the period 2005-2008 at a slower pace than the aggregate, and declined throughout the period 2009-2015, before recovering from 2016 onwards. After 2009, the growth of Greek non-fuel exports was weaker than that of world exports and, as a result, Greek export market shares declined. Their recovery since 2016 is encouraging, although they have not returned as yet to their 2008 level.

The position of Greek exports in foreign markets depends largely on their composition by product and geographical destination, which is significantly different from that of world exports (see Chart 2). The analysis of exports excluding fuels shows that the share of other manufactured products, mostly low-to-medium tech products, in Greek exports is the largest and declined significantly during the period 2005-2018, mainly in favour of the food, beverages and tobacco sector.[4] Both sectors account for higher percentages of Greek exports compared with the structure of world exports, which overall is more stable and heavily reliant (by close to 50%) on exports of machinery and transportation equipment. At the same time, no major changes in the geographical distribution of Greek exports were observed during the period 2005-2018, with the member countries of the euro area absorbing 48% of Greek exports. World exports depend

3 For a discussion of the factors that determine and contribute to export activity for refined oil products, see Mpardaka and Papazoglou (2019).
4 See also Bank of Greece (2019).

less than Greek exports on the euro area market, as the other advanced economies absorb a larger share of world exports. Moreover, the SEE market represents a relatively minor destination for world exports, while it is a considerably more important market for Greek products.

3 THE CONSTANT MARKET SHARE ANALYSIS (CMSA) METHODOLOGY AND PREVIOUS RESEARCH ON GREEK EXPORTS

The CMSA is essentially an arithmetic breakdown of the change in the export market share, which —according to the formulation employed in our analysis— is approximated by the difference between the rate of change in Greek exports and the rate of change in world exports between any two periods t-1 and t. This is called **the total effect (TE)**:

$$g - g^* = \sum_i \sum_j \theta_{ij}\, g_{ij} - \sum_i \sum_j \theta^*_{ij} g^*_{ij} \qquad (1)$$

where:

$g = \frac{x_t - x_{t-1}}{x_{t-1}}$ $(g^* = \frac{x^*_t - x^*_{i-1}}{x^*_{t-1}})$ is the rate of change in total Greek (world) exports between t-1 and t,

g_{ij} (g^*_{ij}) is the rate of change in Greek (world) exports of product i to destination j between t-1 and t, and

$\theta_{ij} = \frac{x_{ij\,t-1}}{x_{t-1}}$ $(\theta^*_{ij} = \frac{x^*_{ijt-1}}{x^*_{t-1}})$ is the share of exports of product i to destination j in total Greek (world) exports in t-1.

A positive (negative) sign of the difference between the two rates of change denotes an increase (decrease) in the market share of Greek exports.

Equation (1) is finally written as

$$g - g^* = \left[\sum_i \sum_j (\theta_{ij} - \theta^*_{ij})\, g^*_{ij}\right] + \left[\sum_i \sum_j \theta_{ij}\, (g_{ij} - g^*_{ij})\right] \qquad (2)$$

where the first term in brackets is the structure effect and the second term is the competitiveness or "pure" market effect.

The structure effect (SE) expresses the growth differential between Greek and world exports as the weighted average of export growth rates in individual product/destination markets. The weights are the differences in the shares of individual products/destinations in total Greek and world exports $(\theta_{ij} - \theta^*_{ij})$, reflecting the country's specialisation relative to the rest of the world. This term incorporates the comparative advantage of the country. A positive (negative) sign means that the country specialises in products and destinations where demand is growing faster (slower) than world demand, leading to gains (losses) in market share, even when individual market shares are constant.

The structure effect can be further decomposed into three terms that account separately for the effects of (i) the product composition and (ii) the geographical distribution of exports, as well as (iii) the interaction between these two, in the following way:

$$\sum_i (\theta_i - \theta^*_i) g^*_i + \sum_j (\theta_j - \theta^*_j)\, g^*_j + \sum_i \sum_j \left[(\theta_{ij} - \theta^*_{ij}) - (\theta_i - \theta^*_i)\frac{\theta^*_{ij}}{\theta^*_i} - (\theta_j - \theta^*_j)\frac{\theta^*_{ij}}{\theta^*_j}\right] g^*_{ij}$$

where

$\theta_i = \sum_j \theta_{ij}$ $\left(\theta^*_i = \sum_j \theta^*_{ij}\right)$ is the share of product i in total Greek (world) exports in period t-1,

$\theta_j = \sum_i \theta_{ij}$ $(\theta^*_j = \sum_i \theta^*_{ij})$ is the share of destination j in total Greek (world) exports in period t-1 and

$g^*_i = \frac{\sum_j \theta^*_{ij}\, g^*_{ij}}{\theta^*_i}$ $(g^*_j = \frac{\sum_i \theta^*_{ij}\, g^*_{ij}}{\theta^*_j})$ is the rate of change in world exports of product i (to destination j) between t-1 and t.

In turn, the three terms of the sum are explained as follows:

(i) The product composition effect (PCE). This reflects the impact of the diversification of Greek exports by product relative to world exports. A positive (negative) sign of this term

means that Greek exports include products for which demand is rising faster (slower) than world demand.

(ii) The geographical distribution effect (GDE). This reflects the effect of the diversification of Greek exports by geographical destination relative to world exports. A positive (negative) sign of this term means that Greek exports are directed to markets where demand is growing faster (slower) than in the world market.

(iii) The interaction effect (IE). This is the effect of the interaction of product and geographical structure and reflects the fact that the demand conditions that an exported product faces differ across destinations. The greater the interdependence between the product and the destination, the larger in absolute value is the IE.

The competitiveness or "pure" market effect (CE) is a residual that measures the difference between the actual change in the market share and the change measured by the structure effect. It reflects the impact of the changes in the individual product/destination market shares as reflected in the difference of export growth rates $(g_{ij} - g^{*}_{ij})$, weighted by the respective shares in total exports (θ_{ij}), which in turn are assumed to be constant and equal to their level observed at the beginning of the period. This term captures the impact of factors that, given a country's specialisation in products and geographical areas, determine both cost/price competitiveness and structural competitiveness. A positive (negative) sign on this term means that the country gains (loses) market share.

The formulation employed in this study addresses a number of limitations that have been identified in the traditional CMSA methodology.[5] In more detail:

1. *Index number problem:* In the traditional CMSA, the weights (i.e. market shares) of the initial period were used, thereby overlooking the fact that the export structure of a country changes continuously. In our analysis, this is addressed by calculating annual changes and then aggregating the changes over a period, as the structure of exports is not expected to change considerably from one year to another. This approach was one of the solutions suggested by Milana (1988).

2. *Asymmetric calculation of product and geographical effects:* In the traditional CMSA, the calculation sequence of the two effects could impact the outcome, as the interaction term was included in either the one or the other. In our analysis, the interaction effect is calculated explicitly; thus a product, a geographical and an interaction effect are calculated.

Despite these refinements, a couple of limitations still remain. First, the level of data disaggregation (product and area) can affect the results of the analysis.[6] A finer disaggregation of the data tends to increase the structure effect and decrease the competitiveness effect. The level of disaggregation is at the discretion of the researcher and is usually based on data availability. In our analysis, the selection of the geographical areas along with a two-digit level product disaggregation allows us to strike a fine balance between data availability and data granularity.[7] Second, the analysis is performed in export values rather than volumes. This is dictated by the lack of export volume data at the required level of disaggregation. With a view to minimising any further price effects, energy products, which are generally characterised by volatile prices, were excluded from our analysis.

To the best of our knowledge, the most recent CMSA on Greek exports was conducted by Athanasoglou, Backinezos and Georgiou

5 For a discussion of the CMSA methodology and its shortcomings, see for example Richardson (1971a, b) and Milana (1988).
6 See Richardson (1971b).
7 The analysis at the two-digit level was employed by Jiménez and Martin (2010), de Munnik, Jacob and Sze (2012) and Pandiella (2015). The Task Force of the MPC of the ESCB (2005) uses the three-digit level, while Amador and Cabral (2008) a four-digit level product disaggregation.

(2010). The authors employed the traditional CMSA methodology[8] extended by refining the calculation of the product and the geographical effect, so as to minimise the asymmetric element in the calculation of such effects. Their analysis was performed for the period 1996-2006 and indicated that —overall— the geographical effect had a significant positive impact, while the competitiveness effect was of a smaller magnitude and the commodity composition effect was negative and declining in absolute value.[9] As our analysis covers the period from 2005 onwards and employs a further refined CMSA methodology, it is not directly comparable. However, their assessment on the significant role of the geographical effect in the pre-crisis period is confirmed by our analysis as well.[10]

A Task Force of the MPC of the ESCB (2005) performed a CMS analysis on developments in the market share of the euro area as a whole (i.e. extra-euro area trade) for the period 1985-2001, using the same methodology as in our study. They concluded that the euro area market share loss could be attributed to an underspecialisation in fast-growing markets such as those in Asia (especially in the 1990s and after the Asian crisis in 1998) and to a lesser extent to the United States and Japan. The former result was partly attributed to the intra-area trade in Asia (assisted also by the proximity of the Asian countries) and associated with outsourcing to China. The product effect turned out to be —in general— neutral. For the period 1985-2001, the competitiveness effect accounted for one-third of the loss, while the structure effect for the remaining two-thirds.

Jiménez and Martin (2010) used the CMSA framework for the euro area and its member countries over the period 1994-2007. As far as Greece is concerned, its market share declined throughout this period by approximately 0.6% per annum, due to both the competitiveness effect (-0.3% p.a.) and the structure effect (-0.3% p.a.), despite the fact that the geographical distribution effect was positive (0.5% p.a.). In the subperiod 2001-2007, the Greek export market share was increasing by 4.4% p.a., as all effects were positive; the greatest effect was the competitiveness effect (2.2% p.a.), while the geographical distribution effect was 1.5% p.a. In the case of the geographical distribution effect, the euro area, the rest of the EU and the rest of Europe had a positive contribution (slightly higher than 4%), while other destinations (e.g. the United States, China, the rest of the world) had a negative contribution of approximately 3%. Although our analysis started from 2005, the importance of the geographical effect in the pre-crisis period is confirmed in our analysis as well. In addition, our results are similar as regards the contribution of the destination markets to the geographical effect (see Table 2). However, our analysis indicates that the competitiveness effect in the pre-crisis period (2005-2008) is negative. This divergence could stem from the positive effects of non-price competitiveness in the early years of Greece's euro area participation, which is captured by Jiménez and Martin (2010) as their analysis covers the period 2001-2007.

Amador and Cabral (2008), using the same methodology as in this study, analysed the evolution of the export market share of Portugal in comparison with the respective developments for Spain, Ireland, Greece and Italy. They found that the Greek market share increased by 55.7% in the period 1968-2006 (the respective increase for Portugal was 14.5%). Additionally, the structure effect is slightly positive for Greece, as it benefits from a small positive impact of the geographical distribution of exports. Specifically, the geographical structure

8 They decomposed the growth of Greek exports into four effects: world growth; commodity competition; geographical structure; and competitiveness effect.

9 The commodity disaggregation was at the four-digit level and commodities were further classified according to their technological intensity. Energy products were excluded.

10 An earlier analysis was performed by the IMF (2007) and focused on Greek export changes for the period 1992-2005. The study found that, for the subperiod 2000-2005, the increase in Greek exports (9.8% p.a.) is attributed to the world trade effect (i.e. rising world trade) and —to a lesser extent— to the positive market distribution effect stemming from the rapidly growing SEE economies. However, marginally negative effects were calculated for commodity composition (tilted towards goods for which world demand has been growing at below-average rates) and for competitiveness (i.e. residual effect).

effect is favourable, due to the positive contribution from Greece's non-specialisation in the US market (a market growing below world average in the period examined) and from its higher specialisation in the Bulgarian and Romanian markets. The product structure effect though was unfavourable.

4 DATA

The analysis is based on data from the United Nations database COMTRADE and uses bilateral trade data on merchandise exports of goods (in US dollars) for the period 2005-2018. Greece's market shares are calculated in relation to a group of 60 countries, which is defined as the "world" and includes the country's major trading partners (see the Appendix).

However, exports from Greece and the "world" are also directed to countries other than the group of partners. Included in this analysis are only those countries for which data are available for the whole period, accounting for about 90% of Greek exports and around 85% of exports of the "world". It should be noted that the euro area data include total exports of each member country, both intra- and extra-euro area. As a further enhancement, we have excluded the value of Greek exports from the "world" aggregate. This improvement is expected to have a small impact in the case of Greece; however, for large countries this impact could be significant. Also, 59 products are used from the two-digit categories of the Standard Classification of International Trade (SITC Rev. 4), excluding fuels and non-classified goods (see the Appendix). Fuels are excluded because of the volatility of oil prices which may distort the results. In addition, both the market shares of Greek fuel exports and the share of the latter in total Greek exports recorded changes more extensive than the average during the period under consideration, which may also distort the results. Note that all calculations are made in nominal terms, given the lack of sufficient data for the desired sectoral and geographical analysis merchandise trade in volume terms. As a result, it is not possible to separate the effects of changes in prices and in volumes, respectively, on market shares. A final note of caution relates to USD/EUR exchange rate movements. Since the figures are denominated in US dollars (USD), developments are also affected by fluctuations in the dollar exchange rate. For example, if the portion of USD-priced exports is lower for Greece than for the rest of the world, an appreciation of the USD vis-à-vis the euro leads, ceteris paribus, to a decrease in Greece's market share. Therefore, changing exchange rates and prices will have an impact on the evolution of market shares, thus affecting the competitiveness effect.[11]

5 RESULTS OF THE CMSA

5.1 OVERALL RESULTS

The analysis covers the 2005-2018 period; it includes several years prior to the Greek economic crisis and extends to the more recent years (2018). In order to facilitate the analysis, the period under consideration is divided into four distinct subperiods. The first subperiod refers to the years prior to the economic crisis, i.e. 2005-2008. The other three span the period from the start of the economic crisis to the most recent past, i.e. 2009-2018. In particular, the second subperiod (2009-2012) captures the onset of the Greek economic crisis, the initiation of the first economic adjustment programme, the pricing-in of the Greek redenomination risk and the implementation of the PSI programme. These events are expected to have impacted the availability of credit to Greek exporters.[12] The third subperiod (2013-2015) —still amid the Greek economic crisis— marks the stabilisation of the economy and runs until the resurgence of the Greek redenomination risk and the imposition of capital

11 On the mechanical impact of the USD exchange rate on USD-denominated exports, see also Task Force of the MPC of the ESCB (2005) and Amador and Cabral (2008).
12 For a discussion on credit and exports, see inter alia Del Prete and Federico (2014).

Table 1 Results of the constant market share analysis*

(excluding fuel, percentage changes, current prices)

Year/ Period	Exports growth rate		Total effect	Competitive-ness effect	Structure effect	Breakdown of the structure effect		
	Greece	World				Product composition effect	Geographical distribution effect	Interaction effect
	1	2	3=1-2=4+5	4	5=6+7+8	6	7	8
2005	8.5	9.6	-1.1	-2.1	1.0	0.3	0.4	0.3
2006	18.4	16.2	2.2	-4.8	7.0	1.1	3.5	2.5
2007	12.7	7.9	4.8	0.8	4.0	-1.2	5.2	0.1
2008	16.0	13.5	2.5	-2.9	5.3	1.7	2.9	0.8
2009	-20.5	-19.3	-1.2	-1.3	0.1	3.2	-3.5	0.5
2010	5.3	21.2	-15.8	-8.3	-7.5	-1.5	-7.6	1.6
2011	13.9	17.4	-3.5	-5.7	2.2	2.3	0.9	-1.0
2012	-8.6	-1.3	-7.3	-3.4	-3.9	-1.6	-4.6	2.3
2013	1.9	3.4	-1.4	-3.2	1.8	0.5	0.7	0.7
2014	1.2	2.5	-1.3	-1.9	0.6	-1.1	0.6	1.1
2015	-9.3	-8.4	-0.9	1.9	-2.8	-1.2	-2.4	0.8
2016	2.8	-2.1	4.9	1.5	3.4	-0.4	2.8	0.9
2017	6.1	3.2	2.9	-1.6	4.6	3.1	2.0	-0.5
2018	20.2	14.3	5.9	6.4	-0.5	-1.0	1.4	-1.0
Averages								
2005-2008	13.9	11.8	2.1	-2.3	4.3	0.5	3.0	0.9
2009-2018	1.3	3.1	-1.8	-1.6	-0.2	0.2	-1.0	0.5
2009-2012	-2.5	4.5	-7.0	-4.7	-2.3	0.6	-3.7	0.8
2013-2015	-2.1	-0.8	-1.2	-1.1	-0.1	-0.6	-0.4	0.9
2016-2018	9.7	5.1	4.6	2.1	2.5	0.6	2.1	-0.2

Source: United Nations, COMTRADE database; authors' own calculations.
* Table 1 should read as follows: column 3 is the difference of columns 1-2 or the sum of columns 4+5, and column 5 is the sum of columns 6+7+8. Due to rounding, numbers may not add up to totals.

controls in June 2015. The fourth subperiod refers to the more recent years, i.e. 2016-2018, during which the economy —despite the presence of capital controls— gradually entered a phase of recovery, mostly driven by strong export performance.

The pre-crisis subperiod is associated with increasing market shares of Greek exports, as is also the case with the fourth subperiod, while the two subperiods in between are characterised by declining market shares. It appears that the market share gains during the first (pre-crisis) subperiod were more than offset by the considerable drop during the subsequent two subperiods, affected also by financing constraints due to credit scarcity and the imposition of capital controls.[13] Despite the reversal of its downward trend that took place in the last subperiod, the Greek export market share at the end of 2018 still fell short of its end-2008 level. The results of the CMSA are summarised in Table 1 and Chart 3, where changes in market shares are broken down into components. In addition, the contribution of each destination area to the geographical distribution effect and the contribution of each product category

13 For a further discussion on exports, capital controls and the credit crunch in Greece, see Kotidis and Malliaropulos (2018).

Chart 3 Results of the constant market share analysis (all destinations and all products)

(excluding fuel, percentage changes, current prices)

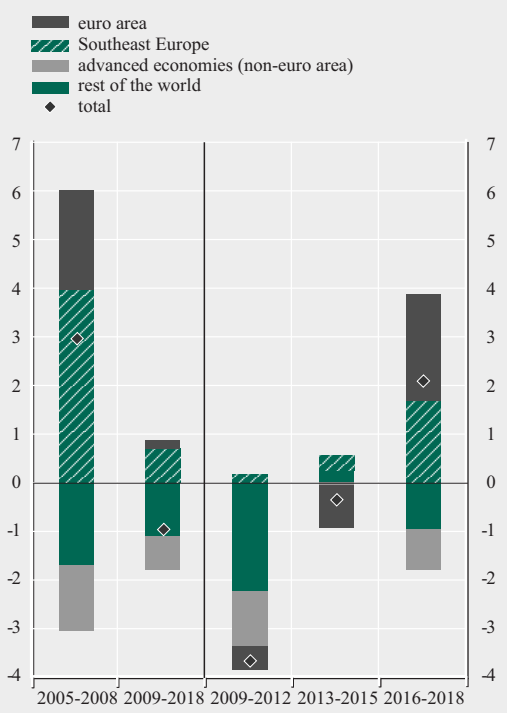
Source: United Nations, COMTRADE database; authors' own calculations.

to the product composition effect are shown in Charts 4 and 5.

Turning to a more detailed analysis, with respect to the pre-crisis subperiod (2005-2008), Greek exports appear, on average, to have gained market share, which can be attributed to the particularly strong positive structure effect that counterbalanced the large negative competitiveness effect. At this point, it should be noted that the developments in market shares, as captured by the competitiveness effect, are consistent with the decline in price/cost competitiveness observed throughout the 2000-2009 period and the prolonged appreciation of the real exchange rate. However, these competitiveness effect developments incorporate also the effect of non-price factors that may be associated with the position of the country in the international market, other than those related to the product/destination structure of Greek exports. The impact of the geographical distribution is almost exclusively responsible for the positive structure effect, as the product composition effect was quite small. The high growth rates of the euro area and SEE, which then absorbed 70% of Greek exports, explain the strong positive effect connected with the geographical composition, as indicated by the contribution of both areas (see Chart 4). On the other hand, the contribution of the advanced economies and the rest of the world to the geographical distribution effect was negative. Regarding the product composition effect, the contribution of food, beverages and tobacco, chemicals and plastics, and other manufactured products combined was almost offset by the negative contribution of machinery and transportation equipment (see Chart 5).

Chart 4 Contribution of destination markets to the geographical distribution effect

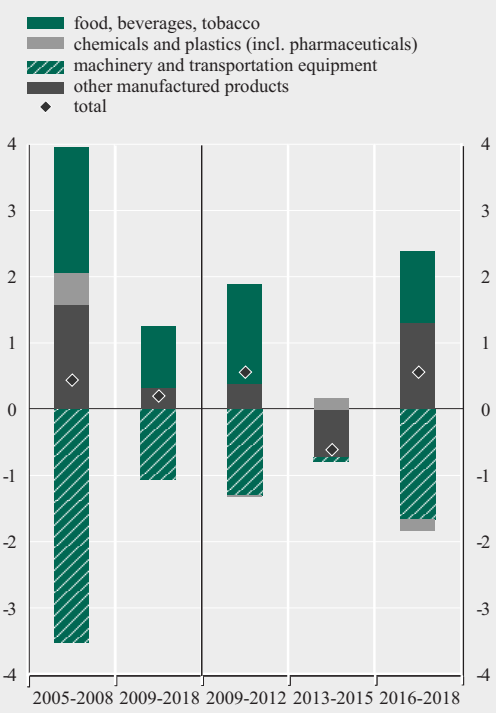
(excluding fuel, percentage changes, current prices)



Source: United Nations, COMTRADE database; authors' own calculations.

Chart 5 Contribution of product sectors to the product composition effect

(excluding fuel, percentage changes, current prices)



Source: United Nations, COMTRADE database; authors' own calculations.

This positive trend was reversed in the subsequent two subperiods (2009-2012 and 2013-2015) after the crisis broke out and Greek export market shares entered a path of decline. However, the declining trend began to decelerate (2013-2015), and in the last subperiod (2016-2018) Greek export market shares started increasing. The loss of market share is linked with the negative impact of both the competitiveness effect and the structure effect. The negative competitiveness effect appears to dominate, at least initially, even though it followed a declining trend, reflecting mostly the impact of: (a) the gradual recouping of pre-crisis price and cost competitiveness losses; and (b) the structural reforms implemented, in particular the measures aimed to enhance labour market flexibility. The fact that these competitiveness gains were not enough to support an even better performance can be associated with the still low ranking of the country in terms of non-price competitiveness. More specifically, financing constraints, coupled with excess bureaucracy and an unfavourable tax system, posed considerable obstacles to the attempts of exporting firms to enter new markets, in terms of new products and/or new destinations, and increase their shares in both old and new export markets.[14] To some extent, as mentioned earlier, the currency of denomination and exchange rate movements also affect the results.[15]

Regarding the structure effect, this turned negative —on average— in the 2009-2015 period, due to an adverse geographical distribution effect, while the product composition effect

14 See also the World Bank's *Doing Business reports* (various issues).
15 It is recalled that our analysis is performed on nominal USD-denominated export data. A depreciation of the euro vis-à-vis the USD will initially have a negative effect on Greece's nominal market shares, but a positive effect is expected to follow on the back of improved price competitiveness.

had a minimal impact. Specifically, the geographical distribution effect was particularly profound in the period 2009-2012, reflecting the global slowdown, and was more intense in the markets outside the euro area and SEE, i.e. the main destinations of Greek exports. However, it should be noted that the SEE region has always a positive contribution (see Chart 4), having the advantage of proximity and, in many cases, of shared borders that reduces freight costs.[16] On the other hand, the product composition effect had a minimal impact, as the small positive effect in the second subperiod was offset by a negative effect of equal magnitude in the third subperiod. The main positive contribution came from food, beverages and tobacco, while the effect from machinery and transportation equipment partly eroded these gains (see Chart 5).

In the last subperiod (2016-2018), a strong positive total effect was recorded, which indicates that the solid growth of Greek exports was associated with significant gains in market shares. In particular, the structure effect constituted the main force behind the gains in Greek export market shares. Indeed, the geographical distribution effect appears to have recovered and turned strongly positive, especially on account of the euro area and SEE, largely reflecting the high growth rates recorded in both these regions. The product composition effect turned positive and increased in absolute size relative to past subperiods on the back of the strong contribution of food, beverages and tobacco and of other manufactured products. The competitiveness effect was also positive, although smaller than the structure effect.

Overall, for the period that followed the crisis, the loss of market share of Greek exports is primarily linked with a negative, although diminishing, competitiveness effect, despite the considerable gains in price and cost competitiveness. That means that other factors, mainly related to non-price competitiveness such as difficulties in access to credit and political uncertainty, kept the competitiveness effect negative, although declining in absolute size. In addition, the drastic decline in the positive geographical distribution effect contributed to this result as well. Finally, it should be pointed out that the product composition effect of Greek exports throughout the period under consideration (before and after the crisis) is limited, which can be attributed to the fact that Greek exports traditionally consist of mostly low- and medium-technology products with not so fast increasing demand. Specifically, the sector of machinery and transportation had a negative contribution in all subperiods. At the same time, the sector of food, beverages and tobacco had a positive contribution.

5.2 RESULTS FOR THE INDIVIDUAL PRODUCT/DESTINATION MARKETS

In this subsection, we will examine the importance of the structure and competitiveness effects within broad destination and product markets, in an attempt to isolate the influence of specific characteristics of these destinations and products that make them more important for Greek exports. The distinct groups of countries belonging to the euro area and SEE have been chosen, as they receive the bulk of Greek exports. Both areas are of special interest because of the membership status and proximity, respectively. Two additional groups of countries are considered, with the first comprising the advanced economies outside the euro area and the second all other destinations. The grouping of products is based on their ranking in the revealed comparative advantage (RCA) status. The individual product categories are "food, beverages and tobacco", "chemicals and plastics", "machinery and transportation equipment" and "other manufactured products". The first two groups include products in which the country has a comparative advantage and therefore a relatively higher market share than the overall market share, while the third group

16 For a discussion on a gravity model approach for Greek exports, see for instance Papazoglou (2007).

Table 2 Results of the constant market share analysis by geographical destination*

(excluding fuel, percentage changes, current prices)

		Exports growth rate		Total effect	Competitiveness effect	Structure effect	Breakdown of the structure effect		
		Greece	World				Product composition effect	Geographical distribution effect	Interaction effect
	Period	1	2	3=1-2=4+5	4	5=6+7+8	6	7	8
Averages									
Euro area	2005-2008	13.2	11.3	1.8	-0.2	2.1	0.8	0.9	0.4
	2009-2018	1.7	1.4	0.2	-0.1	0.4	0.2	-0.3	0.5
	2009-2012	-3.8	-0.4	-3.4	-4.0	0.6	1.1	-1.2	0.6
	2013-2015	-0.5	-1.4	0.9	1.7	-0.8	-0.4	-1.5	1.1
	2016-2018	11.1	6.7	4.4	3.2	1.2	-0.3	1.9	-0.4
Southeast Europe	2005-2008	17.3	18.6	-1.3	-6.6	5.2	3.8	2.0	-0.5
	2009-2018	-0.4	3.3	-3.7	-3.6	-0.1	0.0	0.3	-0.4
	2009-2012	-4.4	3.0	-7.4	-6.4	-1.0	0.9	-1.6	-0.3
	2013-2015	-3.9	0.8	-4.7	-4.3	-0.4	0.1	0.7	-1.2
	2016-2018	8.3	6.0	2.3	-0.4	2.7	-0.1	2.7	0.1
Advanced economies (non-euro area)	2005-2008	8.0	8.2	-0.2	-3.1	3.0	2.2	0.8	0.0
	2009-2018	2.4	3.3	-1.0	-0.6	-0.4	-0.2	-0.7	0.5
	2009-2012	-3.1	4.7	-7.8	-6.4	-1.4	-0.7	-1.8	1.1
	2013-2015	4.0	0.5	3.4	3.5	-0.1	-0.4	0.4	-0.1
	2016-2018	8.1	4.3	3.8	3.1	0.7	0.7	-0.3	0.3
Rest of the world	2005-2008	21.1	17.3	3.8	-0.4	4.1	-0.1	6.2	-1.9
	2009-2018	2.3	4.6	-2.3	-2.0	-0.3	0.2	-1.8	1.3
	2009-2012	6.1	9.4	-3.3	-2.0	-1.3	1.0	-3.8	1.5
	2013-2015	-10.1	-1.9	-8.2	-9.2	1.0	0.2	-0.8	1.6
	2016-2018	9.7	4.7	5.0	5.1	-0.1	-0.7	-0.3	0.8

Source: United Nations, COMTRADE database, January 2019; authors' own calculations.
* Table 2 should read as follows: column 3 is the difference of columns 1-2 or the sum of columns 4+5, and column 5 is the sum of columns 6+7+8. Due to rounding, numbers may not add up to totals.

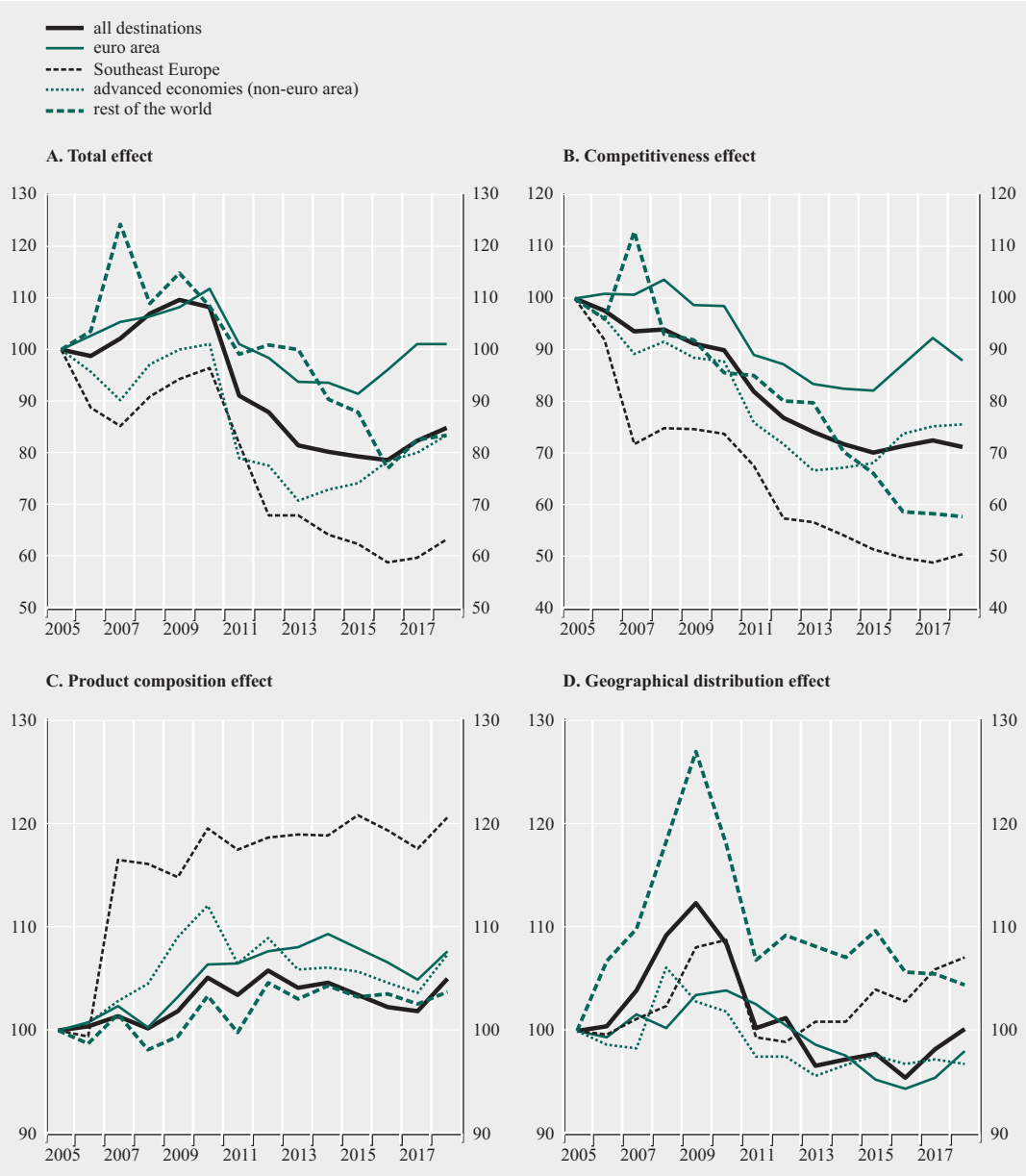
includes products characterised by dynamic export activity, despite their relatively smaller market shares. This analysis differs from the one in Section 5.1 as it focuses on each market and on each product category and attempts to break down the change in the export market share in each individual market into the different components, as described in Section 3.

5.2.1 Analysis by geographical destination

Although our analysis for each individual destination area revealed a number of common trends, a number of notable differences were identified. Table 2 and Chart 6 show the detailed results for the different markets and subperiods. In the pre-crisis subperiod (2005-2008), despite the negative competitiveness effect, Greek exports were gaining market shares on the back of a strong structure effect, with the exception of the SEE region, where this effect did not compensate for the negative competitiveness effect, resulting in market share loss in this area. In the euro area, the impact of the negative competitiveness effect is marginal compared with the other regions. This finding could reflect the positive effects

Chart 6 Results of the constant market share analysis by geopraphical destination (2005-2018)

(2005=100)



Source: United Nations, COMTRADE database; authors' own calculations.

of Greece's participation in the currency union. At the same time, the product composition effect is larger in SEE and the non-EU advanced economies relative to other regions. It is also almost equal to the geographical distribution effect in the euro area. Especially in the advanced economies, the product composition effect is the dominant driver of the structure effect. The geographical distribution effect is stronger in the rest of the world than in the other markets.

In the post-crisis period (2009-2018), the competitiveness effect, which prevails over the

structure effect, is negative, with lower absolute values in the euro area and the advanced economies than in the other areas. At the same time, the structure effect is weak. In the recent subperiod (2016-2018), with the exception of the SEE region, the competitiveness effect was positive in the other three areas, with the advanced economies posting the strongest effect among them. The structure effect was positive in all areas apart from the rest of the world, driven by the geographical effect in the euro area and the SEE countries and by the product effect in the non-euro area advanced economies.

5.2.2 Analysis by product category

In the pre-crisis period, our analysis for each product category indicated that —in general— Greek exports gained market share in all the key product markets, except that of other manufactured products, which includes most of the traditional Greek exports (textiles and apparel, metals, non-metallic minerals) characterised by low-to-medium technological content (see Table 3 and Chart 7). This development was the result of a positive structure effect, driven by the geographical distribution of exports within each market. Only in the

Table 3 Results of the constant market share analysis by product sector*

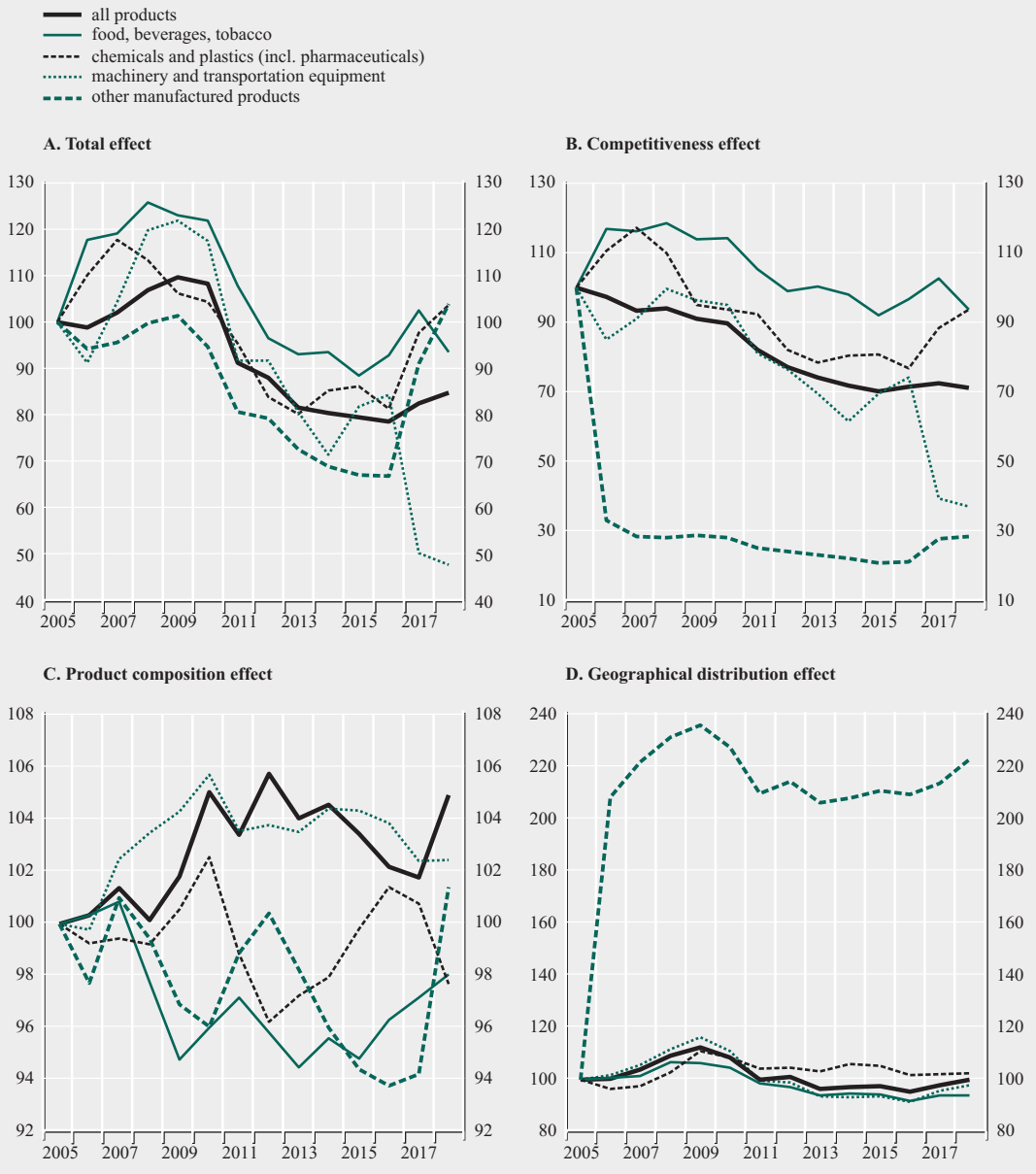
(excluding fuel, percentage changes, current prices)

		Exports growth rate		Total effect	Competitiveness effect	Structure effect	Breakdown of the structure effect		
		Greece	World				Product composition effect	Geographical distribution effect	Interaction effect
	Period	1	2	3=1-2=4+5	4	5=6+7+8	6	7	8
Averages									
Food, beverages, tobacco	2005-2008	18.5	11.9	6.7	4.9	1.7	-1.3	1.6	1.4
	2009-2018	2.1	4.3	-2.2	-1.4	-0.8	0.2	-1.2	0.2
	2009-2012	0.5	7.1	-6.6	-3.0	-3.6	-0.1	-3.1	-0.5
	2013-2015	-1.0	-0.9	0.0	-1.0	1.0	0.7	-0.7	1.1
	2016-2018	7.3	5.9	1.4	0.3	1.1	0.1	0.7	0.3
Chemicals and plastics (incl. pharmaceuticals)	2005-2008	14.9	13.2	1.7	-0.5	2.2	0.1	2.7	-0.6
	2009-2018	2.7	3.5	-0.8	0.0	-0.8	-0.5	-0.5	0.1
	2009-2012	-1.6	5.1	-6.7	-4.2	-2.5	-0.8	-1.8	0.1
	2013-2015	-1.5	-2.1	0.6	-0.4	1.0	1.4	-0.3	-0.1
	2016-2018	12.5	6.9	5.7	6.1	-0.4	-1.9	1.2	0.2
Machinery and transportation equipment	2005-2008	16.6	11.2	5.3	0.1	5.2	1.1	3.9	0.3
	2009-2018	0.9	3.2	-2.2	-1.5	-0.8	0.0	-1.5	0.7
	2009-2012	-5.5	3.9	-9.4	-7.0	-2.4	-0.2	-5.2	3.0
	2013-2015	2.2	0.2	2.0	2.9	-0.9	0.1	-0.8	-0.2
	2016-2018	8.1	5.1	3.0	1.4	1.6	0.2	2.7	-1.3
Other manufactured products	2005-2008	10.5	11.9	-1.4	-6.1	4.8	-0.3	3.4	1.7
	2009-2018	0.8	2.6	-1.9	-2.5	0.6	0.5	-0.4	0.5
	2009-2012	-3.4	4.5	-7.9	-5.2	-2.7	0.4	-3.3	0.1
	2013-2015	-4.5	-1.9	-2.6	-2.8	0.1	-1.5	0.5	1.2
	2016-2018	11.6	4.6	7.0	1.3	5.7	2.9	2.6	0.2

Source: United Nations. COMTRADE database; authors' own calculations.
* Table 3 should read as follows: column 3 is the difference of columns 1-2 or the sum of columns 4+5, and column 5 is the sum of columns 6+7+8. Due to rounding, numbers may not add up to totals.

Chart 7 Results of the constant market share analysis by product sector (2005-2018)

(2005=100)



Source: United Nations COMTRADE database; authors' own calculations.

food, beverages and tobacco sector was the competitiveness effect significantly positive. This is an exception to the situation in the total product market. In all other markets, the competitiveness effect was negative and only recently (2016-2018) there has been a strong reversal in the sectors of chemicals and plastics and of other manufactured products. In all product categories, the strongly negative geographical effect in the early years of the crisis (2009-2012) weakened in the following subperiod and turned positive in the recent period. This effect could reflect the economic growth trajectory of the main Greek export markets

(i.e. the euro area and SEE). Another striking finding is the strong positive product composition and geographical distribution effects of other manufactured products in the recent period that can be attributed to improvements in the technological content, quality and marketing of these products.

6 CONCLUSIONS

This analysis examined the evolution of the total market share of Greek exports in the world market during the period 2005-2018, with particular focus on the period after the 2008 crisis, and investigated the effects of their composition by product and by geographical destination on Greece's position in foreign markets. Changes in market shares were approximated by the growth differential between Greek exports and exports of Greece's major trading partners that are defined here as the "world".

According to the results of the analysis, during the pre-crisis period (2005-2008), Greek exports gained market share, as their growth rate outpaced world export growth. By contrast, the increase in Greek exports during most of the period 2009-2018 was slower than the corresponding increase in world exports, resulting in an average annual market share loss of 1.8%. However, the loss is concentrated in the period 2009-2015, as the most recent period of 2016-2018 saw an increase of about 4.6% in the share of Greek exports in the world export market. Greek export market shares have not yet returned to their 2008 levels, despite the significant cost and price competitiveness gains during the period 2010-2015.

It should be noted that a large part of the changes in market shares, in this analysis, is explained by the product/destination structure of Greek exports, while the calculated competitiveness effect is a residual that includes all factors other than prices and structure, which could strengthen the country's position in foreign markets, but have not yet had time to exert an adequate positive influence.

The limited impact of the product composition of Greek exports should also be stressed, and this concerns the period both before and after the crisis. This means that Greek exports consist mainly of products for which demand is below the world average. Therefore, an improvement in the performance of Greek exports would require a shift to high-demand products on the world markets. This requires a further restructuring of the country's production base with the aim of strengthening industries with higher technology content. Of course, attracting sufficient foreign investment in these sectors would be an important prerequisite for this to happen. Finally, Greek exports could benefit from a further expansion of their share into more dynamic markets such as South East Asia, although so far the destination structure of Greek exports seems to have had a rather positive influence.

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APPENDIX

Greece's major trading partners – "World"

EU Member States		Non-EU countries	
Austria	Italy	Albania	Mexico
Belgium	Latvia	Algeria	Morocco
Bulgaria	Lithuania	Argentina	New Zealand
Croatia	Luxembourg	Australia	Norway
Cyprus	Malta	Brazil	Republic of North Macedonia
Czechia	Netherlands	Canada	Philippines
Denmark	Poland	Chile	Russian Federation
Estonia	Portugal	China	Serbia
Finland	Romania	Egypt	Singapore
France	Slovakia	Hong Kong	South Africa
Germany	Slovenia	Iceland	South Korea
Greece	Spain	India	Switzerland
Hungary	Sweden	Indonesia	Thailand
Ireland	United Kingdom	Israel	Turkey
		Japan	Ukraine
		Malaysia	United States of America

Geographical destination areas

Euro area			
Austria	France	Lithuania	Slovakia
Belgium	Germany	Luxembourg	Slovenia
Cyprus	Ireland	Malta	Spain
Estonia	Italy	Netherlands	
Finland	Latvia	Portugal	
Southeast Europe			
Albania	Croatia	Serbia	Turkey
Bulgaria	Romania	Republic of North Macedonia	
Advanced economies (non-euro area)			
Czechia	Sweden	Canada	South Korea
Denmark	Switzerland	Israel	United States of America
Iceland	United Kingdom	Japan	
Norway	Australia	New Zealand	
Rest of the world			
Belarus	Egypt	Syria	Singapore
Hungary	Iran	China	Thailand
Poland	Kuwait	Hong Kong	Argentina
Russian Federation	Morocco	India	Brazil
Ukraine	Oman	Indonesia	Chile
Algeria	Qatar	Malaysia	Mexico
Bahrain	Saudi Arabia	Philippines	South Africa

SITC code (two-digit) and description

Food, beverages & tobacco	
00	Live animals other than animals of division 03
01	Meat and meat preparations
02	Dairy products and birds' eggs
03	Fish (not marine mammals), crustaceans, molluscs and aquatic invertebrates, and preparations thereof
04	Cereals and cereal preparations
05	Vegetables and fruit
06	Sugars, sugar preparations and honey
07	Coffee, tea, cocoa, spices, and manufactures thereof
08	Feeding stuff for animals (not including unmilled cereals)
09	Miscellaneous edible products and preparations
11	Beverages
12	Tobacco and tobacco manufactures
22	Oil-seeds and oleaginous fruits
29	Crude animal and vegetable materials, n.e.s.
41	Animal oils and fats
42	Fixed vegetable fats and oils, crude, refined or fractionated
43	Animal or vegetable fats and oils, processed; waxes of animal or vegetable origin; inedible mixtures or preparations of animal or vegetable fats or oils, n.e.s.
Chemicals & plastics	
23	Crude rubber (including synthetic and reclaimed)
27	Crude fertilizers, other than those of division 56, and crude minerals (excluding coal, petroleum and precious stones)
51	Organic chemicals
52	Inorganic chemicals
53	Dyeing, tanning and colouring materials
54	Medicinal and pharmaceutical products
55	Essential oils and resinoids and perfume materials; toilet, polishing and cleansing preparations
56	Fertilizers (other than those of group 272)
57	Plastics in primary forms
58	Plastics in non-primary forms
59	Chemical materials and products, n.e.s.
62	Rubber manufactures, n.e.s.
Machinery & transportation equipment	
71	Power-generating machinery and equipment
72	Machinery specialized for particular industries
73	Metalworking machinery
74	General industrial machinery and equipment, n.e.s., and machine parts, n.e.s.
75	Office machines and automatic data-processing machines
76	Telecommunications and sound-recording and reproducing apparatus and equipment
77	Electrical machinery, apparatus and appliances, n.e.s., and electrical parts thereof (including non-electrical counterparts, n.e.s., of electrical household-type equipment)
78	Road vehicles (including air-cushion vehicles)
79	Other transport equipment
87	Professional, scientific and controlling instruments and apparatus, n.e.s.
88	Photographic apparatus, equipment and supplies and optical goods, n.e.s.; watches and clocks
Other manufactured products	
21	Hides, skins and furskins, raw
24	Cork and wood
25	Pulp and waste paper
26	Textile fibres (other than wool tops and other combed wool) and their wastes (not manufactured into yarn or fabric)
28	Metalliferous ores and metal scrap
61	Leather, leather manufactures, n.e.s., and dressed furskins
63	Cork and wood manufactures (excluding furniture)
64	Paper, paperboard and articles of paper pulp, of paper or of paperboard
65	Textile yarn, fabrics, made-up articles, n.e.s., and related products
66	Non-metallic mineral manufactures, n.e.s.
67	Iron and steel
68	Non-ferrous metals
69	Manufactures of metals, n.e.s.
81	Prefabricated buildings; sanitary, plumbing, heating and lighting fixtures and fittings, n.e.s.
82	Furniture and parts thereof; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings
83	Travel goods, handbags and similar containers
84	Articles of apparel and clothing accessories
85	Footwear
89	Miscellaneous manufactured articles, n.e.s.

THE EVOLUTION OF NEW FIRMS' CHARACTERISTICS IN GREECE BEFORE AND DURING THE ECONOMIC ADJUSTMENT PROGRAMMES

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ABSTRACT

This paper examines the factors that affect new firms' survival, growth and export decisions in Greece. Using firm-level data for the 2000-2016 period and the appropriate econometric techniques and performing separate estimations for the pre-crisis and the post-crisis periods (2000-2007 and 2008-2016), we obtain a number of novel results. The survival estimations highlight the importance of producing technologically advanced and high value-added products that can be competitive in foreign markets and the significance of the regulatory framework under which new firms are established and grow, as well as the central role of bank financing. The estimations of a firm growth model indicate that small, high-leveraged new firms, with poor liquidity, operating in high concentration markets and facing increased credit cost, grow more slowly, although differences in these results are found between the pre-crisis period (2000-2007) and the total period. More experienced firms, as well as those with sufficient liquidity and access to bank finance, have a higher probability to export. The same holds for those firms which are located in large urban areas and are active in knowledge or ICT intensive sectors.

Keywords: new firms, survival, entry, exit, firm growth, firm age, firm size, Cox Proportional Hazard Model, Probit Model, Logit Model, Panel Data Fixed Effects Model

JEL classification: C23, C25, C26, C41, L11, L25

Η ΕΞΕΛΙΞΗ ΤΩΝ ΧΑΡΑΚΤΗΡΙΣΤΙΚΩΝ ΤΩΝ ΝΕΩΝ ΕΠΙΧΕΙΡΗΣΕΩΝ ΣΤΗΝ ΕΛΛΑΔΑ ΤΗΝ ΠΕΡΙΟΔΟ ΠΡΙΝ ΑΠΟ ΤΑ ΠΡΟΓΡΑΜΜΑΤΑ ΟΙΚΟΝΟΜΙΚΗΣ ΠΡΟΣΑΡΜΟΓΗΣ ΚΑΙ ΚΑΤΑ ΤΗ ΔΙΑΡΚΕΙΑ ΤΟΥΣ

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ΠΕΡΙΛΗΨΗ

Η μελέτη εξετάζει τους παράγοντες που επηρεάζουν την επιβίωση, την ανάπτυξη και την απόφαση για εξαγωγές των νέων επιχειρήσεων στην Ελλάδα, οι οποίες ξεκίνησαν τη δραστηριότητά τους την περίοδο 2000-2016. Από τη χρήση διαστρωματικών και χρονολογικών σειρών και κατάλληλων οικονομετρικών τεχνικών, καθώς και από την πραγματοποίηση εκτιμήσεων τόσο για ολόκληρη την εξεταζόμενη περίοδο όσο και χωριστά για τις περιόδους πριν και μετά την κρίση (2000-2007 και 2008-2016), προκύπτουν ενδιαφέροντα αποτελέσματα. Οι εκτιμήσεις επιβίωσης αναδεικνύουν τη σημασία της παραγωγής τεχνολογικά προηγμένων προϊόντων και υπηρεσιών, υψηλής προστιθέμενης αξίας, που να μπορούν να είναι ανταγωνιστικά στις διεθνείς αγορές. Επίσης, αναδεικνύεται ο σημαντικός ρόλος του ρυθμιστικού πλαισίου λειτουργίας των επιχειρήσεων, καθώς και της τραπεζικής χρηματοδότησης. Οι εκτιμήσεις του υποδείγματος ανάπτυξης δείχνουν ότι οι νέες επιχειρήσεις μικρού μεγέθους με υψηλό επίπεδο μόχλευσης και περιορισμένη ρευστότητα, οι οποίες δραστηριοποιούνται σε κλάδους με μεγάλο βαθμό συγκέντρωσης και αντιμετωπίζουν υψηλό χρηματοοικονομικό κόστος, αναπτύσσονται πιο αργά. Ωστόσο, ορισμένα από τα αποτελέσματα διαφοροποιούνται μεταξύ των εκτιμήσεων που αφορούν τις περιόδους πριν και μετά τη διεθνή και την εγχώρια κρίση. Επιχειρήσεις με συσσωρευμένη εμπειρία, ικανοποιητική ρευστότητα και πρόσβαση στην τραπεζική χρηματοδότηση παρουσιάζουν υψηλότερη πιθανότητα πραγματοποίησης εξαγωγών. Το ίδιο ισχύει και για νέες επιχειρήσεις που είναι εγκατεστημένες στις δύο μεγαλύτερες αστικές περιοχές της χώρας, καθώς και για όσες δραστηριοποιούνται σε κλάδους έντασης γνώσης ή τεχνολογίες πληροφορικής και επικοινωνιών (ΤΠΕ).

THE EVOLUTION OF NEW FIRMS' CHARACTERISTICS IN GREECE BEFORE AND DURING THE ECONOMIC ADJUSTMENT PROGRAMMES*

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I INTRODUCTION

Well before the beginning of the economic crisis, the Greek economy had already started to show significant weaknesses, as reflected in the deterioration of its current account and fiscal balances. From 2010 onwards, three Economic Adjustment Programmes (hereinafter EAPs) have been implemented, with the first starting in May 2010, the second in February 2012 and the last in August 2015. All programmes comprised fiscal adjustment measures to improve public finances, as well as structural reforms primarily in several goods and services sectors, in the labour market and in the functioning of the public sector, with a view to ensuring the transition of the Greek economy to a new growth model. These reforms had, to some extent, a positive impact on business environment in terms of efficiency (Vettas et al. 2017). That said, during the first two programmes, GDP decreased sharply, mainly because of the collapse in investment, causing also a significant increase in unemployment.

At the same time, the domestic banking sector has been severely affected by the crisis and especially by the "haircut" of Greek government bonds due to the PSI in March 2012, the outflow of deposits from chronic uncertainty about the ability of the Greek economy to implement the reforming policies, and the inability of a significant proportion of households and firms to repay their debts. As a result of the above, banks were recapitalised three times (in 2012, 2014 and 2015) with a total amount of €39.1 billion.

During the third EAP, which was concluded in August 2018, fiscal adjustment continued, resulting in high primary fiscal surpluses and moderate GDP growth in 2017 and 2018. The banking sector has undergone an extensive restructuring of its assets (reduction of non-performing loans) and liabilities have started to rise (increase of deposits).

In this context, as Greece makes efforts to enter a sustainable growth path, the restructuring of the country's production base is an issue of crucial importance. Shifting economic activity from low value-added sectors to activities with high productivity and knowledge-intensive sectors, attracting more foreign direct investment (through privatisations and otherwise), as well as acquiring the necessary funding to support these goals, are key issues.

All these developments are gradually reshaping the business environment in Greece. In this respect, the main objective of the present study is to examine which factors affect new firms' survival and growth in Greece and how. We do this by using firm-level data for the 2000-2016 period. Further, the study aims to trace the fac-

* This study was conducted by the Foundation for Economic and Industrial Research (IOBE) with the support of the Bank of Greece.

tors that affect firms' exporting performance throughout this period. The possible effects of the economic adjustment period are highlighted by separate estimations for 2008-2016, compared with estimations for the previous period of 2000-2007.

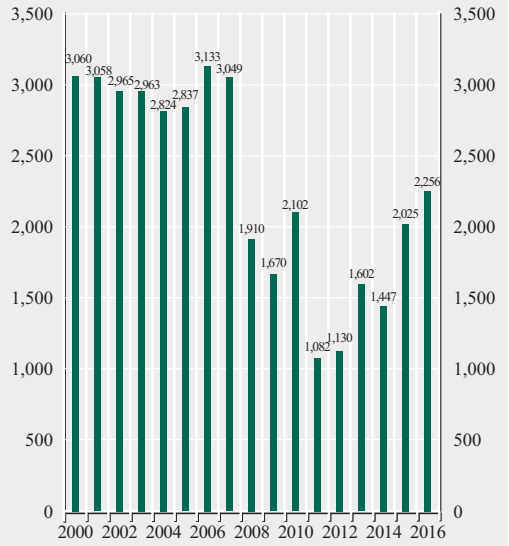
The article is structured as follows: Part 2 presents the data used, as well as some preliminary findings regarding the characteristics of new firms, with respect to their region of origin, size, sector of activity, etc. Part 3 reviews the literature on the factors that affect firm survival and describes the econometric methodology for survival analysis employed in this study; subsequently, the estimation results are presented and interpreted. Part 4 starts with a brief presentation of the literature on the importance of firms' growth, and continues with the econometric model and variables used to examine the factors that affect new firm growth; it ends with a presentation-discussion of the econometric results. Part 5 has the same structure as the previous two parts: a brief discussion on the factors found in the literature affecting the exporting performance of firms is followed by the presentation of the econometric model and variables used in the estimations about the determinants of firms' exporting decision and a discussion of the estimations results. Part 6 summarises the main findings and concludes.

2 ENTRY AND EXIT DESCRIPTIVE STATISTICS FOR NEW FIRMS

This part analyses the data on new firm entry and exit during the 2000-2016 period. The constructed unbalanced panel dataset was mainly based on data from the Infobank-Hellastat database, which collects data on firms, of all legal forms, that publish financial statements. The dataset consists of 39,113 firms that were established in 2000-2016. Before analysing the available data on firm entry, we should point out that the analysis is divided into three distinct subperiods, namely 2000-2007, 2008-2012 and 2013-2016. This approach was followed in order to examine the entry and exit behaviour of new firms: (i) before the global financial and domestic debt service crises (2000-2007: 23,889 new firms); (ii) from the beginning of the global financial crisis up to the completion of the first EAP (2008-2012: 7,894 new firms); and finally, (iii) during the second EAP and up to the last year for which data are available (2013-2016: 7,330 new firms).

Chart 1 New firms in Greece (2000-2016)

(number of firms)

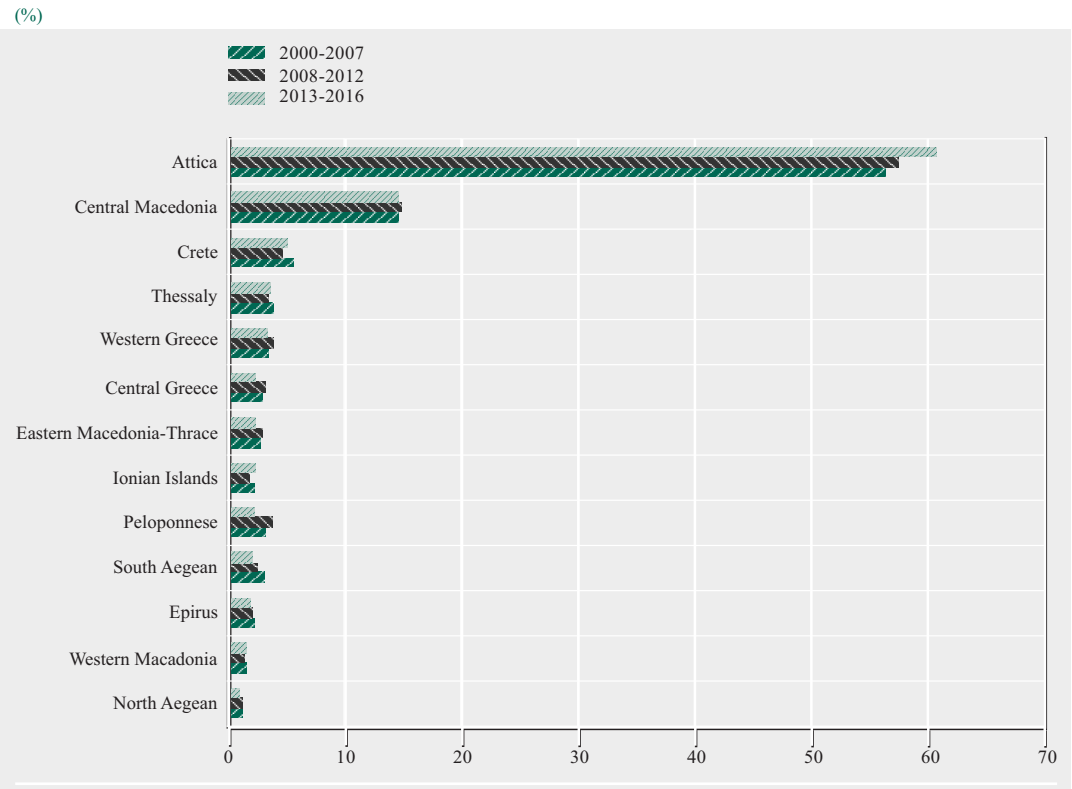


Source: Infobank-Hellastat; data processing: IOBE.

In Chart 1 we observe that until 2007 the number of new firms fluctuated around 3 thousand per year. It then declined sharply, up to 2011-2012, when it stood at 1.1 thousand annually. This trend can be attributed to the severe economic downturn at the domestic level during 2009-2012, which had a very strong negative impact on the creation of new firms. However, after 2012 the number of new firms started to rise, probably due to the easing of the recession and the prevailing economic stabilisation trends during 2014-2016, but failed to reach its pre-crisis levels.

The majority of new firms throughout the 2000-2016 period were established in the region of

Chart 2 Distribution of new firms in Greece by region of headquarters (2000-2016)



Source: MagnaCarta (2018).

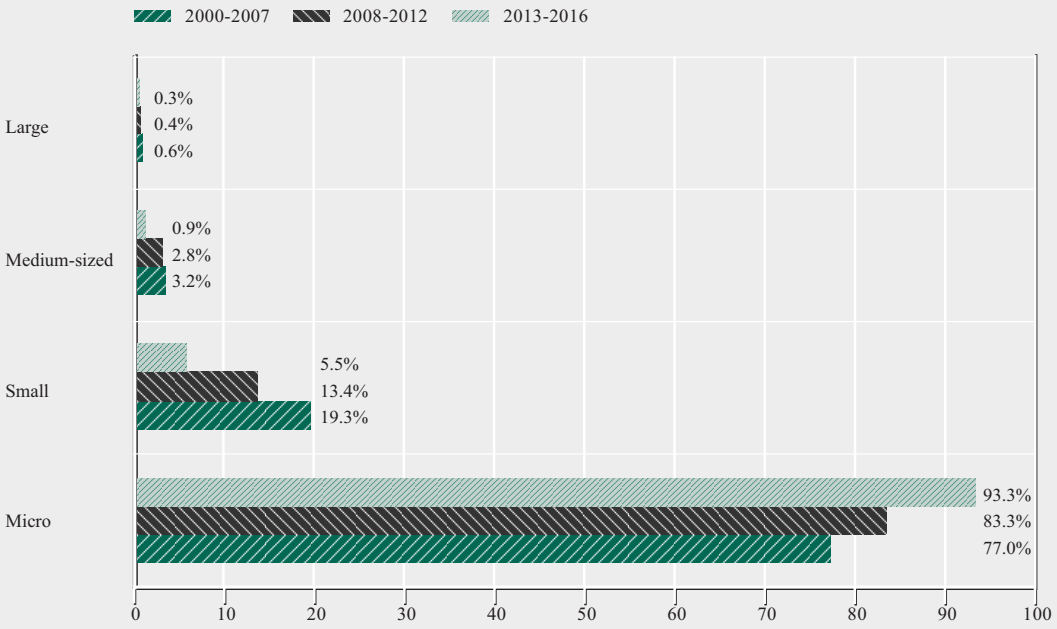
Attica (see Chart 2). During the pre-crisis period (2000-2007) the corresponding percentage was 56.2%; during the 2008-2012 subperiod, when the recession was at its height (GDP declined at an average annual rate of 5.3%), it remained almost unchanged (57.3%), and then, during the 2013-2016 subperiod, geographical concentration intensified to reach 60.6%. Attica is followed, at a much lower percentage, by the region of Central Macedonia (14.3%, 14.6% and 14.4%, respectively), whereas the North Aegean is the region with the smallest share in firms' births throughout the 2000-2016 period (1.0%, 1.0% and 0.7%, respectively).

In addition, the vast majority of new firms were micro-sized firms, i.e. firms with turnover less than €2 million, with their share increasing during the examined period (see Chart 3). From 77% in 2000-2007, it increased to 83.3% in 2008-2012 and to 93.3% in the last years (2013-2016) of the period under examination. On the other hand, only 0.6% of new firms in 2000-2007, 0.4% in 2008-2012 and 0.3% in 2013-2016 were large-scale businesses, i.e. firms with turnover over €50 million. In addition, we observe a significant decline in the share of small (turnover from €2 million to €10 million) and medium-sized (turnover between €10 million and €50 million) new firms, from 19.3% to 5.5% and from 3.2% to 0.9%, respectively.

Most of the new firms established during the 2000-2016 period were active in the sectors of Wholesale-Retail trade, Real estate, Manufacturing and Hotels-Restaurants (see Chart 4). However, there exist some differences in the shares between 2000-2007 and 2013-2016. The shares of the Construction and Wholesale-Retail trade sectors dropped by 4.8 (from 9.7% to 4.9%) and 4.5 (from 33.6% to 29.1%) per-

Chart 3 Distribution of new firms in Greece by size category (2000-2016)

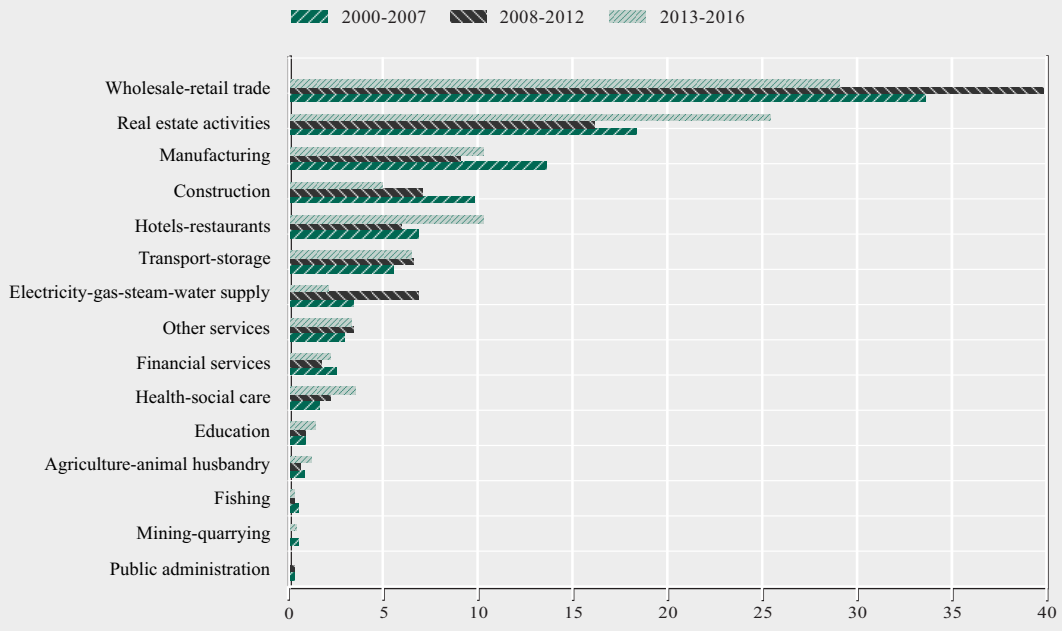
(%)



Source: Infobank-Hellastat; data processing: IOBE.

Chart 4 Distribution of new firms in Greece by sector (2000-2016)

(%)



Source: Infobank-Hellastat; data processing: IOBE.

centage points, respectively, and this is also the case for the Manufacturing sector (a drop of 3.4 percentage points, from 13.6% to 10.3%). These developments are considered to reflect the impact of recession on the disposable income of households and, accordingly, on their demand for goods, services and new dwellings. In the case of Manufacturing, apart from the domestic crisis, the economic downturn in 2009 and in 2012-2013 in the euro area, which is the most significant destination of Greek exports, took its toll on the activity of the sector. Furthermore, the share of new firms established in the Real estate sector was much higher in the latter subperiod, 25.4% against 18.3%. This was probably the result of the sharp fall in real estate prices during the period of the severe economic downturn (2008-2012), which created a strong incentive for private investors to invest their money in this market afterwards. The share of the Hotels-Restaurants sector exhibited a strong increase, from 6.8% to 10.2%, a development which is in line with the sectors's much higher receipts from inbound travellers (according to Bank of Greece data, between 2003 and 2016 travel receipts increased by 39.1% or €3.71 billion, i.e. from €9.50 billion to €13.21 billion).

3 ECONOMETRIC ANALYSIS OF NEW FIRM SURVIVAL DETERMINANTS

The purpose of this part is to trace the factors that affect new firm survival in Greece and quantify their impact. These factors are classified as firm-, sector, macroeconomic environment- and reform-specific, and originate from an unbalanced panel dataset that covers the entire 2000-2016 period. As previously mentioned, this dataset includes firms of all sizes and legal forms that are active in all sectors of the Greek economy and are located in all regions of the country. The structure of this part is as follows: The first section provides a brief literature review on the factors that affect firm survival. The second section offers a description of the econometric model and the variables used in estimations and, finally, in the third section the econometric estimations are presented and discussed.

3.1 LITERATURE REVIEW

Starting the literature review with firm-level factors, many studies find that the large initial size is associated with a higher probability of survival (Mata and Portugal 1994; Audretsch and Mahmood 1995; Strotmann 2007) because larger firms are usually closer to the minimum efficient scale of the market than smaller ones, which operate at a higher point of the cost curve (Audretsch and Mahmood 1995; Geroski 1995). However, Mata, Portugal and Guimarães (1995) support that also the current size better explains the effect of size on survival because it reflects the ability of the firm to adjust its function to the changing environment of the markets. Although the vast majority of the studies estimate that the probability of firm survival increases with age (Dunne, Roberts and Samuelson 1988; Mata and Portugal 1994; Louri, Peppas and Tsionas 2006), according to the theory of "liability of senescence" (Baum 1989; Hannan 1998), the danger of failure is greater for old firms because their response to market changes is delayed (Esteve-Pérez and Máñez 2008). In addition, Audretsch and Mahmood (1995) and Audretsch, Houweling and Thurik (2000) estimated that profitability increases survival probability. Profitability is an indication that the firm is efficient, has market power (Esteve-Pérez and Máñez 2008) and is able to finance its cash flow, investment and R&D expenditures (Caballero 1997; Hubbard 1998). However, according to Ravenscraft (1987), very profitable firms may face a higher risk of merger or acquisition by another competitor. For the opposite reasons, highly indebted firms are more likely to fail (Fotopoulos and Louri 2000a; Tsionas and Papadogonas 2006).

A number of studies have estimated that the probability of survival is higher for productive firms (Ericson and Pakes 1995; Melitz 2003) because they have a smaller unit cost of production and, as a result, they increase their

profitability. However, Esteve-Pérez and Máñez (2008) estimated that the impact of productivity on survival is non-linear because after a certain threshold its impact becomes negligible. Moreover, Audretsch, Houweling and Thurik (2000) and Fotopoulos and Louri (2000a, b) estimated that firms using a large amount of physical capital are less likely to fail and have higher growth rates. Although acquiring machinery and equipment may reduce firm liquidity, it also gives the firm a bigger production capacity and thus the ability to reduce its unit cost of production and increase its profitability, thereby enhancing its probability to survive. There is no clear evidence from the existing literature about the role of location in firm survival. On the one hand, firms that are located in or near large cities are closer to their suppliers, customers, the labour market and the companies with which they cooperate (Fotopoulos and Louri 2000a). On the other hand, large urban areas have characteristics that increase the cost of production, such as high level of wages/salaries as well as traffic congestion, thereby increasing overall costs and putting pressure on the probability to survive (Strotmann 2007). As far as the legal form of the firm is concerned, Harhoff, Stahl and Woywode (1998) estimated that limited liability firms have in general fewer chances to survive because their owners are not (legally) responsible for the company's total liabilities. However, Buehler, Kaiser and Jaeger (2005) found that sociétés anonymes have a higher probability of survival than limited liability firms because the former have higher total assets and better access to funding than the latter, which are features that improve their probability of growth and survival.

Moreover, the results of export performance on firm survival are clear. Firms that export have better survival probabilities (Buehler, Kaiser and Jaeger 2005; Esteve-Pérez, Sanchis-Llopis and Sanchis-Llopis 2004). Competition in international markets is harsher and impels domestic firms to become more productive in order to cope with the competition they face. R&D activity and innovation are closely linked, as the first is the main input to the innovation process (Cefis and Marsili 2005). Hall (1987) estimated that the higher R&D spending is, the lower the risk of failure becomes, as R&D activities contribute to the accumulation of specialised knowledge that increases the value of the firm. Moreover, Choonwoo, Kyungmook and Pennings (2001) found that high-technology usage has a positive effect on new firm performance, while Doms, Dunne and Roberts (1995) estimated that high technology positively affects firm survival. Finally, Cefis and Marsili (2005) found evidence that process innovation also has a positive impact on chances to survive. Intellectual property, in the form of patents and intellectual property rights, enables firms to acquire comparative advantages against competitors and, as a result, increases their probability to survive (Audretsch and Lehmann 2005).

With respect to the effects of sector-specific factors, the role of the minimum efficient scale has been examined by the literature, with ambiguous results about the impact of this variable on firm survival. According to Strotmann (2007), this outcome can be attributed to the different measures used in the literature to construct this variable. Audretsch (1995), Tsionas and Papadogonas (2006) and Strotmann (2007) estimated that there exists a positive relationship between minimum efficient scale and survival because firms operating on or above minimum efficient scale of the sector have a cost advantage compared to other smaller competitors. However, Mata and Portugal (1994) and Tsekouras, Skuras and Daskalopoulou (2007) found no statistically significant relationship between minimum efficient scale and probability of survival. Many studies estimate a positive relationship between sectoral growth rate and survival (Audretsch 1995; Audretsch and Mahmood 1994, 1995; Mata and Portugal 1994; Segarra and Callejón 2002), as growing demand due to market growth increases firms' sales and, ceteris paribus, the price-cost margin. However, Burke, Görg and Hanley (2006) estimated that newcomers to high-tech sectors

with high growth rates face a greater risk of failure due to harsh competition in terms of technology. In addition, several studies have estimated that there are fewer chances to survive in sectors where the number of entering firms is large (Mata and Portugal 1994; Mata, Portugal and Guimarães 1995; Fotopoulos and Louri 2000a; Strotmann 2007), due to the fact that new firms, as well as those already active in the market, are facing stronger competitive pressure and many of them are forced to exit. Therefore, even if entry into a market is easy, survival is difficult (Geroski 1995).

As far as market concentration is concerned, Görg and Strobl (2003) estimated that the risk of failure increases with market concentration, whereas Audretsch (1991) found that high concentration facilitates survival only in the short run, while in the long run it has no statistically significant effect. In addition, Tsionas and Papadogonas (2006) and Strotmann (2007) estimated that concentration positively affects firm survival, while Mata and Portugal (1994) and Tsekouras, Skuras and Daskalopoulou (2007) found no statistically significant relationship between market concentration and firm survival. Regarding the impact of sectoral R&D activity, Audretsch, Houweling and Thurik (2000) estimated that in R&D intensive industries, firms exhibit high failure rates. Similarly, Segarra and Callejón (2002) found a negative relationship between chances to survive and sectoral R&D, while Audretsch, Houweling and Thurik (2000) estimated that its negative impact on firm survival is limited in the short run. According to Audretsch, Houweling and Thurik (2000), this result implies that firms which succeed in adapting their functioning to the standards of an industry with high uncertainty, such as R&D intensive industries, eventually manage to survive. Finally, according to the literature, the higher the sunk cost in an industry, the greater the survival probability of a firm that incurs that cost. In other words, firms that incur high sunk costs are strategically committed to their competitors that they will not exit from the industry, i.e. high sunk cost is implicitly a barrier to exit.

Regarding the effects of macroeconomic factors, the literature does not give a clear answer to their role in firm survival probability. Audretsch and Mahmood (1995) estimated that the probability of failure was greater for new US manufacturing firms during periods of high unemployment (i.e. recession). For a sample of new firms established in Greece during the 1982-1984 period, Fotopoulos and Louri (2000b) estimated that firms established closer to an economic recession faced a higher exit probability. This result was attributed to their lack of experience due to their short-time activity in the market, which did not allow them to adapt their strategies appropriately to the upcoming adverse macroeconomic conditions. Buehler, Kaiser and Jaeger (2005) found for Swiss manufacturing enterprises during the 1995-2000 period that the increase in the exchange rate of the Swiss franc raised the risk of failure. This increase made Swiss products more expensive abroad, thereby deteriorating the competitiveness of domestic firms abroad and improving the competitiveness of foreign products in the Swiss market. Finally, in their study of Finnish manufacturing during the 1988-1993 period, Ilmakunnas and Topi (1999) estimated that the impact of macroeconomic conditions on the decision to exit was not clear. More specifically, they estimated that the change in money supply had a statistically insignificant effect on the exit decision, whereas the effect of the level of real interest rates, although positive, was small. GDP growth and access to capital markets were estimated to have a negative impact on the exit decision, but their magnitude was also marginal.

In recent years, the literature has focused on the role of the entrepreneur's characteristics on firm survival. In this respect, the findings about the role of the entrepreneur's age are not clear. On the one hand, Wennderg et al. (2010) argue that age is linked with entrepreneurial characteristics, such as experience and maturity in problem solving. In this context, firms managed by older entrepreneurs have higher chances to survive. However, Van Praag

(2003) argues that the non-failure of firms managed by older owners is due to the fact that they have no incentive to sell them, as they do not have the time to establish a new one; that is, these entrepreneurs face a high switching cost, which prevents them from deciding to close their firms. On the contrary, Taylor (1999) estimated that firms owned by older people are more likely to fail. In this vein, Bates (2005) noted that older entrepreneurs have a greater motive to sell their business not as a result of failure, but because they want to retire. The entrepreneur's experience is one of the most important intangible resources for predicting the probability of survival of a firm. Entrepreneurs' experience is related to characteristics such as management skills and knowledge that are essential for survival. Kocak et al. (2010) and Van Praag (2003) argue that firms managed by an experienced entrepreneur have lower probability of failure. However, other studies have estimated the opposite result or do not give a clear answer on the role of experience in failure probabilities (e.g. Gimeno et al. 1997; Jørgensen 2005). In addition, Van Praag (2003) and Bates (2005) argue that entrepreneurs with previous business start-up experience are more experienced in the way firms grow and survive, while Westhead and Wright (1998) argue that these have better knowledge of alternative sources of financing for their firms. Finally, according to theory, a highly educated entrepreneur has specialised knowledge and skills that enable them to evaluate alternative business choices and make the right decision. Kocak et al. (2010) argue that a high level of education of an entrepreneur is associated with better firm performance, whereas Brüderl et al. (1992) estimated that a high level of entrepreneurs' education is associated with a higher probability of survival.

3.2 ECONOMETRIC MODELS AND VARIABLES USED IN THE ESTIMATIONS OF THE FIRM SURVIVAL MODEL

In the survival literature, the main econometric model used for survival analysis is the Cox Proportional Hazard Model (Cox 1972), which estimates the probability of a firm to exit from a market in period t, given that it has survived up to period t-1. The main advantage of this model is that it does not impose a specific distribution on the survival time of firms, as opposed to parametric survival models (e.g. Weibull, Exponential, Log-normal). Thus, the Cox Proportional Hazard Model can be applied without restrictions to any survival data. The model in the case of unbalanced panel data is the following:

$$h_i(t) = h_0(t)\mu_i(t)$$

where $\mu_i(t) = e^{\beta X_i(t)}$, with $h_i(t)$ being the risk that a firm exits from the market in period t given that it has survived up to period t-1, $h_0(t)$ is the baseline hazard function at time t for a vector of null covariates which depends solely on time and $\beta X_i(t)$ is the vector of covariates that are firm-, industry- and macroeconomic environment-specific. A general form of the partial likelihood that allows for time-varying covariates is given by:

$$L = \prod_{j=1}^{M} \frac{\mu_{ij}(t_j)}{\sum_{\kappa \in R_j} \mu_{\kappa}(t_j)}$$

Lancaster (1990) suggests that an important feature of this expression is that, as the jth term of the product is calculated at time $t_{(j)}$ for each of the j=1...M observed exit times, and R_j defines the set of individuals at risk at each time, the entire path of covariates for each firm (i) up to time t, when the firm becomes censored or exits, can be accommodated. That is, it allows for multiple observations per firm.

As a first step, we estimate the effects of firm, sector and macroeconomic environment covariates on firm survival using the Cox model. However, in order to check for the sensitivity of the results, we also estimate Probit and Logit models for unbalanced panel data. The literature has developed a Random Effects approach for the Probit model and the Fixed and Random Effects approaches for the Logit model. For comparability reasons, we

estimate in the present study Probit and Logit Random Effects models, where both x_{it} and u_i are assumed to be uncorrelated.

In addition, we estimate a discrete hazard dynamic Logit model using the Maximum Likelihood Method (Charalambakis 2013). This is a more flexible approach that allows the baseline hazard to be estimated non-parametrically, which has been shown to reduce potential biases in estimating the β's and reduces negative duration bias (Shumway 2001). This is very important, since in the present study we use time-varying covariates. This model is constructed with the use of time dummies, and its functional form is as follows:

$$\log\left[\frac{h_{it}}{1-h_{it}}\right] = \theta_t + \beta X_i(t)$$

where h_{it} is the risk that firm i exits from the market in period t given that it has survived up to period t-1 and $\beta X_i(t)$ is the vector of covariates. Discrete time enters the model through parameter θ_t for each possible failure time.

The variables used in the estimations are the following:

- **current size (size):** the logarithm of a firm's total assets. The data used to construct this variable come from the Infobank-Hellastat database.

- **fixed capital to total assets (fixedtotal):** the ratio of a firm's fixed capital to its total assets. The data used to construct this variable come from the Infobank-Hellastat database.

- **total liabilities (leverage):** the ratio of a firm's total liabilities to its total assets. The data used to construct this variable come from the Infobank-Hellastat database.

- **profitability (profit):** the ratio of a firm's earnings before interest and taxes (EBIT) to its turnover. The data used to construct this variable come from the Infobank-Hellastat database.

- **market concentration (herf):** the Herfindahl-Hirschman concentration index is used, which is as follows:

$$H = \sum_{i=1}^{n} \left(\frac{x_{ij}}{X_j}\right)^2$$

where x_{ij} is the turnover of firm i in sector j and X_j is the total turnover of sector j. The data used to construct this variable come from the Infobank-Hellastat database.

- **GDP change (gdp):** annual percentage changes in Greek GDP during the 2000-2016 period. Data for this variable come from the IMF database.

- **tax burden (taxrate):** dummy variable equal to 1 when firms' tax burden is reduced on a year-on-year basis, and zero otherwise. The index used to construct this variable was derived from the World Bank's *Doing Business* annual report database. This index measures the tax cost, including profit taxes, consumption taxes, labour taxes and mandatory contributions, as a percentage of profit borne by the standard firm.

- **export activity (exp):** dummy variable equal to 1 in a year when a firm exports its products, and zero otherwise. The data to construct this variable come from the ICAP database.

- **finance (funding):** dummy variable equal to 1 when bank financing of firms increases on a year-on-year basis, and zero otherwise. The data to construct this variable come from the Bank of Greece database.

- **location (location):** dummy variable equal to 1 when a firm is located within the regions that include the two largest cities (Athens and Thessaloniki) of Greece, namely Attica and Central Macedonia. The database used to construct this variable is from Infobank-Hellastat.

- **legal form (dummy variables ae, epe and ike):** dummy variables equal to 1 when firms have

the legal form of a Société Anonyme (ae), a Limited Liability Company (epe) and a Private Company (ike), respectively, and zero otherwise. The data to construct this variable were derived from the Infobank-Hellastat database.

- **sector (dummy variables manufacture, trade, tourism, electrgaswater and services):** dummy variables equal to 1 in case firms are active in the sectors of Manufacturing, Wholesale-Retail trade, Hotels-Restaurants, Electricity-Gas-Water supply and Services, respectively, and zero otherwise. The data to construct this variable were drawn from the Infobank-Hellastat database.

- **knowledge-ICT intensive firms (dummy variables kibs, kis, ictmanuf, ictserv):** dummy variables equal to 1 if a firm is a knowledge intensive business services firm (kibs), a knowledge intensive services firm (kis), an ICT manufacturing firm (ictmanuf) or an ICT services firm (ictserv), respectively, and zero otherwise. The data to construct this variable come from the Infobank-Hellastat database.

- **minimum capital required to start a business (mincapstart):** dummy variable equal to 1 if the minimum capital (% of income per capita) required to start a business is reduced on a year-on-year basis, and zero otherwise. The data to construct this variable come from the World Bank's *Doing Business* annual report database.

- **cost to export/import (dummy variables costexp and costimp):** dummy variables equal to 1 if the cost for a firm to export or import is reduced on a year-on-year basis, and zero otherwise. The index used to construct these variables comes from the World Bank's *Doing Business* database. This index covers documentation requirements and procedures at customs and other regulatory agencies as well as at ports. It also covers logistical aspects, including the time and cost of inland transport between the largest business city and the main port used by traders.

3.3 ECONOMETRIC RESULTS OF THE SURVIVAL ANALYSIS

3.3.1 Results for the 2000-2016 period

The presentation of the results begins with those for the basic econometric specification, which contains covariates that are usually used in the survival analysis literature, namely current size, ratio of fixed to total assets, leverage, profitability, and market concentration. In every alternative estimation, we include one of the independent variables presented in the previous section. Not all additional variables are simultaneously included in the estimations, in order to avoid econometric problems (e.g. multicollinearity). For each estimation, the results of the likelihood ratio test are also presented in order to check for the statistical significance of the econometric results, the variance inflation factor test is performed to check for the existence of multicollinearity, and the Akaike and Bayesian information criteria are used in order to check for the relative quality of different model specifications. In all the model specifications, the survival time is represented by a non-negative, continuous, random variable T, which indicates the number of years a firm has survived during the 2000-2016 period. We should also mention that a negative sign of an explanatory variable means that it negatively affects the risk of exit, i.e. positively affects firm survival. Accordingly, a positive sign of an explanatory variable means that it positively affects the risk of exit, i.e. negatively affects firm survival.

As mentioned above, except for the Cox proportional hazard model, we also estimated Random Effects Probit and Logit models, where x_{it} and u_i are assumed to be uncorrelated, as well as a discrete time hazard model. We repeated the above estimations with the inclusion of time dummies and sector dummies in order to control for the effects of macroeconomic and sectoral conditions. We will present here the results for all three models only in the case of the basic econometric specifications. For all other estimations, we only present the results with the Cox model, while

the results with the Probit and Logit models as well as those with time and year dummies are not presented due to space limitations, but are available upon request.

Proceeding with the results, in all cases (Cox, Logit and Probit models), current size (size) negatively affects the risk of exit or, in other words, positively affects firm survival and in all estimations it is statistically significant at the 1% level (see Table 1 in the Appendix). This result is in line with the literature, according to which larger firms have better chances to survive. In order to check the literature's finding that the positive effect of size decreases with time (e.g. Cefis and Marsili 2005; Strotmann 2007), the models were re-estimated using the square of this variable. However, the sign and the statistical significance of the results remain unchanged.

In addition, firms with a high fixed capital/total assets ratio (fixedtotal) have a higher probability of survival (statistically significant at the 1% level in all estimations). According to Fotopoulos and Louri (2000b), firms with a high fixed capital commitment have on the one hand lower liquidity, but on the other hand this indicates their commitment to remain in the market because the exit choice is costly (Doms, Dunne and Roberts 1995). At the same time, high fixed capital commitment enhances productivity, while fixed capital can be used as collateral in order to get access to financing from the banking system.

Moreover, highly leveraged firms (leverage) have a higher risk of failure (statistically significant at 1% in all estimations). Higher payments for increased liabilities reduce the available resources for other productive choices such as investment in new technologically advanced equipment, financing of customer network expansion, etc. (e.g. Fotopoulos and Louri 2000b; Louri, Peppas and Tsionas 2006; Tsionas and Papadogonas 2006).

Regarding the effect of profitability (profit), in all models it was found to be statistically insignificant. Although the literature estimated that firms with high profitability are more likely to survive (Doi 1999; Fotopoulos and Louri 2000a, b), there is a number of studies that do not estimate a statistically significant relationship between profitability and survival (e.g. Evans and Siegfried 1993; Tsionas and Papadogonas 2006).

In line with the literature, it was estimated that market concentration (herf) negatively affects firm survival. In markets where concentration is high, firms with a high market share are likely to adopt an aggressive behaviour towards other smaller firms, with negative effects on their probability of survival (Görg and Strobl 2003b). In all estimated models, the result is statistically significant at the 1% level.

Year and sector dummies were also included in the estimations, in order to check for the consistency of the results. In all cases, the sign and the size of the variables as well as the significance level of the results remained unchanged. However, in the case of Probit, Logit and discrete time hazard Logit models, due to the use of many dummies, especially when using simultaneous year and sector dummies, multicollinearity problems emerged, as indicated from the variance inflation factor test.

As mentioned above, in each of the additional estimations we also include a different explanatory variable, which is firm-, sector-, macroeconomic environment- or reform-specific (see Table 2 in the Appendix).

Column 1 of Table 2 shows that GDP change (gdp) negatively affects the risk of exit, i.e. positively affects firm survival. However, this result is statistically significant only in Probit and Logit models (at the 1% level), and the size of the estimated coefficients is high, implying a strong positive effect. Thus, a favourable macroeconomic environment seems to provide opportunities for young firms to grow and survive (Audretsch and Mahmood 1995; Fotopoulos and Louri 2000b; Buehler, Kaiser and

Jaeger 2005). It is stressed that when using the gdp variable, the result for the fixedtotal variable is statistically insignificant in Probit and Logit estimations.

In addition, a lower tax burden (taxrate) positively affects firm survival (see column 2 of Table 2), with this result also being statistical significant. Reducing the tax burden allows firms to finance their investment projects (e.g. acquire new equipment) or cash flow, recruit additional staff, develop new advertising campaigns, etc. However, in this specification, the results for the leverage variable in the Cox regression model and for the fixedtotal variable in Probit and Logit models are statistically insignificant.

Along the same lines with the literature (Buehler, Kaiser and Jaeger 2005; Esteve-Pérez, Sanchis-Llopis and Sanchis-Llopis 2004), export orientation (exp) strengthens the probability of survival (see column 3 of Table 2). This result probably stems from higher competition in international markets. Thus, domestic firms become more productive, which in turn reduces the risk of failure. This effect is statistically significant at the 1% level with all models.

Location of a firm within the regions of Attica and Central Macedonia (location) increases the risk of exit, i.e. negatively affects its chances to survive (see column 4 of Table 2). This result is consistent with that strand of the literature, which argues that the establishment of a firm near large urban areas increases the risk of failure because new firms face intense competition from a large number of other firms operating in the same sector. At the same time, large urban areas have characteristics that increase production and operating costs (e.g. Strotmann 2007).

Concerning the impact of the legal form (see columns 5-7 of Table 2), it was found that being a Société Anonyme (ae) raises the probability of survival. The structural characteristics of such firms, such as the existence of shareholders, separation between management team and shareholders, minimum capital required, which is very high in some sectors, the obligation to publish financial statements audited by chartered accountants, etc., constitute a framework that, to some extent, ensures sound financial performance and solvency, thereby reducing the risk of failure. On the other hand, being a Limited Liability Company (epe) or a Private Company (ike) increases the risk of exit. Firms with this legal form have lower capital and more limited access to financing sources, as opposed to Sociétés Anonymes. Therefore, they are more vulnerable during periods of poor performance or adverse macroeconomic conditions. In addition, management control mechanisms are not as stringent as in a Société Anonyme and, as a result, risks to survival arising from wrong management decisions are heightened. Moreover, the coefficient in the case of the ike dummy is higher than the coefficient of the epe dummy, implying that the former firms face a higher risk to their survival than the latter ones, probably because the legal form of a Private Company is usually adopted by very small firms, making them vulnerable to market fluctuations and competition from larger firms.

As far as the effect of the sector of activity on survival is concerned (see columns 8-12 of Table 2), operating in the Trade (trade) and Services (services) sectors increases the risk of failure. This result reflects the fact that firms in these sectors are smaller, on average, than firms in the Manufacturing or Electricity-Gas-Water supply sectors, and more vulnerable to competition. We should also stress that firms in the former sectors have come under increasing pressure due to the protracted recession, which has led to the reduction of households' and firms' disposable income and consumption. Firms in the Manufacturing sector (manufacture) have, on average, a higher probability to survive, perhaps because a sharp decline in domestic demand can be partially offset by higher sales in international markets. This result is statistically significant at the 5% level only in Probit and Logit estimations. Also,

firms in the Electricity-Gas-Water supply sector (electrgaswater) have a lower risk of failure, probably because competition in this sector is not so intense, as fewer firms are active in this specific market, compared with other sectors. In addition, in certain segments of this market, e.g. in photovoltaic power generation, production is absorbed at feed-in tariffs, which practically eliminates business risk. However, this effect was statistically significant only in the Cox model estimation. Finally, the estimations for the tourism dummy were statistically insignificant in all models.

Regarding firms in sectors that are knowledge or ICT intensive (see columns 13-15 of Table 2), namely knowledge intensive business services (kibs), knowledge intensive services (kis) and ICT services (ictserv) firms, they appear to have a lower risk of failure. Their characteristics, such as the fact that they are more innovative than firms in other sectors (e.g. Wholesale-Retail trade or Tourism), thereby making it easier for them to create strategic technological competitive advantages and exploit experience economies, contribute to achieving a sustainable dynamic path (Giotopoulos 2014). That said, the result for the ictmanuf dummy was statistically insignificant in all models.

The reduction in the minimum capital required to start a business (mincapstart) was estimated in all models to lower the risk of failure (see column 16 of Table 2). This minimum capital reduction (only €1 in the case of a Private Company) saves valuable financial resources for new firms that can be directed to other purposes, such as acquisition of better machinery and equipment, recruitment of skilled staff that raises productivity and, thus, survival probabilities, etc.

As far as the cost of imports (costimp) and exports (costexp) is concerned, estimations (see columns 17 and 18 of Table 2) were limited only to firms that produce goods, because the World Bank's relevant Doing Business indices evaluate the cost of imports/exports of goods. In all three models, it was estimated that the decrease of these costs reduces the risk of failure, most probably because it makes the process of importing and exporting less costly, which in turn increases the price-cost margin and, thus, the profitability of firms. However, in the estimation with the costimp dummy, the result for the effect of market concentration on firm survival (herf) is statistically insignificant in all models.

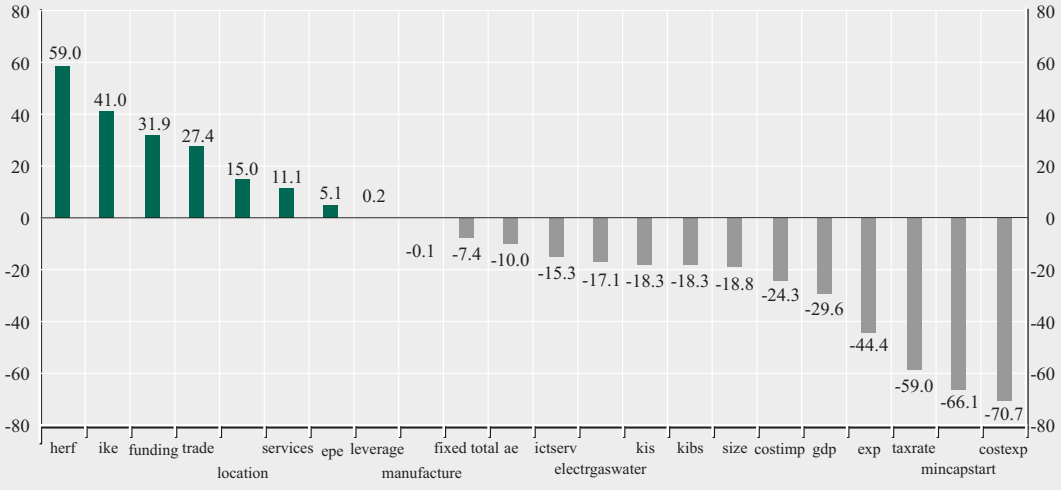
Finally, the reduction of firms' financing from the banking sector (funding) increases the risk of failure.[1] Lack of bank financing limits the ability of firms to fund investment projects or other activities (purchase of raw materials, advertising campaigns, etc.) and puts pressure on their cash flow, with adverse effects on their probability of survival.

Concluding the discussion of the results for the 2000-2016 period, we focus on the magnitude of the effects of each explanatory variable (see Chart 5). The strongest positive effects on the survival of new firms come from the reduction in export costs (70.7% lower risk of failure), minimum capital required to start a business (66.1% lower risk) and tax burden (59% lower risk), as well as from the export orientation of firms (44.4% lower risk of failure). That is, from factors that are significant aspects of the regulatory framework under which new firms operate and from their export orientation. These findings are particularly important and should be taken into consideration by policy makers in the process of designing reforms that will further improve the business environment and contribute to the transformation of the growth model of the Greek economy.

On the other hand, the strongest negative risks for new firm survival stem from the degree of market concentration (59% higher risk of fail-

1 Due to space limitations, this estimation is not presented in Table 2 of the Appendix, but is available upon request. The estimated coefficient of this variable has value 0.2765, standard error 0.0236 and level of significance 1% in the Cox model. In the Logit model, the coefficient has value 0.9286, standard error 0.0223 and level of significance 1%. In the Probit model, the coefficient has value 0.4644, standard error 0.0110 and level of significance 1%.

Chart 5 Calculated probability of higher risk of failure (red columns) and lower risk of failure (blue columns) per explanatory variable (2000-2016)



Source: IOBE.

ure), the legal form of a Private Company (41% higher risk), lack of financing (31.9% higher risk) and operation in the Wholesale-Retail trade sector (27.4% higher risk).

In these estimations, year and sector dummies were also included, in order to check for the consistency of the results. Some small differences have emerged, with respect to the direction and the size of the effects of explanatory variables. They are not presented herein, however they are available upon request.

3.3.2 Results for the 2000-2007 subperiod

In order to examine whether the effects of explanatory variables on survival change after the global financial crisis and the implementation of fiscal consolidation measures and structural reforms in Greece, the same estimations were carried out for two distinct periods. For this purpose, two datasets were created from the initial dataset. The first concerns firms that were established during the years 2000-2007, a period of high credit expansion, strong economic growth and historically low unemployment. The second dataset covers the 2008-2016 period, when Greece lost access to the financial markets and the fiscal consolidation efforts, coupled with the gradual restructuring of the economy, led to a protracted, severe recession, sky-high unemployment and capital inadequacy of the banking sector.

Starting from the 2000-2007 subperiod (see Table 3 in the Appendix), the econometric results slightly differ from those for the 2000-2016 period. More specifically, as previously estimated, new firms of large size (size), which do not spend a large part of their resources on the minimum starting capital (mincapstart), have a high fixed capital to total assets ratio (fixedtotal), have a Société Anonyme (ae) legal form, are active in the Manufacturing (manufacture) or Electricity-Gas-Water supply (electrgaswater) sectors, are knowledge-ICT intensive (kibs, kis, ictserv) and export-oriented (exp), and face lower costs for imports/exports (costimp, costexp) and a lower tax burden (taxrate), have a higher probability of survival.

Also, as evidenced by the initial estimations, new Limited Liability firms (epe), located in

the regions of Attica or Central Macedonia (location), operating in the Wholesale-Retail trade (trade) or Services sectors (services) and in sectors with high market concentration (herf), that are highly leveraged (leverage) and do not have access to financing from the banking system (funding)[2], have a greater risk to fail.

Again, profitability (profit) and activity in the tourism sector do not exert a statistically significant effect on new firm survival. The effect of being a Private Company (ike) on survival was not estimated, as such a legal form did not exist at the time.

Regarding any differences compared with the results for the overall period, although favourable macroeconomic conditions (gdp) were estimated with the Logit and Probit models to increase the probability of firm survival, the opposite result was estimated with a Cox regression model, but it is not possible to justify this result, especially given the strong economic growth of 2000-2007. The coefficients of the gdp variable in Logit and Probit models have higher values than in the case of the 2000-2016 estimations. This result indicates that the high growth rates of the Greek economy during the 2000-2007 subperiod exerted a considerable positive effect on new firm survival.

In the case of the epe variable, although its effect is positive and significant in the Logit and Probit estimations, suggesting a negative effect of the "Limited Liability Firm" legal form on new firm survival, in the Cox regression model the sign is negative and the result is statistically significant at the 5% level. The latter result cannot be justified by the available data.

Concerning the ae and ictserv variables, although under the estimations with the Logit and Probit models the results for the 2000-2007 subperiod are the same as the results for the 2000-2016 period, they are different and statistically insignificant in the case of the Cox model.

As far as the magnitude of the estimated coefficients is concerned, in the case of variables that positively and significantly affect firm survival, i.e. size, fixedtotal, taxrate, kibs, kis, mincapstart, costexp and costimp, in all three models the estimated coefficients for the 2000-2007 subperiod are lower in absolute value. As a result, their positive impact on new firm survival is weaker.

In the case of variables that negatively affect firm survival (variables with a positive sign), there are variables (leverage, location) whose estimated coefficients in all three models for the 2000-2007 subperiod are higher in absolute value than those for 2000-2016. This result indicates that the negative risks that they pose to new firms' survival are higher. The estimated coefficient of the trade variable for the 2000-2007 subperiod is lower in absolute value, so its negative effect on survival is lower. For the remaining variables that have statistically significant results, we do not observe any specific trend in the magnitude of the coefficients, as opposed to the initial estimations.

3.3.3 Results for the 2008-2016 subperiod

The results for the 2008-2016 subperiod (see Table 4 in the Appendix) differ significantly from those for the entire 2000-2016 period. Size continues to affect positively firm survival. In addition, profitability (profit) again does not affect new firm survival, but contrary to the results about the overall period under examination, most estimations about high fixed capital commitment (fixedtotal) and high market concentration (herf) over the 2008-2016 subperiod do not affect firm survival in a statistically significant way. Only in the Cox model the estimations for the fixedtotal variable are statistically significant in all specifications. For the leverage variable, in most specifications of

2 Due to space limitations, this estimation is not presented in Table 3 of the Appendix, but is available upon request. The estimated coefficient of this variable has value -0.0267 and standard error 0.0294, but the result is statistically insignificant in the Cox model (level of significance 36%). In the Logit model, the coefficient has value 0.8744, standard error 0.0243 and level of significance 1%. In the Probit model, the coefficient has value 0.4320, standard error 0.0120 and level of significance 1%.

all models, the results are also statistically insignificant. However, where these are statistically significant, the sign of the variable remains positive, which implies a negative effect on firm survival, but the level of significance drops to 10%, from 1% under the 2000-2016 estimations.

The effect of GDP on firm survival is estimated negative in all models and statistically significant at the 1% level in all models. The fact that in eight out of the nine years of the 2008-2016 period the Greek economy has been in recession justifies this result.

Moreover, the results in the recent subperiod regarding the effects on firm survival from location in the regions of Attica and Central Macedonia (location) and from activity in the sectors of Manufacturing (manufacture), Electricity-Gas-Water supply (electrgaswater) or Services (services) are, contrary to the initial estimations, statistically insignificant. Estimations with Probit and Logit models concerning the impact of being either a Limited Liability Company (epe) or a Private Company (ike) on firm survival are also insignificant. In the Cox model estimations, being a Private Company negatively affects new firm survival, whereas the opposite effect is estimated for firms that have the legal form of a Limited Liability Company. The latter effect is the opposite of that for the 2000-2016 period. However, being a Société Anonyme (ae) still positively affects new firm survival, but this result is statistically significant in two out of the three models (Logit and Probit models).

The reduction of tax burden (taxrate) continues affecting positively the probability of new firm survival during 2008-2016 and the estimated coefficients are, in absolute value, higher than those for the 2000-2016 period, implying that the positive effect is stronger in the recent years. Thus, during the period of fiscal consolidation and reforms, it was crucial to facilitate firms' operation through tax cuts, allowing them to save valuable financial resources. It is noted that the estimates with the exp variable are not presented, due to multicollinearity problems.

Operation of new firms in the Wholesale-Retail trade sector (trade) negatively affects survival during 2008-2016, as is also the case for the overall period under review. This result is in line with the fact that the sector witnessed a sharp decline in its turnover, due to fiscal consolidation measures and the contraction of credit to households, which put pressure on households' disposable income. These developments are reflected in the trend of the seasonally adjusted volume index in retail trade, which cumulatively declined by 38.7% during the examined subperiod.

At the same time, operation in the Tourism sector (tourism) negatively affected the probability of survival, whereas its impact was initially found to be insignificant. Despite an increase of 13.5% in receipts from travel services to non-residents during 2008-2016 (from €11.6 billion to €13.2 billion), the estimates showed that new firms' survival was not favoured by this development. This result is likely to reflect on the one hand the sharp decline in domestic tourism and on the other hand the escalating competition from neighbouring countries.

It is noteworthy that despite the strong recession of 2008-2016, firms operating in knowledge-ICT intensive sectors (kibs, kis, ictserv) continue having better chances to survive, with a stronger positive effect, as evidenced by the higher estimated coefficients in absolute value, compared with the 2000-2016 period as a whole. Therefore, the estimates suggest that particularly in times of recession, as in the case of the 2008-2016 subperiod, it is important to facilitate the start-up of knowledge-ICT intensive firms, which can develop comparative advantages easier than other businesses and thus generate more value added for the economy.

Moreover, lower costs to start a new business (mincapstart) and to export/import (costexp and costimp) were found to have a positive

impact on new firms' survival. These positive effects are stronger, as indicated by the higher estimated coefficients for those variables. Thus, except for the reduction of the tax burden, it is imperative that new firms are facilitated in terms of both the cost to start their operation and the cost to export their products and import raw materials, machinery, etc.

Finally, as in the previous estimations, the lack of financing from the banking system (funding) increases the risk of failure, a result that is statistically significant under the Probit and Logit models at 1% level of significance.[3]

4 ECONOMETRIC ANALYSIS OF THE FACTORS THAT AFFECT NEW FIRMS' GROWTH

The study continues with the econometric estimations of the factors that affect new firm growth. These factors can be categorised as firm-specific, including financial variables (e.g. liabilities, liquidity) and variables concerning firm characteristics (age, size), and sector-specific, such as market concentration. As in the previous part of the study, data and estimations cover the 2000-2016 period, but separate estimations are carried out for the 2000-2007 and 2008-2016 subperiods. The structure of this part is as follows: the next section offers a brief discussion on the factors that affect growth at the firm, industry and economy level, based on the relevant literature; then follows the description of the econometric model and the variables used in the estimations of the present study; finally, in the third section, we present and discuss the econometric results.

4.1 LITERATURE REVIEW ON THE IMPORTANCE OF FIRM GROWTH

The study of the factors that affect firm growth is very extensive in the literature, mainly because fast growing firms are the driving force behind job creation (Wagner 1992; Delmar et al. 2003). Moreover, the growth rate of new firms is closely linked with survival. The literature estimates that a high growth rate is positively related with firm survival (Mata 1994; Fotopoulos and Louri 2000).

At the regional level, firm growth can also be important, because it is expected to have a positive impact on regional economic development. In particular, acceleration of firm growth in a specific sector can boost demand for products/services from other related sectors of the same region and thereby boost economic activity at the regional level. Conversely, a decline in the number of employees of large firms may lead to a significant drop in the economic activity of a specific region (Penrose 1959).

In addition, the goal of higher growth may indirectly motivate firms to adopt innovations in order to achieve it (Pagano and Schivardi 2003). For example, if a new firm seeks to achieve a high growth rate and increase its probability of survival in a highly competitive industry, a strategic action could be to adopt new technologies in order to be more efficient in terms of production.

Furthermore, the evolution of the size distribution of new entrants and of existing incumbents can affect the degree of market concentration. As small firms grow fast, competition becomes more intense and more significant market changes are expected. On the other hand, if large firms grow, then an increase in market concentration is expected. Thus, the monitoring of business growth at the sectoral level helps to follow trends in the degree of market concentration and competition, and could provide valuable information to competition regulatory authorities in order to intervene and avoid monopolistic or oligopolistic market structures in a sector (Shepherd 1979).

3 Due to space limitations, this estimation is not presented in Table 4 of the Appendix, but is available upon request. In the Logit model, the estimated coefficient has value 0.6727, standard error 0.1476 and level of significance 1%. In the Probit model, the coefficient has value 0.3519, standard error 0.0738 and level of significance 1%. Surprisingly, in the Cox model, the estimated coefficient of this variable has negative value -0.2578 and standard error 0.1461, but the result is statistically significant at the 10% level.

Moreover, the study of firm growth can shed light on the importance of the selection process after a firm enters the market (Audretsch and Mata 1995). Once a firm enters a market, a selection process takes place (Jovanovic 1982), during which the least efficient firms exit from the market and the most efficient ones survive and grow. Therefore, firm growth analysis highlights the way firms behave after they have entered a market, the opportunities that they have, the degree of mobility and the level of efficiency in a market.

In general, firm growth can affect employment and economic growth at the macroeconomic level. Therefore, during economic policy planning it is important to consider firm growth policies as a tool for reducing unemployment and boosting economic activity (Wagner 1992). Firm growth is important in Greece, especially at the current juncture, as the country's economic recovery achieved in 2017-2018 must continue and accelerate pace in order to counterbalance the effects of the prolonged recession and reduce the unemployment rate, which, albeit on a downward trend, remains the highest among euro area countries. These facts make firm growth a top priority issue for policy makers.

4.2 ECONOMETRIC MODEL AND VARIABLES USED IN THE ESTIMATIONS OF A FIRM GROWTH MODEL

Two of the widely accepted methodologies for estimating models with panel data are the fixed effects model and the random effects model (Wooldridge 2010). Random effects estimators are calculated from the differences within each firm over time and their impact incorporates information both between firms and across time.

In order to identify which of the two approaches (fixed or random effects model) is the most appropriate for the purpose of the current study, the Hausman test (1978), which indicates which of the two methods is the most reliable, was used, ensuring the validity of the applied technique. In the present estimations, the Hausman test indicated (see the last three rows of Table 5 in the Appendix) that the most appropriate technique is the fixed effects approach. In addition, for each estimation the Variance Inflation Factor test was also performed to check for possible multicollinearity problems.

The independent variables used in the estimations are divided into three categories:

i. financial variables at the firm level (leverage, liquidity, bank loans, lending cost, profitability);

ii. variables related to firm characteristics (size, age); and

iii. variables at the sectoral level (market concentration).

In order to avoid potential endogeneity problems in the estimations, time-lagged values of the independent variables were used.

The description of the variables is as follows:

- **initial size (initialsize):** natural logarithm of firm sales in period t-1;
- **liabilities (leverage):** ratio of a firm's total liabilities to total assets in period t-1;
- **liquidity (liquidity):** ratio of a firm's current assets to total assets in period t-1;
- **bank lending (banks):** ratio of a firm's total bank loans to total liabilities in period t-1;
- **lending cost (creditcost):** ratio of a firm's financial expenses to total bank loans in period t-1;
- **profitability (profit):** ratio of a firm's earnings before interest and tax (EBIT) to turnover in period t-1;
- **age (lnage):** natural logarithm of the age of a firm;

- **market concentration (herf):** the Herfindahl-Hirschman concentration index is used, which is as follows:

$$H = \sum_{i=1}^{n} \left(\frac{x_{ij}}{X_j}\right)^2$$

where x_{ij} is the turnover of firm i in sector j and X_j is the total turnover of sector j.

The data to construct the above variables come from the Infobank-Hellastat database.

As mentioned above, apart from the estimations for the 2000-2016 period, different estimations for the 2000-2007 and 2008-2016 subperiods were performed, so as to investigate the evolution of firms' growth behaviour before and during the domestic debt service crisis and the economic adjustment period, respectively. Besides, in order to give a regional dimension to the analysis, based on the degree of urbanisation, different models were estimated for those firms, which are (a) located in the regions where the cities of Athens and Thessaloniki are located and (b) located in the other regions of Greece.

4.3 ECONOMETRIC RESULTS FOR THE FIRM GROWTH MODEL

The results for the 2000-2016 period (see column 1 of Table 5 in the Appendix) reveal that the initial size (initialsize) of new firms negatively affects their growth. This is in line with the findings of Audretsch and Mahmood (1994), who argue that small start-ups typically operate below the minimum efficient scale and therefore have a higher probability of failure. Leverage (leverage) is estimated to negatively affect new firm growth, which suggests that the greater the dependence of new firms on external financing, the less likely it is that they will grow. This result is also consistent with the literature. Becchetti and Trovato (2002) and Fotopoulos and Louri (2004) estimated that there exists a negative correlation between liabilities to third parties and firm growth. In addition, Lang et al. (1996) argue that firms, whose capital structure is heavily reliant on external funds, may face significant difficulties in gaining access to additional external financing, even for investment projects with a positive net present value.

Moreover, liquidity (liquidity) has a positive impact on new firm growth. In the finance literature, the issue of liquidity is of paramount importance, because it may significantly affect the ability of a firm to overcome periods of uncertainty and low profitability (Myers and Rajan 1998). Thus, liquidity retention can be crucial for firms that adopt investment projects which are characterised by fluctuating future returns (Myers 1977). In addition, Opler et al. (1999) provide empirical evidence that firms with high growth prospects or high-risk activities tend to retain assets that are easily liquidable.

Both bank lending (bank) and credit cost (creditcost) were found to negatively affect firm growth. Bank lending can on the one hand finance a firm's investment projects, but on the other hand its repayment reduces a firm's cash flow.

The profitability (profit) of new firms in the previous period seems to negatively affect firm growth. The estimated negative relationship can be interpreted under Marris' (1964) theoretical approach. According to it, managers link their success to the size of the firm they manage. Thus, their salaries, bonuses and other benefits as well as non-financial incentives such as prestige, social status, etc. are closely associated with the achievement of this target. However, when the manager is not the owner of the firm, then the goal of increasing its size may be at the expense of the goal of maximising its profits. Thus, within firms there may be a conflict of interest between shareholders' (improving financial performance) and managers' objectives (increasing firm size).

As far as the effect of age (lnage) is concerned, it is negatively correlated with firm growth. This result suggests that, as a new firm enters

the market and ages, its growth rate decelerates (Dunne et al. 1989; Fariñas and Moreno 2000; Becchetti and Trovato 2002; Calvo 2006). At the same time, this result confirms Jovanovic's (1982) theory. According to his model, firms do not know how efficient they are unless they enter the market. In a learning process, firms enter the market, acquire experience and adjust their expectations regarding their efficiency.

Finally, market concentration (herf) was estimated to negatively affect new firm growth. This finding suggests that the higher the concentration in an industry, the lower the potential for new firms to grow. Thus, it appears that in sectors with a monopolistic or oligopolistic structure, there is no room for changes in market shares and therefore the growth prospects for new firms are limited.

Minor differences emerge from the comparison of the estimation results for the 2008-2016 subperiod (see column 3 of Table 5) with those for the whole 2000-2016 period (see column 1 of Table 5). Specifically, the sign and the statistical significance of the estimated coefficients remain unchanged, but in most cases the size of the effects is greater. Regarding the estimation results for the 2000-2007 subperiod (see column 2 of Table 5), liquidity (liquidity), credit cost (creditcost) and market concentration (herf) do not affect firm growth during the pre-crisis period, whereas their effect during the crisis period of 2008-2016 was statistically significant and stronger. Contrary to the estimates for the whole sample, profitability (profit), leverage (leverage) and age (lnage) exert a positive effect on new firm growth.

Next, column 4 of Table 5 presents the results for firms that are located in Athens and Thessaloniki. The criterion for performing this estimation is related to the exploitation of network externalities that new firms are able to develop in large urban areas. According to the theory of new economic geography (Krugman 1998), such externalities are observed in regions with a high degree of urbanisation, as they are characterised by a higher concentration of high-skilled human resources, which reduces the search cost of finding skilled workforce. In addition, when an economic activity is concentrated in a certain geographical area, then it is highly possible that the suppliers of a given industry will be concentrated in the same area too, thereby enabling firms to find the necessary inputs such as raw materials, equipment, etc. at a lower cost. Given the above, Audretsch and Dohse (2007) argue that knowledge spillovers take place within a specific region, enabling firms operating in that region to achieve higher growth rates. However, our results do not indicate any important differences in the effect of financial factors on new firm growth, with the exception of credit cost (creditcost) and market concentration (herf) which do not exert a statistically significant effect. Taking into account that competition between firms is usually more intense in large urban areas, it was not possible to interpret the statistically insignificant effect of the variable herf.

Moreover, sector-specific estimations were performed. The estimations for the Manufacturing and Services sectors are presented in columns 5 and 6 of Table 5, respectively, but the estimations for the Electricity-Gas-Water supply, Wholesale-Retail trade and Tourism sectors are not reported due to multicollinearity problems. In the Manufacturing sector (column 5), it is credit cost rather than the level of loans that negatively affects firm growth. Entry into a market requires, among other things, the investment of a significant amount of financial capital in machinery, equipment, etc., which is usually provided by the banking sector. However, what seems to mostly affect firm growth in this sector is the financial cost, since an excessively high debt service cost limits a firm's cash flow. At the same time, market concentration negatively affects firm growth and its impact is very strong, as indicated by the size of the estimated coefficient. This result is expected in sectors such as Manufacturing, where competition among firms is harsh. However, the impacts of

leverage and liquidity on new firm growth are statistically insignificant, and both results cannot be justified by the available data. In the Services sector (column 6), the results do not differ from the initial estimates (see column 1 of Table 5), except for the effects of credit cost and profitability. In both cases, these are statistically insignificant.

Furthermore, estimations for the groups of firms that are knowledge-ICT intensive and export-oriented were carried out. According to the variance inflation factor test results, multicollinearity problems arose in all these estimates. Finally, we ran estimations for firms that are not knowledge-ICT intensive and firms that are not export-oriented (see columns 7-9 of Table 5). Once again, the results are not different in terms of sign, size and statistical significance from the results for the overall sample of firms (column 1).

5 ECONOMETRIC ANALYSIS OF THE FACTORS AFFECTING NEW FIRMS' EXPORT BEHAVIOUR

Export activity is an important aspect of new and small firms' function that allows them to create value, grow and have access to new knowledge and technology (Yeoh 2004). In the current era of expanding globalisation, where competition continuously escalates, new firms need to adopt internationalisation strategies for their production process and sales in order to be sustainable, exploit opportunities to enter several markets and reduce specific country risk (Porter 1986, 1990). McDougall et al. (1994) and Oviatt and McDougall (2005) developed a theoretical background, according to which export-oriented firms have the ability to identify opportunities in foreign markets, are ready to combine resources from different international markets and can utilise skills related to knowledge absorption and network expansion. Thus, to a great extent, new export-oriented firms are of particular importance, because they can play a key role in knowledge spillovers and technology absorption. In turn, such developments can contribute to the introduction of new innovative solutions, to productivity gains and therefore to economic growth.

5.1 DESCRIPTIVE STATISTICS ABOUT EXPORTING FIRMS

The presentation and discussion of the econometric results regarding the factors that affect new Greek firms' export activity is preceded by a brief description of their export behaviour on the basis of some key characteristics, such as their sector of activity, size and location of headquarters.

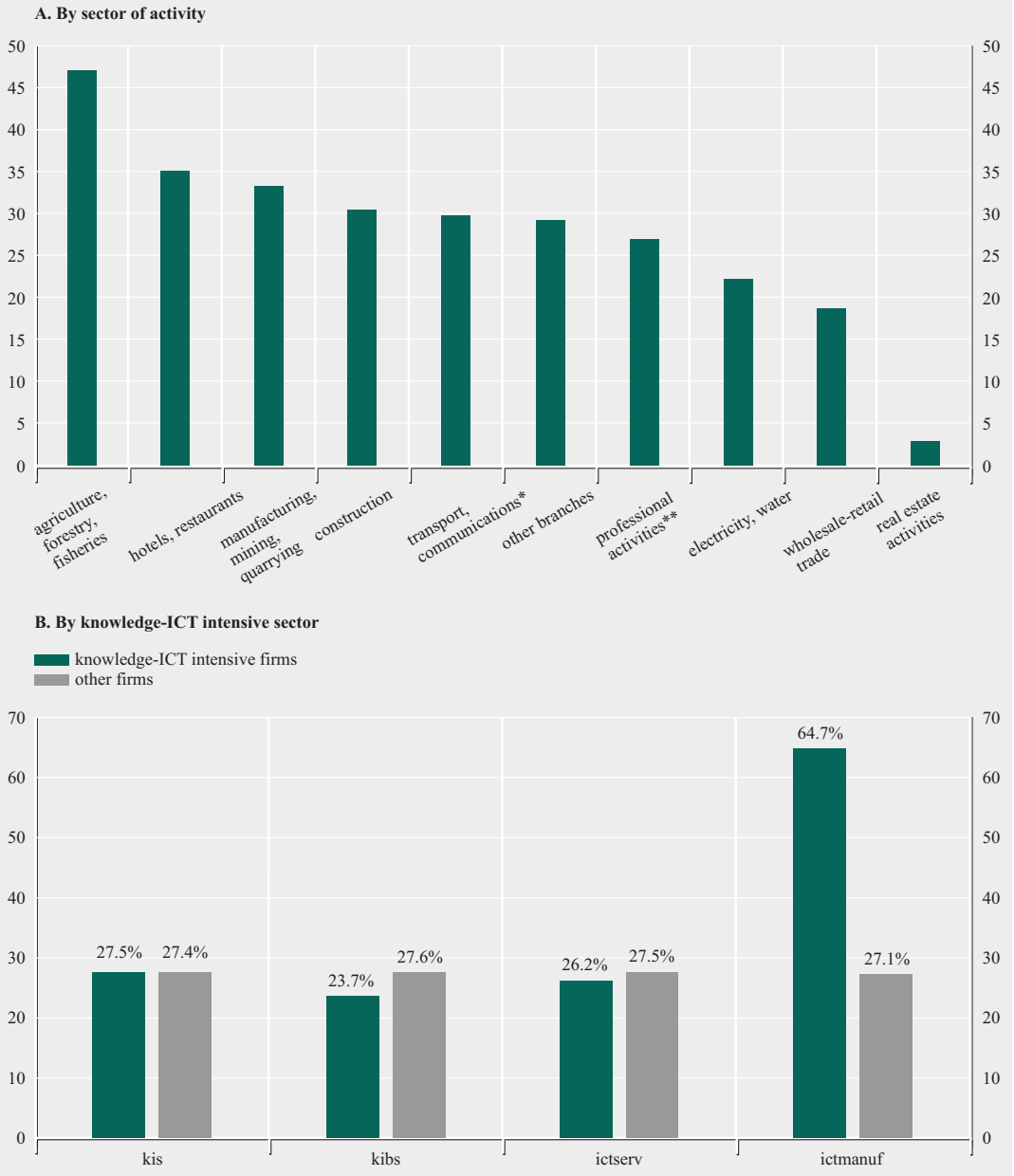
As far as export performance by sector of activity is concerned (see Chart 6A), the sector with the highest exports as a percentage of turnover is Agriculture-Forestry-Fisheries (47.2%), followed by Hotels-Restaurants (35%), Manufacturing-Mining-Quarrying (33.4%), Construction (30.4%) and Transport-Communications (29.8%). The sector with the lowest export share is Real estate activities (3%).

Regarding knowledge-ICT intensive firms (see Chart 6B), manufacturing ICT firms (ictmanuf) have the highest share of exports relative to turnover (64.7%), compared with other firms (27.1%) and with the rest of knowledge-ICT intensive firms (kis, kibs and ictserv). By contrast, for ICT intensive services firms (ictserv: 26.2%) and knowledge intensive business services firms (kibs: 23.7%), export shares are lower than those of other firms in the sample (27.5% and 27.6%, respectively). Finally, knowledge intensive services firms (kis) have a similar share of exports relative to turnover (27.5%) as other firms of the sample (27.4%).

With respect to the export performance of new firms according to their size, as proxied by turnover (see Chart 7A), the highest export share is observed for large firms (turnover > €50 million), i.e. 11.3%, and the lowest for micro firms (turnover < €2 million), i.e. 1.8%. Furthermore, export shares as a percentage of turnover increase with size. With respect to headquarters location (see Chart 7B), the per-

Chart 6 Export shares as percentage of turnover, by sector of activity and by knowledge-ICT intensive sector (2000-2016)

(%)

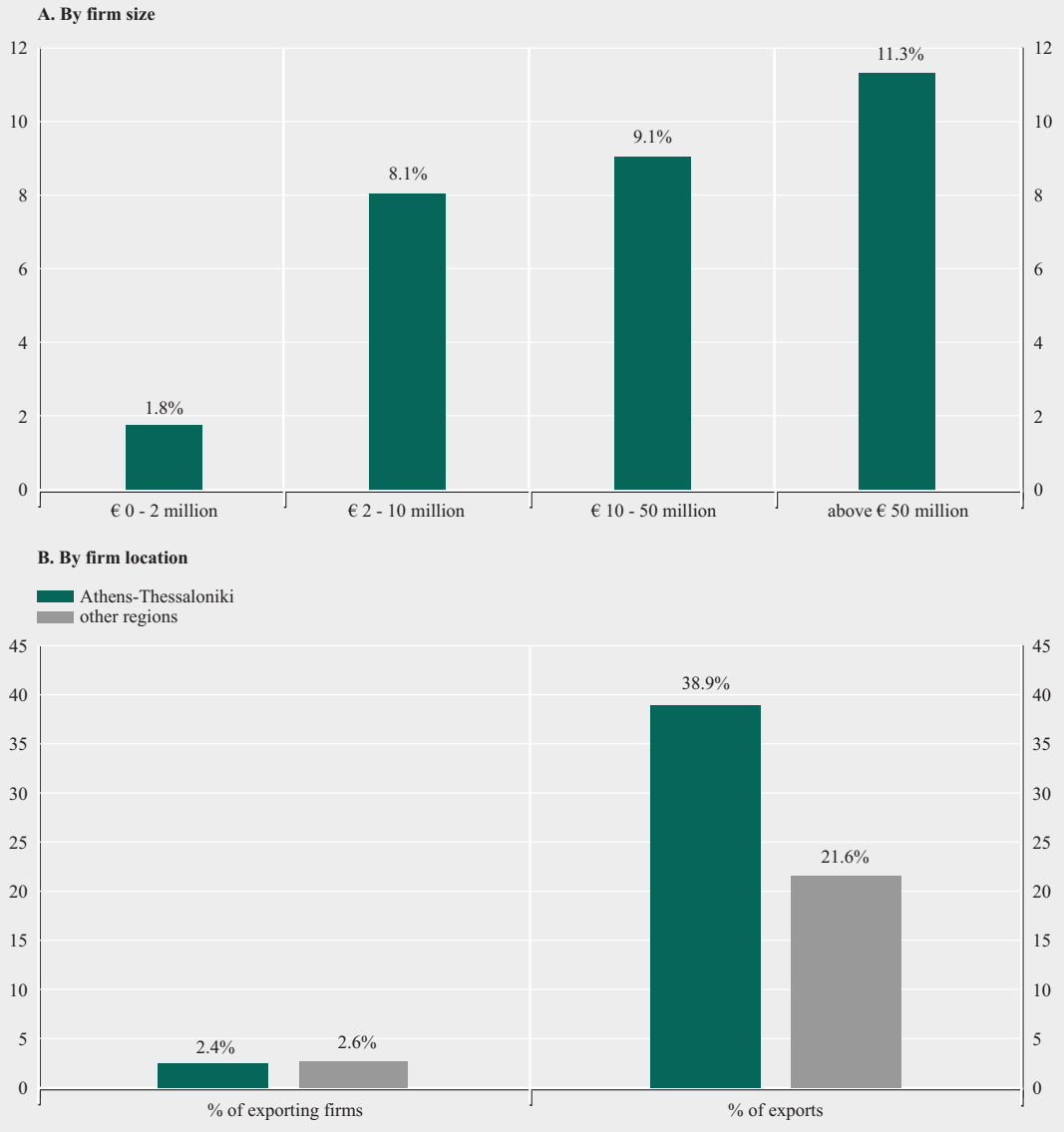


Source: IOBE.
* Except Sea transport.
** Including Scientific, technical, administrative and supporting activities.

centage of new firms with export activity is almost the same both for firms located in Athens/Thessaloniki (2.4%) and for firms located in other regions of Greece (2.6%). However, exports as a percentage of turnover are much higher in the case of firms located in Athens/Thessaloniki (38.9%) than in the case of firms located in the rest of Greece (21.6%).

Chart 7 Export shares as percentage of turnover, by firm size and location (2006-2016)

(%)



Source: IOBE.

5.2 ECONOMETRIC MODEL AND VARIABLES USED IN THE ESTIMATIONS ABOUT THE FACTORS AFFECTING NEW FIRMS' EXPORT BEHAVIOUR

As far as the econometric examination of the factors affecting the export activity of new firms is concerned, the available dataset used for the estimations contains information about whether firms established in 2000-2004 export or not each year of the 2000-2016 period. It does not contain information about the value of each firm's exports, as such data for all the sectors of the economy and the surveyed period are not available. This data limitation led to the selection of a binary choice model in order to examine the effects of firm and sectoral characteristics on new firms' decision to export. In this respect, a logistic

regression was used with the following algebraic form:

$$\ln\left(\frac{p}{1-p}\right) = \alpha_0 + \alpha_1 X_1 + \cdots + \alpha_n X_n$$

where p is the probability that a firm exports and X_1, X_2, ...,X_n are the variables that affect the decision of a new firm to export or not, α_0 is the constant term and α_1, α_2, ..., α_n are the coefficients of the regressors to be estimated.

The dependent variable of the above model is a dummy variable that takes the value 1 when a new firm exports in a specific year, and zero otherwise. The variables used in the estimations are the following:

- **age:** logarithm of the age of a firm;
- **location:** dummy variable equal to 1 when a firm is located in the regions where Athens and Thessaloniki are situated;
- **lncash:** logarithm of a firm's available cash;
- **lnnomfunding:** logarithm of total bank loans of a firm;
- **sizegroup:** it distinguishes firms into four categories according to their average turnover during the 2000-2016 period:
  - micro firms (average turnover<€2 million);
  - small firms (€2 million≤average turnover≤ €10 million);
  - medium-sized firms (€10 million≤ average turnover≤€50 million);
  - large firms (average turnover=>€50 million).

Alternatively, the logarithm of a firm's total assets was used as a proxy for firm size (size).

- **kibs:** dummy variable equal to 1 if a firm is a knowledge intensive business services firm;
- **ict:** dummy variable equal to 1 if a firm is an ICT intensive manufacturing firm or an ICT intensive services firm;
- **sector:** 1-digit business activity sectors.[4]

The data to construct the above variables come from the Infobank-Hellastat database.

5.3 ECONOMETRIC RESULTS OF THE MODEL ABOUT NEW FIRMS' EXPORT BEHAVIOUR

Turning to the estimation results (see Table 6 in the Appendix), the coefficient of the age (lnage) variable has a positive sign, which implies that, as a firm ages, it is easier for it to decide to export. According to Calof (1994), the export behaviour of firms is reinforced as their life cycle evolves. As a firm ages and its market position strengthens, it realises that export activity is a strategic choice for increasing its chances to survive. Zahra et al. (1997) confirm a positive relationship between age and export behaviour of firms.

In addition, the location variable has a positive sign, which means that location in Attica or Thessaloniki positively affects the decision of a new firm to export. This result is in line with the literature, according to which firms in large metropolitan areas have easier access to export-related networks, infrastructures and advisory services and hence are more likely to engage in export activity and achieve a better performance than firms located away from the biggest cities (Freeman et al. 2012).

Regarding the impact of cash available, a positive coefficient was estimated for the lncash variable, which implies that firms with satisfactory liquidity have a higher probability to export, compared with those that have low liquidity, probably because they can finance the

4 The examined sectors are the following: (1) Agriculture, Forestry, Fisheries; (2) Manufacturing, Mining, Quarrying; (3) Electricity, Gas, Water; (4) Construction; (5) Wholesale-Retail trade; (6) Hotels, Restaurants; (7) Communications, Transport (except Sea transport); (8) Sea transport; (9) Real estate activities; (10) Professional, scientific, technical, administrative and supporting activities; and (11) Other branches.

development of a commercial network abroad, customer relationship marketing activities, etc.

Moreover, the estimated coefficient of lnnomfunding is positive. This result indicates that new firms with easier access to bank financing have a higher probability to export, because they can finance the costs associated with export activities. According to Bellone et al. (2010), financial constraints, e.g. lack of funding from the banking system, act as a barrier to entry into foreign markets. Besides, it is usually observed that exporting firms have better access to bank finance, mostly because the fact that their product is exported is considered a factor strengthening their viability and solvency.

In addition, knowledge intensive business services firms (kibs) are more likely to export, probably because these firms are usually active in internationally tradable sectors.

The coefficient of the ict dummy was found to be positive and statistically significant, implying that if a firm is ICT intensive in the Manufacturing or Services sectors, this characteristic supports its decision to export. This result can be justified by the fact that technology is a very important source for obtaining a competitive advantage in international markets (Miller 1994). Technological specialisation according to Ito and Pucik (1993) is positively related with the export behaviour of new firms, while new firms specialised in the production of high-technology products/services are expected to have more chances to export than firms specialised in the production of low-technology products/services (Samiee and Walters 1990).

Regarding the impact of the sector of activity on exports, its effect was statistically significant and negative, indicating that the Primary and Manufacturing sectors are more likely to export than the other sectors.

It is stressed that size variables (sizegroup and size) were also included in the estimations. Although the coefficients of these variables were found to be positive and statistically significant at the 1% level, the variance inflation factor test showed that these results suffered from multicollinearity problems.

6 SUMMARY OF FINDINGS

The purpose of the present study was to analyse the factors that affect new firm survival, growth rate and export decision in Greece during the 2000-2016 period. Furthermore, the study aspires to examine whether the effects of these factors were different in the period of the global financial and Greek debt service crises, as well as during the fiscal consolidation and structural adjustment of the domestic economy, in comparison to the previous years. To that end, an unbalanced panel dataset concerning Greek new firms active in all sectors of the economy was used in the estimations of a number of appropriate econometric models and their variations.

The descriptive statistics about new firms revealed that their number declined sharply after 2007. Although after 2012 the number of new firms increased, it failed to return to its pre-crisis levels. The vast majority of new firms were established in Athens and were micro firms. Most of these firms are active in the Wholesale-Retail trade, Real estate and Manufacturing sectors, but a rise in the number of firms in the Hotels-Restaurants sector and a decrease in the Construction sector were observed after the crises. Regarding the knowledge-ICT intensity of new firms, most of them, regardless of the period examined, are either knowledge intensive services firms or knowledge intensive business services firms. In all of these activity categories, the respective share drops between 2000-2007 and 2008-2012 to rise in 2013-2016.

With regard to the econometric results about new firm survival for the overall 2000-2016 period, we estimated that large new firms with a high fixed capital to total assets ratio, which

are not leveraged and operate in less concentrated markets, have a higher probability to survive. Also, new firms which were established during the period of high economic growth in Greece, face a smaller tax burden, have smaller minimum capital requirements to start their business, are export-oriented, face lower import and export costs, have the legal form of a Société Anonyme, operate in the knowledge-ICT Manufacturing or Electric power sectors and have good access to finance from the banking sector, have better chances to survive. On the other hand, new firms located in large urban areas, which have the legal form of a Limited Liability or Private Company and operate in the Wholesale-Retail trade or Services sectors, face a greater risk of failure.

Regarding the magnitude of these effects, the strongest positive impact comes from the reduction in export costs, minimum capital required to start a business and tax burden, as well as from firms' export orientation, i.e. from factors that constitute significant aspects of the regulatory framework under which new firms operate and from their decision about whether to develop or not export activity. These findings are particularly important and should be taken into consideration by policy makers in the process of designing reforms that will help to further improve the business environment and contribute to the internationalisation of the Greek economy.

On the other hand, the strongest negative effects on new firm survival are exerted by the degree of market concentration, the legal form of a Private Company (ike) and lack of bank financing. The latter has emerged in recent years, mainly due to the effects of severe fiscal consolidation on the debt servicing capacity of the private sector and of public debt restructuring on bank assets. Thus, the declining tax burden and a return to corporate credit expansion would significantly improve the business climate and would contribute to the establishment of more new domestic firms. Moreover, the export orientation of the Greek economy should not only rely on lower cost of exports and taxation and increased financial resources from the banking system, but mainly on high value-added and technologically competitive products, coupled with other tradable goods and services.

Overall, the above results remain unchanged in the estimations for the 2000-2007 subperiod. Nevertheless, significant differences emerge in the results regarding the 2008-2016 subperiod. More specifically, the effect of GDP change on firm survival becomes negative. Moreover, operation in the Wholesale-Retail trade and Tourism sectors negatively affect new firm survival. The reduction of the tax burden again positively affects firm survival, and this effect is stronger compared with the entire 2000-2016 period. This is also the case for firms operating in knowledge-ICT intensive sectors, as the positive effects from operation in these sectors were greater. Therefore, particularly in times of protracted recession, as in 2008-2016, it is important to facilitate the start-up of knowledge-ICT intensive firms that can easier develop comparative technological advantages than other businesses and thus create more value added for the economy.

Similarly, during a period of falling liquidity, as observed in the past few years, the reduction of both the cost to start a new business and the cost to export/import has a stronger positive impact on new firm survival. Thus, apart from the reduction of the tax burden, it is crucial that new firms are facilitated in terms of both the cost to start their operation and the cost to export their products and import raw materials, machinery, etc.

The econometric results regarding the factors affecting firm growth during the 2000-2016 period show that a small initial firm size and high leverage negatively affect new firm growth prospects. In addition, high indebtedness to banks as well as increased credit cost hamper firm growth. The opposite effect emerges when a firm has adequate liquidity. Moreover, market concentration negatively affects new firm growth, most probably

because, in sectors characterised by a monopolistic or oligopolistic structure, there is no room for new firms to survive and grow. These results remained unchanged in the estimations for the 2008-2016 subperiod. However, on the basis of the estimations for 2000-2007, profitability, leverage and age exerted a positive effect on new firm growth. Also, liquidity, credit cost and market concentration did not affect firm growth.

In order to examine whether there exist some effects from the networking of new firms established in large urban areas on their growth, we performed separate estimations for new firms in Attica and Thessaloniki. However, the results failed to show any significant differences regarding the effects of financial factors on new firm growth. Moreover, we performed estimations for the Manufacturing and Services sectors. In the former sector, what seems to affect firm growth most is the cost of funding. Furthermore, market concentration negatively affects firm growth, probably because in such sectors competition among firms is harsh. In the Services sector, the results did not differ from the initial estimates, except for the effects of credit cost and profitability that are statistically insignificant.

Finally, with respect to new firms' export decision, we estimated that firms which are active many years, have satisfactory liquidity and access to bank finance, are located in large urban areas and operate in knowledge-ICT intensive sectors, have a higher probability to export.

The aim of the present study was to shed light on the factors affecting new firm survival, growth and export decision during a period that was marked by significant economic fluctuations. Among other factors affecting survival, growth and export orientation that are usually included in the applied literature, the present study highlighted the importance of producing technologically advanced, high value-added products that can be competitive in foreign markets. Moreover, the study emphasises the relevance of the regulatory framework under which new firms operate, since lower taxation, lower export costs and less capital required to start a business were estimated to contribute to new firms' probability of survival. In this respect, many reforms have taken place in recent years, which helped to improve the business environment. Nevertheless, there still remains much to be done in order to facilitate the transition of the Greek economy to a new growth model, which will be mainly driven by productive investment and stronger structural competitiveness. The range of the necessary policies should include actions with a direct effect on businesses' everyday activity (e.g. transactions with public services, non-wage labour costs, investment incentives and funding). However, restructuring policies should also address issues indirectly affecting entrepreneurial activity, such as the interaction of the educational system with production, environmental protection and waste management, the sustainability and structure of the social security system, the length and quality of judicial procedures, the completion of the cadastre, etc.

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APPENDIX

Table 1 Cox, Logit and Probit models' survival estimations for the basic econometric specification (2000-2016)

	Cox	Logit random effects	Probit random effects
size	-0.2083*** (0.0071)	-0.2326*** (0.0074)	-0.1151*** (0.0037)
fixedtotal	-0.0768*** (0.0150)	-0.0130*** (0.0044)	-0.0033** (0.0016)
leverage	0.0020*** (0.0007)	0.0196*** (0.0059)	0.0043*** (0.0011)
profit	0.0000 0.8395	0.0000 0.8287	0.0000 0.8113
herf	0.4635*** (0.1109)	0.6085*** (0.1183)	0.3251*** (0.0621)
constant		0.7695*** (0.1007)	0.1898*** (0.0506)
$\ln(\sigma_v^2)$		-13.8227 (9.3318)	-12.4653*** (2.7372)
σ_v		0.0010 (0.0046)	0.0020 (0.0027)
$\varrho=\sigma_v^2/\sigma_v^2+1$		0.0000 (0.0000)	0.0000 (0.0000)
Likelihood ratio test of $\varrho=0$			
$\chi^{2\,(01)}$		0.0007	0.0100
Prob>= χ^2		0.4900	0.4590
Wald χ^2		1,066.70	1,035.22
Prob>χ^2		0.0000	0.0000
Log likelihood		-32,794.55	-32,810.77
LR χ^2	891.33		
Prob>χ^2	0.0000		
Log likelihood	-89,442.05		
Observations	113,196	113,196	113,196
No of subjects	23,284	23,284	23,284
No of failures	9,798		
Mean VIF	1.62		
AIC	178,894	65,603	65,636
BIC	178,942	65,671	65,703

Source: IOBE.
Notes: Standard error in parentheses. Level of statistical significance: *** p<0.01, ** p<0.05, * p<0.1%.

Table 2 Cox model survival estimations (2000-2016)

	1	2	3	4	5	6	7	8	9
size	-0.2076*** (0.0072)	-0.2121*** (0.0075)	-0.2016*** (0.0072)	-0.2029*** (0.0072)	-0.1955*** (0.0077)	-0.2025*** (0.0077)	-0.2061*** (0.0072)	-0.2074*** (0.0072)	-0.2105*** (0.0072)
fixedtotal	-0.0765*** (0.0150)	-0.0798*** (0.0157)	-0.0806*** (0.0152)	-0.0650*** (0.0145)	-0.0704*** (0.0148)	-0.0741*** (0.0150)	-0.0753*** (0.0150)	-0.0764*** (0.0150)	-0.0493*** (0.0133)
leverage	0.0020*** (0.0007)	0.0014 (0.0009)	0.0021*** (0.0007)	0.0020*** (0.0007)	0.0021*** (0.0007)	0.0020*** (0.0007)	0.0020*** (0.0007)	0.0020*** (0.0007)	0.0020*** (0.0007)
profit	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)
herf	0.4576*** (0.1110)	0.5697*** (0.1158)	0.4602*** (0.1109)	0.4459*** (0.1108)	0.4451*** (0.1110)	0.4562*** (0.1110)	0.4651*** (0.1109)	0.4651*** (0.1108)	0.6847*** (0.1113)
gdp	-0.3246 (0.2548)								
taxrate		-0.8918*** (0.0226)							
exp			-0.5877*** (0.0820)						
location				0.1401*** (0.0224)					
ae					-0.1054*** (0.0237)				
epe						0.0495** (0.0242)			
ike							0.3433*** (0.0894)		
manufacture								-0.0239 (0.0289)	
trade									0.2421*** (0.0223)
tourism									
electrgaswater									
services									
kibs									
kis									
ictserv									
mincapstart									
costexp									
costimp									
Observations	113,196	85,731	113,196	113,196	113,196	113,196	113,196	113,196	113,196
No of subjects	23,284	21,608	23,284	23,284	23,284	23,284	23,284	23,284	23,284
No of failures	9,798	8,601	9,798	9,798	9,798	9,798	9,798	9,798	9,798
LR χ^2	892.96	2,201.21	952.42	931.13	910.92	895.50	904.63	892.02	1,006.73
Prob>χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log likelihood	-89,441.24	-75,836.90	-89,411.51	-89,422.16	-89,432.26	-89,439.97	-89,435.41	-89,441.71	-89,384.36
Mean VIF	1.54	2.76	1.53	2.11	3.25	1.58	1.52	1.59	1.69
AIC	178,895	151,686	178,835	178,856	178,877	178,892	178,883	178,895	178,781
BIC	178,952	151,742	178,893	178,914	178,934	178,950	178,941	178,953	178,839

Source: IOBE.
Notes: Standard error in parentheses. Level of statistical significance: *** p<0.01, ** p<0.05, * p<0.1%.

	10	11	12	13	14	15	16	17	18
size	-0.2088*** (0.0072)	-0.2076*** (0.0072)	-0.2033*** (0.0072)	-0.2180*** (0.0073)	-0.2216*** (0.0073)	-0.2108*** (0.0072)	-0.1896*** (0.0071)	-0.2125*** (0.0207)	-0.1879*** (0.0209)
fixedtotal	-0.0826*** (0.0158)	-0.0760*** (0.0150)	-0.0771*** (0.0150)	-0.0813*** (0.0151)	-0.0713*** (0.0148)	-0.0770*** (0.0150)	-0.0645*** (0.0150)	-0.2978*** (0.0586)	-0.3792*** (0.0595)
leverage	0.0020*** (0.0007)	0.0020*** (0.0007)	0.0020*** (0.0007)	0.0018*** (0.0007)	0.0017*** (0.0007)	0.0020*** (0.0007)	0.0022** (0.0009)	0.0734*** (0.0151)	0.0910*** (0.0155)
profit	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0001)	0.0000 (0.0000)	0.0000 (0.0000)
herf	0.4867*** (0.1118)	0.5763*** (0.1199)	0.5157*** (0.1104)	0.4061*** (0.0332)	0.6247*** (0.1124)	0.4594*** (0.0531)	0.3614*** (0.1129)	0.5385** (0.2650)	0.1122 (0.2717)
gdp									
taxrate									
exp									
location									
ae									
epe									
ike									
manufacture									
trade									
tourism	0.0555 (0.0392)								
electrgaswater		-0.1870** (0.0858)							
services			0.1053*** (0.0231)						
kibs				-0.2024*** (0.0332)					
kis					-0.2017*** (0.0240)				
ictserv						-0.1661*** (0.0531)			
mincapstart							-1.0825*** (0.0228)		
costexp								-1.2271*** (0.0647)	
costimp									-0.2790*** (0.0758)
No of subjects	23,284	23,284	23,284	23,284	23,284	23,284	22,681	3,937	3,937
Observations	113,196	113,196	113,196	113,196	113,196	113,196	100,647	15,104	15,104
No of failures	9,798	9,798	9,798	9,798	9,798	9,798	9,402	1,392	1,392
LR χ^2	893.31	896.28	912.40	930.43	963.75	901.61	3,221.36	581.92	182.79
Prob>χ2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log likelihood	-89,441.06	-89,439.58	-89,431.50	-89,422.50	-89,405.85	-89,436.92	-83,767.13	-9,703.47	-9,903.03
Mean VIF	1.57	1.62	2.22	1.56	1.63	1.53	2.28	2.24	2.14
AIC	178,894	178,891	178,875	178,857	178,824	178,886	167,546	19,419	19,818
BIC	178,952	178,949	178,933	178,915	178,882	178,944	167,603	19,465	19,864

Table 3 Cox model survival estimations (2000-2007)

	1	2	3	4	5	6	7	8	9
size	-0.1654*** (0.0084)	-0.1658*** (0.0084)	-0.1672*** (0.0091)	-0.1555*** (0.0085)	-0.1591*** (0.0084)	-0.1690*** (0.0089)	-0.1711*** (0.0089)	-0.1649*** (0.0085)	-0.1676*** (0.0084)
fixedtotal	-0.0441*** (0.0140)	-0.0436*** (0.0139)	-0.0462*** (0.0153)	-0.0474*** (0.0145)	-0.0347*** (0.0126)	-0.0455*** (0.0142)	-0.0462*** (0.0142)	-0.0439*** (0.0139)	-0.0278** (0.0111)
leverage	0.0024*** (0.0007)	0.0024*** (0.0007)	0.0018* (0.0010)	0.0026*** (0.0007)	0.0024*** (0.0007)	0.0024*** (0.0007)	0.0024*** (0.0007)	0.0024*** (0.0007)	0.0024*** (0.0007)
profit	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
herf	0.4407*** (0.1308)	0.4566*** (0.1306)	0.5647*** (0.1387)	0.4339*** (0.1308)	0.4174*** (0.1307)	0.4460*** (0.1308)	0.4475*** (0.1307)	0.4418*** (0.1307)	0.6458*** (0.1312)
gdp		1.4912*** (0.3162)							
taxrate			-0.7394*** (0.0268)						
exp				-0.6317*** (0.0821)					
location					0.1604*** (0.0251)				
ae						0.0365 (0.0290)			
epe							-0.0585** (0.0297)		
manufacture								-0.0122 (0.0317)	
trade									0.2217*** (0.0253)
tourism									
electrgaswater									
services									
kibs									
kis									
ictserv									
mincapstart									
costexp									
costimp									
Observations	99,973	99,973	72,508	99,973	99,973	99,973	99,973	99,973	99,973
No of subjects	16,872	16,872	15,196	16,872	16,872	16,872	16,872	16,872	16,872
No of failures	7,627	7,627	6,430	7,627	7,627	7,627	7,627	7,627	7,627
LR χ^2	418.14	440.42	1,042.75	489.28	459.76	419.74	422.05	418.29	493.18
Prob>χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log likelihood	-67,998.37	-67,987.23	-55,623.05	-67,962.80	-67,977.56	-67,997.57	-67,996.42	-67,998.29	-67,960.85
Mean VIF	1.65	1.55	2.81	1.56	2.12	3.89	1.58	1.62	1.71
AIC	136,007	135,987	111,258	135,938	135,967	136,007	136,005	136,009	135,934
BIC	136,054	136,044	111,313	135,995	136,024	136,064	136,062	136,066	135,991

Source: IOBE.
Notes: Standard error in parentheses. Level of statistical significance: *** p<0.01, ** p<0.05, * p<0.1%.

	10	11	12	13	14	15	16	17	18
size	-0.1654*** (0.0084)	-0.1645*** (0.0084)	-0.1606*** (0.0085)	-0.1729*** (0.0086)	-0.1770*** (0.0086)	-0.1667*** (0.0085)	-0.1757*** (0.0085)	-0.1638*** (0.0244)	-0.1388*** (0.0246)
fixedtotal	-0.0440*** (0.0143)	-0.0437*** (0.0139)	-0.0443*** (0.0141)	-0.0468*** (0.0143)	-0.0405*** (0.0135)	-0.0442*** (0.0140)	-0.0533*** (0.0157)	-0.2817*** (0.0636)	-0.3385*** (0.0642)
leverage	0.0024*** (0.0007)	0.0025*** (0.0007)	0.0025*** (0.0007)	0.0023*** (0.0007)	0.0022*** (0.0007)	0.0024*** (0.0007)	0.0021** (0.0010)	0.0850*** (0.0154)	0.1020*** (0.0156)
profit	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
herf	0.4402*** (0.1322)	0.6032*** (0.1394)	0.4858*** (0.1302)	0.3963*** (0.1314)	0.5878*** (0.1326)	0.4392*** (0.1306)	0.3927*** (0.1340)	0.4144 (0.3226)	0.0617 (0.3288)
gdp									
taxrate									
exp									
location									
ae									
epe									
manufacture									
trade									
tourism	-0.0012 (0.0435)								
electrgaswater		-0.3099*** (0.1117)							
services			0.1004*** (0.0258)						
kibs				-0.1522*** (0.0379)					
kis					-0.1676*** (0.0274)				
ictserv						-0.0775 (0.0588)			
mincapstart							-0.8780*** (0.0275)		
costexp								-1.0570*** (0.0737)	
costimp									-0.2321*** (0.0829)
Observations	99,973	99,973	99,973	99,973	99,973	99,973	87,424	12,865	12,865
No of subjects	16,872	16,872	16,872	16,872	16,872	16,872	16,269	2,814	2,814
No of failures	7,627	7,627	7,627	7,627	7,627	7,627	7,231	1,084	1,084
LR χ^2	418.14	426.41	433.54	434.89	456.55	419.92	1,473.30	328.41	104.72
Prob>χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log likelihood	-67,998.37	-67,994.23	-67,990.67	-67,989.99	-67,979.16	-67,997.48	-63,261.50	-7,450.12	-7,561.96
Mean VIF	1.59	1.64	2.22	1.58	1.65	1.55	2.41	2.23	2.15
AIC	136,009	136,001	135,993	135,992	135,970	136,007	126,535	14,912	15,136
BIC	136,066	136,058	136,050	136,049	136,027	136,064	126,591	14,957	15,181

Table 4 Cox model survival estimations (2008-2016)

	1	2	3	4	5	6	7	8	9
size	-0.1924*** (0.0143)	-0.1810*** (0.0144)	-0.1553*** (0.0144)	-0.1912*** (0.0144)	-0.2024*** (0.0157)	-0.2178*** (0.0153)	-0.1828*** (0.0144)	-0.1910*** (0.0145)	-0.1971*** (0.0144)
fixedtotal	-0.1496*** (0.0433)	-0.1502*** (0.0441)	-0.1152*** (0.0433)	-0.1450*** (0.0434)	-0.1554*** (0.0438)	-0.1636*** (0.0443)	-0.1421*** (0.0435)	-0.1488*** (0.0433)	-0.1178*** (0.0425)
leverage	0.0076* (0.0046)	0.0074 (0.0046)	0.0102** (0.0049)	0.0075* (0.0046)	0.0074 (0.0046)	0.0070 (0.0045)	0.0069 (0.0045)	0.0076* (0.0046)	0.0062 (0.0047)
profit	0.0003 (0.0012)	0.0004 (0.0012)	0.0010 (0.0012)	0.0003 (0.0012)	0.0004 (0.0013)	0.0006 (0.0013)	0.0005 (0.0013)	0.0003 (0.0012)	0.0003 (0.0012)
herf	0.3097 (0.2112)	0.3315 (0.2138)	0.4111* (0.2170)	0.3052 (0.2111)	0.3134 (0.2110)	0.3206 (0.2108)	0.3091 (0.2116)	0.3109 (0.2108)	0.5027** (0.2141)
gdp		6.8597*** (0.8279)							
taxrate			-1.5482*** (0.0457)						
location				0.0424 (0.0491)					
ae					0.0764 (0.0485)				
epe						-0.2110*** (0.0465)			
ike							0.5917*** (0.0976)		
manufacture								-0.0565 (0.0706)	
trade									0.1984*** (0.0465)
tourism									
electrgaswater									
services									
kibs									
kis									
ictserv									
mincapstart									
costexp									
costimp									
Observations	13,223	13,223	13,223	13,223	13,223	13,223	13,223	13,223	13,223
No of subjects	6,412	6,412	6,412	6,412	6,412	6,412	6,412	6,412	6,412
No of failures	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171
LR χ^2	198.30	267.80	1,226.43	199.05	200.77	218.79	229.93	198.95	216.24
Prob>χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log likelihood	-17,164.39	-17,129.65	-16,650.33	-17,164.02	-17,163.16	-17,154.15	-17,148.58	-17,164.07	-17,155.42
Mean VIF	1.35	1.90	2.53	2.08	1.63	1.55	1.30	1.34	1.59
AIC	34,339	34,271	33,313	34,340	34,338	34,320	34,309	34,340	34,323
BIC	34,376	34,316	33,358	34,385	34,383	34,365	34,354	34,385	34,368

Source: IOBE.
Notes: Standard error in parentheses. Level of statistical significance: *** p<0.01, ** p<0.05, * p<0.1%.

	10	11	12	13	14	15	16	17	18
size	-0.1932*** (0.0144)	-0.1907*** (0.0144)	-0.1897*** (0.0145)	-0.2056*** (0.0146)	-0.2070*** (0.0147)	-0.1976*** (0.0144)	-0.1682*** (0.0140)	-0.2349*** (0.0406)	-0.2520*** (0.0416)
fixedtotal	-0.1939*** (0.0467)	-0.1432*** (0.0432)	-0.1490*** (0.0432)	-0.1553*** (0.0436)	-0.1467*** (0.0432)	-0.1507*** (0.0433)	-0.1053** (0.0419)	-0.3240** (0.1579)	-0.4979*** (0.1616)
leverage	0.0082* (0.0046)	0.0074 (0.0046)	0.0078* (0.0046)	0.0067 (0.0046)	0.0060 (0.0047)	0.0072 (0.0046)	0.0074 (0.0048)	0.0337 (0.0741)	0.0162 (0.0692)
profit	0.0003 (0.0012)	0.0003 (0.0012)	0.0003 (0.0012)	0.0003 (0.0012)	0.0003 (0.0012)	0.0003 (0.0012)	0.0010 (0.0013)	-0.0060 (0.0087)	-0.0029 (0.0077)
herf	0.4166** (0.2112)	0.4354* (0.2309)	0.3620* (0.2126)	0.2352 (0.2143)	0.4447** (0.2165)	0.2978 (0.2103)	0.4176** (0.2083)	0.5914 (0.4964)	0.2404 (0.5126)
gdp									
taxrate									
location									
ae									
epe									
ike									
manufacture									
trade									
tourism	0.3163*** (0.0870)								
electrgaswater		-0.1595 (0.1358)							
services			0.0699 (0.0525)						
kibs				-0.2947*** (0.0687)					
kis					-0.2413*** (0.0503)				
ictserv						-0.3765*** (0.1247)			
mincapstart							-1.8695*** (0.0624)		
costexp								-1.9721*** (0.1390)	
costimp									-0.3198 (0.1985)
Observations	13,223	13,223	13,223	13,223	13,223	13,223	13,223	2,239	2,239
No of subjects	6,412	6,412	6,412	6,412	6,412	6,412	6,412	1,123	1,123
No of failures	2,171	2,171	2,171	2,171	2,171	2,171	2,171	308	308
LR χ^2	210.60	199.72	200.09	218.02	222.13	208.55	1,451.23	305.53	61.42
Prob>χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log likelihood	-17,158.24	-17,163.69	-17,163.50	-17,154.53	-17,152.48	-17,159.27	-16,537.93	-1,760.71	-1,882.76
Mean VIF	1.34	1.42	2.23	1.33	1.39	1.30	1.46	2.50	2.21
AIC	34,328	34,339	34,339	34,321	34,317	34,331	33,088	3,533	3,778
BIC	34,373	34,384	34,384	34,366	34,362	34,375	33,133	3,568	3,812

Table 5 Firm growth model estimations

	1	2	3	4	5	6	7	8	9
initialsize	-0.4529*** (0.0094)	-0.7547*** (0.0191)	-0.5162*** (0.0125)	-0.4463*** (0.0134)	-0.4486*** (0.0154)	-0.3802*** (0.0118)	-0.4461*** (0.0096)	-0.4626*** (0.0098)	-0.4678*** (0.0102)
leverage	-0.1472*** (0.0348)	0.2338** (0.1080)	-0.2260*** (0.0396)	-0.1346** (0.0527)	-0.0749 (0.0567)	-0.2070*** (0.0375)	-0.1570*** (0.0352)	-0.1595*** (0.0359)	-0.1576*** (0.0375)
liquidity	0.2200*** (0.0575)	0.0825 (0.1077)	0.3427*** (0.0810)	0.2057*** (0.0776)	0.1177 (0.0939)	0.2246*** (0.0633)	0.2335*** (0.0590)	0.2363*** (0.0601)	0.2469*** (0.0634)
banks	-0.1281*** (0.0433)	-0.1866** (0.0788)	-0.2177*** (0.0578)	-0.1047* (0.0600)	0.0765 (0.0723)	-0.1824*** (0.0491)	-0.1343*** (0.0446)	-0.1247*** (0.0456)	-0.1292*** (0.0480)
creditcost	-0.3509*** (0.0971)	-0.0471 (0.3627)	-0.2959*** (0.1024)	-0.1528 (0.0989)	-1.8722*** (0.3513)	-0.1148 (0.1037)	-0.3646*** (0.0978)	-0.3378*** (0.0988)	-0.3447*** (0.1020)
profit	-0.0095*** (0.0011)	0.0114** (0.0045)	-0.0076*** (0.0011)	-0.0162*** (0.0036)	-0.0139*** (0.0047)	-0.0017 (0.0011)	-0.0096*** (0.0011)	-0.0093*** (0.0011)	-0.0092*** (0.0011)
lnage	-0.2344*** (0.0145)	0.2482*** (0.0290)	-0.4919*** (0.0279)	-0.1909*** (0.0198)	-0.1320*** (0.0221)	-0.2513*** (0.0163)	-0.2386*** (0.0147)	-0.2307*** (0.0152)	-0.2530*** (0.0161)
herf	-0.9862*** (0.3291)	-0.2222 (0.4104)	-1.4829*** (0.5323)	0.2440 (0.7441)	-1.8900*** (0.4930)	-0.9359** (0.4232)	-0.9377*** (0.3308)	-0.9756*** (0.3563)	-1.0335*** (0.3549)
constant	7.1353*** (0.1445)	10.8025*** (0.2776)	8.6247*** (0.2145)	6.9420*** (0.2025)	7.0384*** (0.2292)	6.1495*** (0.1833)	7.0702*** (0.1472)	7.2649*** (0.1503)	7.3450*** (0.1567)
σ_u	0.8571	1.09	0.9365	0.7385	0.6950	0.7535	0.8472	0.8796	0.8816
σ_ε	0.4460	0.3140	0.4508	0.4042	0.3737	0.3901	0.4463	0.4522	0.4616
ϱ	0.7869	0.9231	0.8119	0.7695	0.7758	0.7886	0.7828	0.7910	0.7848
Observations	13,171	2,585	10,586	5,455	3,272	8,384	12,453	12,227	11,915
Groups	5,189	1,133	4,828	1,958	1,075	3,407	4,816	4,826	4,929
R-squared	0.2833	0.5967	0.2720	0.3128	0.4016	0.2092	0.2825	0.2904	0.2912
Mean VIF	8.18	9.22	9.85	8.62	9.04	8.31	8.16	8.07	7.79
Hausman test									
$\chi^{2(8)}$	2,040.23	1,500.44	1,632.78	880.90	656.62	864.18	1,871.78	1,954.68	1,879.45
Prob>χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Source: IOBE.
Notes: Standard error in parentheses. Level of statistical significance: *** p<0.01, ** p<0.05, * p<0.1%.

Table 6 Estimations about the factors affecting the decision of new firms to export (2000-2016)

	Coefficient	Odds ratio
lnage	5.85*** (0.099)	349.33*** (31.78)
location	0.40*** (0.034)	1.49*** (0.051)
lncash	0.24*** (0.008)	1.28*** (0.011)
lnnomfunding	4.95*** (0.177)	142.34*** (25.29)
kibs	1.15*** (0.099)	3.18*** (0.315)
ict	1.04*** (0.095)	2.84*** (0.270)
sector	-0.43*** (0.009)	0.65*** (0.0059)
constant	-143.49*** (4.65)	4.78e-63*** (2.23e-62)

Source: IOBE.
Notes: Standard error in parentheses. Level of statistical significance: *** p<0.01, ** p<0.05, * p<0.1%.

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ABSTRACT

The phenomenon of cryptoassets emerged over the past few years and has prompted several national and international institutions to deal with the issue, in particular with its implications for financial stability. In order to assess the impact, a taxonomy is needed. The paper starts with exploring the blockchain, which is the enabling technology, and continues with a discussion on Financial Technology (FinTech) both in general and with a focus on blockchain applications. Further, the ecosystem of cryptoassets is explored and an analysis of cryptocurrencies, which are the most popular application of cryptoassets, is attempted. In each case, a non-technical briefing on the topic is provided, followed by some thoughts on potential financial stability implications. The issue is rather new and largely inconclusive. For the time being, we adhere to international institutions' general recommendation that the risks are not significant as yet, but the phenomenon is dynamic and vigilant monitoring is warranted.

Keywords: blockchain, cryptography, FinTech, cryptoassets, digital assets, money, cryptocurrencies

JEL classification: G1, G2, G11

ΤΑ ΚΡΥΠΤΟΣΤΟΙΧΕΙΑ ΚΑΙ ΟΙ ΔΥΝΗΤΙΚΕΣ ΕΠΙΠΤΩΣΕΙΣ ΤΟΥΣ ΣΤΗ ΧΡΗΜΑΤΟΠΙΣΤΩΤΙΚΗ ΣΤΑΘΕΡΟΤΗΤΑ

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ΠΕΡΙΛΗΨΗ

Το φαινόμενο των κρυπτοστοιχείων αναδείχθηκε τα τελευταία χρόνια και οδήγησε πολλούς εθνικούς και υπερεθνικούς οργανισμούς να ασχοληθούν με το θέμα, ιδιαίτερα με τις επιπτώσεις στη χρηματοπιστωτική σταθερότητα. Για να αξιολογηθούν οι επιπτώσεις, απαιτείται μια ταξινόμηση των επιμέρους θεμάτων. Το άρθρο αρχικώς εξετάζει την τεχνολογία κατανεμημένου καθολικού (blockchain), η οποία είναι η τεχνολογία που επιτρέπει τη δημιουργία κρυπτοστοιχείων, και στη συνέχεια η συζήτηση επικεντρώνεται στη χρηματοοικονομική τεχνολογία (FinTech) ως γενικό φαινόμενο και ως ειδικό φαινόμενο εφαρμογών της τεχνολογίας κατανεμημένου καθολικού. Στη συνέχεια, εξετάζονται το πλαίσιο και το εύρος των κρυπτοστοιχείων, καθώς και τα κρυπτονομίσματα ως η πιο γνωστή εφαρμογή των κρυπτοστοιχείων. Για κάθε περίπτωση, αναπτύσσεται μια μη τεχνική περίληψη και ακολουθούν ορισμένες σκέψεις σχετικά με τις ενδεχόμενες επιπτώσεις στη χρηματοπιστωτική σταθερότητα. Το αντικείμενο είναι καινούργιο χωρίς να υπάρχουν σαφή συμπεράσματα. Προς το παρόν, συντασσόμαστε με τη γενική σύσταση των διεθνών οργανισμών ότι οι κίνδυνοι δεν είναι σημαντικοί, αλλά το φαινόμενο είναι δυναμικό και απαιτεί συνεχή παρακολούθηση.

CRYPTOASSETS: POTENTIAL IMPLICATIONS FOR FINANCIAL STABILITY

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1 INTRODUCTION

Over the past three years, the banking industry has been flooded with new terms such as peer-to-peer/P2P lending, cryptoassets, cryptocurrencies, blockchain, robo-advisors, Big Data, sandbox, etc., all resulting from novel processes and products which have become available for financial services, thanks to digital technological advancements, and which are referred to as Financial Technology (FinTech). The subject is rather complex, as it is necessary to combine elements from three disciplines: economics, cryptography, and computer science.

FinTech is an ecosystem that uses innovative methods and new technologies in order to offer new solutions to existing problems and, therefore, it is in competition with traditional methods for delivering financial services. The prevalent characteristic of FinTech applications is digitisation, and a by-product is the creation of a new asset class, the cryptoassets. These are assets that are created by digital technology, stored in a public ledger and exchanged through a peer-to-peer network, without the need for a trusted intermediary. The best-known example of cryptoassets are the cryptocurrencies, e.g. bitcoin, and their prominence from obscurity prompted the academic community to revisit fundamental questions, such as "what is money?".

The technology underpinning the creation of most cryptoassets is the blockchain technology. It was popularised with the publication of the Bitcoin whitepaper in 2009 as the core mechanism underlying bitcoin. The blockchain technology is an example of decentralised ledger technology (DLT), which enables, through cryptography, the validation of transactions without the control of third parties. The technology has spurred a number of currency-like instruments as well as self-executing contracts, and, in less than a decade, the industry developed from virtually non-existent into a thriving system comprising several cryptoassets. The blockchain technology is expanding to several other fields, blurring the borders between the physical and the cyber space.

In order to analyse the potential implications for financial stability, we may consider the whole issue in concentric circles. In the outermost circle resides the blockchain technology, which is the enabling technology, while in the next inner circle FinTech applications are located, particularly those that employ the blockchain technology. The space in the subsequent inner circle is covered by the cryptoassets, a subset of FinTech applications, and then in the innermost circle we find the cryptocurrencies, the most popular example of cryptoassets. By analogy, the paper follows the same logic. Each circle is mirrored in the four parts of the paper, and each part is divided into two sections, with the first section offering a non-technical briefing on the issue and the second section focusing on the potential implications for financial stability. With this set-up in mind, Part 2 analyses the blockchain technology; Part 3 focuses on FinTech applications in the banking sector; Part 4 deals with cryptoassets and their taxonomy; and finally, Part 5 explores cryptocurrencies as a special case of cryptoassets.

2 THE BLOCKCHAIN: CRYPTOGRAPHY AT ITS HEIGHT

(a) A brief non-technical overview

A software system can follow two main structural approaches, that is a centralised and a decentralised (or distributed) architecture. In

1 The views expressed in this paper are those of the author and do not necessarily reflect those of the Bank of Greece and of the Eurosystem. Any errors or omissions are the author's responsibility.

a centralised system, there is a central node, i.e. a computer user with the appropriate software which coordinates all other nodes that are located around and connected with it. In a distributed system, on the other hand, there are several peer-to-peer interconnected nodes. All nodes are equal, there is no hierarchy, there are no special nodes and no central control unit. The mechanics of each approach can be illustrated with a hypothetical financial transaction.

Assume A wants to send money to B. In centralised systems, there is a central agent (a bank) that manages, for a fee, a private ledger. It ensures that the transaction can be processed and it transfers balances by crediting and debiting the corresponding accounts. Legal rules prevent the falsification of the ledger records. In distributed systems, where such a central agent does not exist, A should broadcast (similar to sending an email) its request to the network, and the participants must validate the transaction. In order to fulfil this task, they have to ensure that A possesses the required amount, which means that all participants should have, at any time, the same information set. Thus, there is a public ledger, open to everyone, with the history of all past transactions that they have reached consensus on. In order to avert any malicious transactions, i.e. a node wrongfully assuring that A possesses the requested amount, there is a consensus mechanism to which all nodes adhere. In effect, this is a protocol that describes the rules which allow users to reach a mutual agreement. The node ensures that A possesses the amount and broadcasts it to the network, which validates the transaction. Once completed, the new block is appended to the ledger simultaneously by all nodes.

The blockchain technology is an implementation layer of a distributed software system (see Box 1). The problem with distributed software systems is how to ensure data immutability, i.e. that no participant can tamper with the transaction after it has been recorded, as well as how to devise a mechanism that prevents two transactions from concurrently modifying a single object in a database. The solution that the blockchain proposes is the public ledger to be organised in blocks chained through cryptography. All pending transactions are grouped in a block, which is chained to the previous block, and therefore the public ledger contains several blocks each one connected with the one before it, in chronological sequence, thus forming a chain (the blockchain). In this sense, a blockchain is like a book, containing the ledger of all past transactions with a new block being a new page that records all current transactions. The integrity of the system is achieved and maintained by chaining the blocks through a hash,[2] a fixed-length summary of a message. This is an efficient way of addressing past information and recognising it again. Each block has the hash of the transactions as well as the hash of the previous block. This is how the blocks are chained, which helps to verify that the information in the previous blocks has not been modified. This iterative process confirms the integrity of the previous blocks, all the way back to the original "genesis" block. This ensures data integrity, as a record cannot be altered retroactively without the alteration of all subsequent blocks and the collusion of the network.

In order for a block to be accepted in the chain, it has to meet two criteria: (i) transaction legitimacy; and (ii) transaction consensus. For the former, the blockchain platforms use a type of digital signatures. A public key (a long, random-looking string of numbers co-shared with the network) is an address on the blockchain (similar to a username in centralised applications), and the digital assets sent across the network are recorded as belonging to that address. A private key (similar to the PIN code

2 A cryptographic hash function is used to produce the hash. The hash function transforms a random-sized input into a fixed-sized output, which is non-human readable. For instance, the hash value of the text "Bank of Greece", using the hush function SHA-256, is: "e2243a139d311f0b72d5b5283d4dd06d8c239edbd7001aa3f514ffde7b05a3e0". A small modification to the text leads to an entirely different hash value. Consider the text "bank of Greece", with the following hash value: "307b68545c3bfbcab40ea22bb0b8b3fc78688951c08dd58cf49d6f7b85d60871".

of a credit card) is used to sign transactions, offering its holder access to the digital assets as well as the means to interact with the various capabilities supported by the blockchain platform.

As regards transaction consensus, this is a mechanism based on some sort of resources investment. Details may vary but, in most cases, it is in effect a hash verification procedure, which is called mining. Each node has a pool of outstanding transactions that have been transmitted to the network but have not yet been included in the blockchain because consensus has not yet been achieved. At regular intervals, every node in the system proposes its own outstanding transaction pool to be the next candidate block. In order to do so, it is required to solve a mathematical puzzle. It has to find a random number, or "nonce" (Number used Once), which, along with the hash of the transaction and the hash of the previous block, creates the hash of the block, i.e. its fingerprint. Nodes try different nonces, looking for the one that results in the block hash being below a certain arbitrary threshold value, fixed by the protocol. The only way to solve this hash puzzle is by trial and error, that is to try enough nonces until the appropriate one is found by luck. The probability of finding the correct nonce depends on the computational power used. At the same time, the threshold is increasing in difficulty for each new candidate block, creating a vicious circle of computing power needed and solution of the mathematical puzzle. For this reason, the procedure, called proof-of-work, is criticised for energy waste. Other validation methods can be used, such as proof-of-stake where the creator of the next block is chosen according to the stake held, but in this case the equality of all nodes is violated.

Actually, the nodes are in competition to each other and are continuously trying to find block candidates that have a hash value satisfying the criterion. If a node succeeds, it broadcasts the block candidate as quickly as possible to the network, so that the other nodes, by some sort of weighted voting, may verify it. By doing so, they agree on the exact order in which new records are appended to the shared ledger and build on top of the block by including its hash in the next block that they create.

Having described the technology in a simplistic way, it is important to point out that a blockchain platform can be either open/public, allowing access to anyone with a computer and the appropriate software, or closed/private, allowing only limited access. In the former case, anyone can start running a public node, validating transactions and participating in the consensus processes, whereas in the latter case permission is needed to participate in the network. Thus, sometimes we refer to permissionless and permissioned blockchain, by analogy with the internet, which is open to everyone, and the intranet with restricted access.[3]

(b) Implications for financial stability

This very brief description of the blockchain technology allows us to make some reflections on its potential implications for financial stability. We focus on the financial applications of the blockchain technology, but it is worth remembering that the applications are expanding into several fields such as health, education, supply chains of various commodities, video content,[4] etc.

The blockchain technology gained popularity as the core mechanism of bitcoin during the global crisis of 2007-08. Coincidence or not, many attributed its rise from obscurity to pub-

3 There is a debate on whether a private system, where the users are authorised (permissioned) by a central authority, should be considered as blockchain. Proponents argue that the term "blockchain" can apply to any data structure that batches data into time-stamped blocks. Opponents say that permissioned systems resemble traditional databases, not supporting decentralised data verification. Despite the debate, it seems that the latest versions of the technology return to a more centralised paradigm. See Demertzis, M. and G.B. Wolff (2018), "The economic potential and risks of crypto assets: is a regulatory framework needed?", Bruegel Institute, *Policy Contribution*, Issue No. 14.

4 By 2023, up to 30% of world news and video content is expected to be authenticated as real by blockchain, countering deep fake technology. See "Gartner Top Strategic Predictions for 2020 and Beyond", available at https://www.gartner.com/smarterwithgartner/gartner-top-strategic-predictions-for-2020-and-beyond/.

lic distrust of institutions, which is a typical behaviour during a crisis. The soundness of the traditional financial services providers was questioned during the crisis, and powerful institutions were perceived to take decisions in favour of some groups and at the expense of others. In such circumstances, people favour a system without a "trusted intermediary". Blockchain, through its novel consensus mechanism, provided that opportunity, and just as the internet changed the way we transfer information, blockchain is changing the way we transfer a value.

Any type of digital or digitised asset can be created, from ownership of assets to contractual obligations, credit exposures or digital identity. The corresponding data can be securely recorded on a blockchain, which provides a proof of their existence at any given moment. In this way, digital or digitised assets can be transferred, exchanged and traded, since cryptographic sealing guarantees that the records are tamper-free and universally accepted and that any illegal uncontrolled duplication and counterfeit can be traced. Can the blockhain technology keep its promise though, particularly so in view of the increasing number of hacking incidents? After all, preserving the integrity of a value transfer system and keeping it operational is a public good. Action should be taken against the various societal and systemic threats that the blockchain technology potentially poses due to inefficiencies and technical limitations. No technology is neutral, and technological advances have always had practical implications, affecting behaviours and ethical values.

The key characteristic of a value transfer system using blockchain technology is the novel model of trust, and therefore it has been dubbed as "the trust machine" by *The Economist*.[5] But the new paradigm of truth revelation in financial transactions has financial stability implications. Shifting from "trusting humans" to "trusting machines" or "trusting cryptography" may undermine the integrity of the system and may lead to a reconsideration of fundamental questions such as "what is the definition of value?" or "what does society look like when authority is decentralised?".

In traditional centralised systems, values are created through managing information. Institutions hold centralised databases, which can be effectively managed, controlled, scaled and operated. The information flow is managed and processed by humans, thus value creation depends on human actions. The blockchain technology has full control of the information process, but no majority can influence the decision process. The decision is taken in relation to the ability to solve cryptographic puzzles and this, in turn, is related to the brut computational power used or some other egalitarian mechanism. This mechanical approach eliminates human intervention and results in automatic massive database replication, where data quality resides in computational trust. No centralised "official" copy exists and no user is "trusted" more than any other. Cryptography ensures that no unauthorised replication will take place, and this immutability eliminates the need for reconciliations. Therefore, the blockchain technology provides a historical, unique reconciled version of the truth. This link between the blocks solves the double-spending problem, that is the possibility of effectively using multiple times the same given value, i.e. spending more than once a given sum of money. The characteristic of infinite reproducibility is inherent in digital assets, but the use of cryptography ensures that each unit of value is transferred only once. This is an important attribute, since financial systems are self-sustained when the public has trust in the feasibility and enforceability of the underlying trading arrangement. Ultimately, this means confidence in asset acceptability, asset future value and market integrity. Any disruption of the automated process devised by the decentralised systems may result in distrusting the value transfer system, with potentially significant implications for financial stability. Trust is something that evaporates in a minute, on

5 *The Economist*, 31 October 2015.

the slightest suspicion regarding the integrity of the system.

Furthermore, the blockchain technology signals a shift from "centralised" to "decentralised" control,[6] which is closely interlinked with the foundations of society, government, economy and financial stability. Back in 1937, Ronald Coase[7] posed a question about the activities directed by market forces and the activities undertaken by firms. He showed that most economic activities are carried out by centralised entities —firms— rather than being organised by "the price mechanism" in a series of market transactions, due to lower transaction costs. The blockchain technology challenges this fundamental idea in economics. In the past, software technology had reduced transaction costs and digital technology had enabled cost-effective solutions, but they all were within the centralised mode. Blockchain technology's disruptive potential lies actually in the shift to the decentralised mode.

In general terms, our societies are centralised with rather strict hierarchies that govern activities. Negotiations and transactions are influenced by information asymmetries among counterparties, which result in problems like moral hazard and adverse selection. These problems have been minimised by the introduction of central authorities, which function as a single point of control (in good times) but also as a potential point of failure (in bad times). Decentralised technologies disrupt the hierarchical structure and reduce the imbalance of information among agents, making data transparent to everyone involved. They enable new business models, innovative organisation forms or new processes of work and production. Their strength (and weakness) resides in the absence of a vulnerable single point of failure and in the community-based verification process through a consensus mechanism. From a financial stability perspective, the question is whether such a consensus mechanism leads to a Nash equilibrium, that is, whether it represents a stable situation, in the sense that an outcome is actually generated and is generated by an honest node.[8] The former refers to consensus impossibility, which is a theoretical case, but in some circumstances the finality of the transactions cannot be guaranteed. Certainly, at any moment, several alternative validation models can be introduced in order to ensure transaction execution, but they all require changes with strong implications for centralisation, security, egalitarian structure and anonymity issues.

With regard to the honesty issue, in academic research it is common to assume that some nodes are honest and some malicious, trying to devise a system that leads to honest equilibrium (good equilibrium), i.e. a system where all honest nodes are in agreement on the value and no node has incentives to deviate from honest behaviour. The problem is whether there are built-in incentives to report truthfully. In a blockchain environment, dishonesty is not impossible, but is costly. The validation process requires costly computational power to solve the mathematical puzzle. In blockchain applications (smart contracts) there is a built-in execution code, thus there is no need to enforce laws against dishonesty.

However, it is very likely that colluding nodes introduce a "fork" into the chain, leading the application to different directions,[9] or it is even possible that a node takes advantage of a bug in the code, creating a new protocol (see Box 2). How can such behaviour be characterised? Honest or not, every time those changes are introduced into the protocol, there are tensions because such changes can impact profits and business models. In addition, such a system

6 Some argue that decentralisation is not the key feature of the blockchain technology, but the better record keeping is valuable in itself.

7 "The main reason why it is profitable to establish a firm would seem to be that there is a cost of using the price mechanism. The most obvious cost of 'organizing' production through the price mechanism is that of discovering what the relevant prices are. [...] The costs of negotiating and concluding a separate contract for each exchange transaction which takes place on a market must also be taken into account". See Coase, H.R. (1937), "The Nature of the Firm", *Economica*, 386-405.

8 There is no particular moral salience to "honest behaviour". It is just one strategy of many.

9 A "fork" may create an upgraded version or a competing version of the blockchain.

is prone to the so-called "Sybil attack", which implies a malicious outcome if a node controls at least 51% of the mining power in the network. It can affect ownership, property rights, acceptance of illicit transactions, denial of legitimate transactions, etc., and destroy the stability of the whole network. Instability, once initiated, strengthens the attacker's position, as an increasing number of honest miners start leaving the network, undermining confidence in the system.

The importance of the blockchain technology and its potential applications prompted several international organisations to get involved. The OECD has created a blockchain policy centre and a blockchain policy forum, and has issued several papers on blockchain technology.[10] The European Commission considers blockchain as a strategic technology and encourages governments, the industry and citizens to benefit from blockchain opportunities. The Commission considers that the blockchain technology "...is still in a maturation phase, and there is a need for more innovation, research, development, piloting and proof of concepts in order to facilitate uptake".[11] The aim is to develop a common approach on blockchain technology for the European Union (EU) in the international arena. To that end, distributed ledger technologies are considered in the Horizon 2020 Work Programme and FinTech cooperation actions, while the EU Blockchain Observatory and Forum was launched, with a view to becoming a knowledge hub on blockchain, mapping relevant initiatives, sharing experiences, and pooling expertise on blockchain and its related challenges.

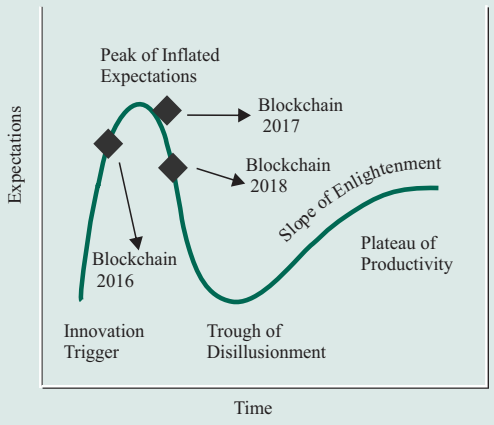
10 OECD (2019), "OECD Blockchain Primer", available at http://www.oecd.org/finance/OECD-Blockchain-Primer.pdf.
11 See https://ec.europa.eu/digital-single-market/en/blockchain-technologies.

Box 1

THE HYPE CYCLE

The implications and the impact of technological advances are likely to be different in the short and in the long run because it takes time for consumers to react, and the necessary investment by financial firms may be delayed. There is a general tendency to overstate the impact of technological change in the short term but to underestimate its longer-term and enduring impact. The maturity and adoption of technologies and applications follow a hype cycle (formulated by Gartner, an IT consultancy firm),[1] where there are five consecutive stages. An innovation trigger creates new expectations, which reach a peak, to be followed by a more realistic interpretation, after which a trough of disillusionment emerges (interest fades, as implementations fail to deliver anticipated results and early entrants either fail or exit).

Figure 1 The Gartner hype cycle



Source: Gartner, Inc.

1 Gartner Hype Cycle, available at https://www.gartner.com, and Fenn, J. and M. Blosch (2018), "Understanding Gartner's Hype Cycles", Gartner Research.

There follows a moderate pace of acceptance until it reaches a sustainable plateau. This seems to be a pattern that has emerged with various examples of technology-based innovations in many sectors of the economy and not just in finance.

In graphical terms, this can be illustrated with the curve shown in Figure 1, where the state of blockchain technology is presented according to the originators of the approach.[2] It should be noted that there is no reference to the technology on reports prior to 2016.

Blockchain technology is entering the trough of disillusionment stage, but how long this will last is unknown. Some innovations mature faster than others, thus the decline is rather short. On the other hand, there is no guarantee that a technology will manage to leave the trough of disillusionment stage in order to mature and reach mainstream adoption.

2 Walker, M. (2018), "Hype Cycle for Emerging Technologies, 2018", Gartner Research.

3 FINTECH REVOLUTION: IS THIS TIME DIFFERENT?

(a) A brief overview

According to the Financial Stability Board (FSB), FinTech is "...technologically enabled financial innovation that could result in new business models, applications, processes or products with an associated material effect on financial markets and institutions and the provision of financial services".[12] The FSB definition is intentionally broad to accommodate the wide array of innovations and the fluidity of FinTech developments.

FinTech companies consist of both incumbent banks and new entrants, being either start-ups or larger technology firms, aiming to enhance the services provided by existing financial companies. The *Financial Times* wrote on 14 October 2015: "The aim is to inflict death by a thousand cuts. FinTech start-ups are nimble piranhas, each focusing on a small part of a bank's business model to attack". Four years later, this prophecy has probably not yet been fulfilled, since *The Economist* claimed on its edition of 4 May 2019 that "...digital disruption is coming to banking at last".

The financial sector has always been a leader in applying technological innovations either as internally driven solutions or as externally developed novelties. Thus, it is reasonable to ask oneself whether this time is different.[13] Some consider that this is a repetition of the dotcom bubble of the early 2000s, which quickly deflated. Sometimes there is a tendency to overstate the short-run implications of technology, while understating the nature and the extent of the long-term implications.[14] For many people there is a sense of *déjà vu*[15] and the existing structures will be adjusted to the new reality.

FinTech innovations can be categorised according to their underlying economic function into three groups:[16]

(i) credit, deposit and capital-raising services, e.g. crowdfunding, neo-banks, lending marketplaces, credit scoring;

12 Financial Stability Board (2017), *Financial Stability Implications from FinTech*, June.
13 This intuitively refers to the same question Reinhart and Rogoff asked about the global financial crisis of 2007-08, which prompted a tsunami of regulatory measures to correct the deficiencies identified. See Reinhart, C.M. and K.S. Rogoff (2011), "This Time Is Different: Eight Centuries of Financial Folly".
14 Llewellyn, D.T. (2018), "Financial technology, regulation, and the transformation of banking", Banco de España / SUERF conference: Financial Disintermediation and the Future of the Banking Sector.
15 Dermine, J. (2016), "Digital banking and market disruption – a sense of déjà vu", Banque de France, *Financial Stability Review*, No. 20.
16 Financial Stability Board (2017), op. cit. A similar taxonomy is proposed by the IMF. See Dong, He et al. (2017), "Fintech and Financial Services: Initial Considerations", IMF Staff Discussion Note No. 17/05.

(ii) payments, clearing and settlement services, e.g. mobile wallets, peer-to-peer transfers, digital currencies, digital exchanges;

(iii) investment management services, e.g. algorithmic trading, high-frequency trading, copy trading, robo-advice.

The prevalent characteristic of FinTech applications is digitisation, and the three basic digital technologies,[17] namely cloud computing, mobile phones and distributed ledger, made it possible to offer solutions across a wide spectrum of financial services. In cases where these innovative solutions are offered by start-ups outside the financial industry, they are in direct competition with traditional banking. Therefore, such innovations may disrupt and fundamentally change the existing structures, blurring the industry boundaries. This may facilitate strategic disintermediation and revolutionise how financial firms supply credit and products and how non-financial firms demand financial services.[18]

(b) Implications for financial stability

Banks are intensive users of both IT and financial technologies, and have a wealth of data available that may be helpful in adopting new technological ideas. In the past, technological advances in the banking sector increased efficiency and productivity but, at the same time, raised questions about the viability of banks. The introduction of credit cards in the 1960s, of ATMs and phone banking services in the 1980s, of complex financial products in the 1990s, of internet banking at the turn of the millennium and the possibility to offer remote services, all raised similar concerns about financial intermediation. Despite gloomy predictions regarding the gradual demise of banking, banking assets-to-GDP ratios grew in both advanced and emerging market economies. However, the nature of financial intermediation has changed and will probably change again.

The extensive work in the field of financial intermediation points to the distinct value of relationship banking. Importantly however, much of this research predates developments in information technology that have facilitated "more distant" banking operations. Digitisation lowered entry barriers, causing long-established boundaries between sectors to blur, and raised opportunities for new market entrants offering services at a lower cost than the legacy players. Demand-side forces further facilitate this. Millennials[19] have developed different consumer habits from their predecessors, since they are accustomed to technologies (digital natives) and are looking for personalised solutions rather than the "mass production" approach of their predecessors. FinTech solution providers offer their services remotely, usually through an internet platform. Online platforms offer a variety of products and services, thus facilitating consumers and investors without banking experience to access financial services. FinTech has brought a new paradigm to the design and implementation strategies for financial inclusion. For example, smartphones for mobile banking and investing services are technologies that are making financial services much more accessible to the general public. Financial inclusion increases through improved access to financial services for underserved groups. It is easier for consumers in remote places to have access to a computer that to a nearby bank branch.

Traditionally, banks combine or bundle services and activities in order to exploit economies of scale and scope. This distinguishes banks from many of their competitors, e.g. non-banking financial institutions such as mutual funds and finance companies. On the other hand, FinTech companies carry out some of these activities in an unbundled way. They unbundle the package, that is they disaggregate the value chain, focusing on the most prof-

17 Kirilenko, A. (2017), "An introduction to FinTech", in Allen, F., E. Carletti, J. Gray and M. Gulati (eds), *The Changing Geography of Finance and Regulation in Europe*.
18 Philippon, T. (2016), "The FinTech opportunity", NBER Working Paper No. 22476.
19 Millennials are those who were born between the mid-1980s and the end of the 1990s. They follow Generation X (1960s to mid-1980s) and Baby Boomers (1940s to 1960s).

itable segments, and offer specialised services. Thus, they are in direct competition with traditional banking.

Furthermore, the method of analysis is different from the traditional approach, since it is based on artificial intelligence, machine learning and big data analytics.[20] These tools are used for assessing credit quality, pricing contracts, automating client interaction, back-testing models, optimising trading execution, etc. These developments benefit consumers as they lower transaction costs and offer individualised products, but a number of potential risks to financial stability may escalate.[21] First and foremost, cyber risk. Risks related to data security, privacy, cybercrime and customer protection arising from outsourced functions may become more difficult to manage. There is a systemic component of cyber risk as well. FinTech will very likely lead to more IT interdependencies, since the large number of participants and their interconnectivity may increase the complexity of the system. A single IT risk or cyberthreat event could easily escalate into a systemic crisis. Then, there is compliance risk. Greater automation and distribution of services among banks and FinTech companies could result in reduced transparency on how transactions are executed and who has compliance responsibilities. Finally, some other considerations may arise, such as new systemically important participants that may fall outside the regulatory perimeter or unexpected forms of interconnectedness between financial markets and institutions.

Certainly, banks cannot distance themselves from developments and they try to adapt to the new reality, but this may profoundly change their business models as well as the scale and scope opportunities. Their response may vary from partnering with and investing in FinTech firms through venture capital or via direct investments to collaborating with other banks and stakeholders (consortia) to develop new technology, or developing FinTech solutions internally. Whatever the outcome, it will put pressure on their traditional business model. Banks have traditionally focused on products, while new entrants are more focused on customers. This may change, and banks will most probably assimilate the FinTech solutions. To put it into context, the BCBS[22] has identified five stylised scenarios. These scenarios are based on the activities that established players are expected to perform in a digitally-intense banking environment. Some banks will digitise and modernise themselves, leveraging enabling technologies and managing to improve the banking services and products offered. Some others will be replaced by new technology-driven banks, such as neo-banks or banks established by big technological companies. Other banks will compete with other players in increasingly modularised financial services and will manage to carve out enough of a niche to survive. However, some banks will be relegated, since other financial services providers will replace them, and some others will exit financial intermediation, since their services will be provided by more agile platforms and technologies. The five scenarios presented are extreme. The expected future development of FinTech may involve a combination of different scenarios, under which both FinTech companies and banks own aspects of the customer relationship while at the same time providing modular financial services.

Two by-products of FinTech, which may enhance financial stability, are the so-called RegTech (Regulatory Technology) and SupTech (Supervisory Technology). RegTech

20 The application of computational tools to address tasks traditionally requiring human sophistication is broadly termed "artificial intelligence". Machine learning may be defined as a method of designing a sequence of actions to solve a problem, known as algorithms, which optimise systems automatically through experience and with limited or no human intervention. Big Data is a loose term to refer to large volumes of both unstructured (e.g. internet traffic) and structured (e.g. databases) data whose analysis is not possible using traditional analytical tools. See Financial Stability Board (2017), *Artificial intelligence and machine learning in financial services. Market developments and financial stability implications*, November.

21 Basel Committee on Banking Supervision (2017), "Sound Practices: Implications of FinTech developments for banks and bank supervisors, Consultative Document", Bank for International Settlements, August.

22 Basel Committee on Banking Supervision (2018), "Sound Practices. Implications of FinTech developments for banks and bank supervisors", Bank for International Settlements, February.

focuses on technology-based solutions to solve regulatory and supervisory challenges, e.g. automating regulatory reporting. It leverages digital data and computer networks to substitute old-style processes, organisational and IT structures, and analytical tools, and improves decision-making. These may help banks to reduce compliance costs, make internal risk management more efficient and pursue regulatory objectives such as consumer protection or anti-money laundering. SupTech refers to the use of innovative technologies to assist supervisory agencies with the assessment of supervised entities' compliance with laws and regulations as well as with the monitoring of their risks.[23]

Again, FinTech is on the radar of international institutions. The European Commission has launched a public consultation[24] seeking input from all stakeholders to the development of a FinTech policy, aiming to promote supportive measures that can contribute to the introduction of FinTech solutions, as well as proactive measures that can encourage new solutions and address emerging risks and challenges. Supportive measures include facilitating the expansion of innovative business models through clear and consistent licensing requirements; encouraging Member States to facilitate the creation of innovative business models through innovation hubs; and examining the appropriateness of existing rules in providing guarantees for accommodating new technologies in the financial sector. The latter is particularly important, as the financial services regulatory framework must be technologically neutral towards FinTech innovation in order to ensure a level playing field. At the same time, it is necessary to ensure respect for financial stability, consumer and investor protection, as well as anti-money laundering considerations.

Finally, the European Central Bank (ECB) requires that the licensing of FinTech banks follows the same policies that apply to the licencing of any bank within the Single Supervisory Mechanism. It defines a FinTech bank as a bank with "...a business model in which the production and delivery of banking products and services are based on technology-enabled innovation".[25] This measure is aimed at ensuring that FinTech banks are properly authorised and have in place risk control frameworks.

4 CRYPTOASSETS: A NEW EXPOSURE CLASS IN THE MAKING?

(a) The concept

As explained above, digitisation is a key characteristic of the FinTech revolution, which enabled the creation of a new class of assets, the digital assets. The vehicle is the blockchain platforms, which were initially used as the technical foundation of the cryptocurrencies, but then became independent allowing the digitisation of any asset through specific built-in applications. These applications are called "smart contracts". In effect, a smart contract is a digital contract, that is a software programme embedded in a blockchain, describing an agreement or set of rules that govern a business transaction. It is self-executed automatically when conditions are met,[26] thus allowing a digital asset to be transferred, exchanged and traded.

For analytical purposes, it is necessary to categorise digital assets. If the criterion is the underlying technology, digital assets can be categorised depending on whether they are developed in a permissioned scheme, where a central agency exists, and this is the case of central bank digital currencies, or in a permissionless scheme, where no central agency exists, and this is the case of cryptoassets. Thus, it is straightforward that central bank digital cur-

23 See di Castri, S., S. Hohl, A. Kulenkampff and J. Prenio (2019), "The suptech generations", *FSI Insights on policy implementation*, No. 19, Bank for International Settlements.
24 European Commission (2018), "FinTech Action plan: For a more competitive and innovative European financial sector", COM(2018) 109/2, March.
25 European Central Bank (2018), "Guide to assessments of fintech credit institution license applications", March.
26 Therefore, a platform allows "A to send x amount to B" according to its protocol, and through a built-in smart contract allows "A to send x amount to B if ... (*condition*) ...".

rencies differ from cryptoassets.[27] If the criterion is the underlying asset, digital assets can be categorised according to the asset's nature, i.e. whether it is a real world asset (with or without the backing of an institution) or a virtual asset. Actually, no categorisation can be accurate, since the market is constantly evolving and flooded with new, very diversified products. There is no standardisation and each new product exhibits several innovative features, thereby increasing ambiguity regarding categorisation as well as its ensuing implications.

As the word suggests, cryptoassets rely heavily on cryptography, which provides a mechanism for securely encoding the rules of a cryptoasset's creation. The process for creating a cryptoasset is called tokenisation. This is the process through which a right to an asset is transformed into a source with intrinsic value. To be more precise, it is a method of digitally representing an interest on a blockchain, which may be an asset with value, or a right to receive a benefit, or a right to perform specified functions, so that they can be transferred via the blockchain protocol or via the built-in code. The outcome of the process produces blockchain-based tokens or simply tokens. This is an umbrella term used for a wide variety of cryptoassets and indicates tradable rights that are specifically designed to be easily transferrable, with relatively few barriers to their acquisition. Tokens do not originate from a blockchain but are created at the top of the chain of blocks and managed by a smart contract.

For conceptualising the issue, suppose that someone wants to tokenise ownership of their house. They create a non-fungible (unique) token or digital certificate, which represents the property rights of the house and the associated land. Then, they need to record the ownership of the token on a blockchain. This token can be transferred, through the auto-executed algorithm of a smart contract where conditions can be attached, and whoever owns the token has full ownership of the house.[28] If a fungible (exchangeable) token is created, then this can be exchanged against fiat money or cryptocurrency. Again, whoever the token is transferred to has full ownership of the house, but this implies that there is a rate of exchange between that token and the currency, which establishes the price of the house.

The above example can be generalised, and it is possible to assume that any asset can be recorded on the blockchain and exchanged via blockchain protocol or smart contract. The assets being tokenised can be a unit of account (e.g. bitcoin), or the right to revenue or dividend flows, or the right to a physical or digital asset, or the right to use someone else's asset (e.g. renting a house for a night), or the right to access the platform, just to name a few. All these rights are described in the computer code underlying the smart contract.

Tokens may be offered to the public, typically, in a process called Initial Coin Offering (ICO), alluding to the initial public offering (IPO) of securities in the traditional capital markets. Start-up companies, instead of taking the path of regulated traditional venture capital funding or crowdfunding, offer tokens to the public in exchange for fiat money or cryptocurrencies. ICO organisers disclose a whitepaper in which they configure their business idea and the potential merits. Usually they seek support on social networks, run a public relations campaign, and then try to sell tokens to those willing to contribute. These can be understood as cryptographically-secured coupons, which embody a bundle of rights and obligations, depending on the nature of the ICO's structure and the participants' activities. The entire process is conducted online, typically without the involvement of investment banks or other professional intermediaries. The organisers collect

27 The issues are discussed in a recent report by the Bank for International Settlements (BIS), which highlights the underlying considerations. It concludes that the strengths and weaknesses of a general purpose central bank cryptocurrency would depend on specific design features. The report further notes that, while no leading contenders have yet emerged, such an instrument would come with substantial financial vulnerabilities, while the benefits are less clear. See Committee on Payments and Market Infrastructures, and Markets Committee (2018), *Central bank digital currencies*, Bank for International Settlements, March.

28 We abstract from legal issues.

the (crypto)funds offered and exchange them for fiat money, so that they can allocate them to the business idea that has been outlined in the whitepaper. Investors, on the other hand, may keep the tokens to benefit from merits associated with them or sell them on the secondary cryptoassets market.

Despite any allusions to IPOs, ICOs have distinctive differences from IPOs. First of all, they are not part of the equity of that underlying company or entity and they simply represent (crypto)funds that the company collects for investment purposes. ICOs are a source of finance without diluting the equity structure. Furthermore, in the case of IPOs the number of units offered is explicitly stated in the prospectus, whereas in the case of ICOs the number of units is growing through the mining or some other process. Usually there is a reference to a "genesis block" followed by a set of mining challenges, as well as a description of the process for appending new blocks to the chain. In addition, in IPOs the issuer is committed through a statutory prospectus informing purchasers about the issuer's financial statements, management, business, and price, as well as about the amount of securities to be offered. The main motive is to reduce asymmetric information. However, in the case of ICOs there is no prospectus obligation and the issuer is usually committed through the publication of the whitepaper. Actually, the ultimate commitment is the algorithm underlying the smart contract, and the whitepaper is subordinated to the algorithm. Understanding the algorithm requires much more specific knowledge than understanding a prospectus. Finally, all ICOs offer their holders a right to exit and sell their tokens on the secondary markets. However, these do not have the safeguards of the traditional markets. For instance, there are no assurances regarding the signalling effect of prices, since the typical capital market gatekeepers such as rating agencies, analysts, underwriters, etc. do not exist. Despite the shortcomings, the OECD considers ICOs as an appropriate instrument for SMEs to raise funds.[29]

(b) Implications for financial stability

In order to assess the implications for financial stability, a taxonomy for ICOs is needed. Taxonomy may focus on the "underlying code layer" distinguishing cryptocurrencies from tokens, since the former are based on blockchain protocol, whereas the latter on applications on top of the chains of blocks. Alternatively, a more appropriate taxonomy can be based on the "functionality" of the instruments and distinguishes three types of ICOs. One type (currency tokens) is launched to create a new cryptocurrency, and the tokens are issued as a means of payment for goods or services external to the platform. A second type (utility tokens) conveys some functional utility to investors, other than the payment of external goods or services, in the form of access to a product that the developers have created or are creating. Thus, utility tokens confer rights to use or consume certain products developed by the issuing company and deposited on the blockchain. A third type (investment tokens) may have an investment component, in the sense that tokens are considered as assets promising investors positive future (crypto)cash flows. They derive their value from possible capital gains through rising market price and from the distribution of profits made by the underlying company or the created investment vehicle.

Some regulators have adopted the functionality approach. For instance, the Monetary Authority of Singapore stated that "...a virtual currency is one particular type of digital token, which typically functions as a medium of exchange, a unit of account or a store of value"[30]. In Europe, the Swiss Financial Market Supervisory Authority (FINMA) announced that it will evaluate ICOs on a case-by-case basis, focusing "... on the economic function and purpose of the tokens (i.e. the

29 OECD (2019), *Initial Coin Offerings (ICOs) for SME Financing*, available at www.oecd.org/finance/initial-coin-offerings-for-sme-financing.htm.

30 Monetary Authority of Singapore, "MAS clarifies regulatory position on the offer of digital tokens in Singapore", media release of 1 August 2017.

blockchain-based units) issued by the ICO organizer". To that end, it has categorised tokens into three types, but warns that hybrid forms are also possible:[31]

(i) payment tokens, synonymous with cryptocurrencies;

(ii) utility tokens, which are intended to provide digital access to an application or service; and

(iii) asset tokens, which represent assets analogous to equities, bonds or derivatives, in terms of their economic function.

A similar taxonomy was presented by the European Banking Authority (EBA), pointing out that "...there is a wide variety of crypto-assets some of which have features spanning more than one of the categories identified". [32]

Having briefly described tokenisation, tokens and cryptoassets, our discussion will focus on issues that may affect financial stability. We have to bear in mind that these markets remain small compared with the global financial system, and that cryptoassets are not yet widely used for financial transactions, but markets are changing rapidly.[33] The growth of cryptoasset trading platforms, the introduction of new financial products related to these platforms and growing interest from retail investors called attention to the implications for financial stability. Several international agencies have started to deal with the issue. The FSB in its report to the G20 on cryptoassets (July 2018)[34] announced that it is conducting research on how its members treat exposures to cryptoassets at the national level. At the same time, the Basel Committee on Banking Supervision (BCBS) is carrying out an extensive quantitative analysis of the materiality of banks' direct and indirect exposures to cryptoassets. Based on its research, the BCBS considers providing clarification of the prudential treatment of cryptoassets under Pillar I or Pillar II. The European Parliament has issued two reports on cryptoasset regulation, of which one highlights the implications for financial crime, money laundering and tax evasion,[35] and the other focuses on the prudential risks and opportunities that FinTech presents for incumbent banks.[36] Subsequently, in the EU, many competent authorities have issued some type of communication to the market, in the form of either formal warnings or statements such as speeches or public interventions. A second round of communications was launched in 2017, and in early 2018 a joint warning by the European Supervisory Authorities was issued.[37] All warnings point to the fact that investment in cryptoassets is high-risk and that investors may incur substantial losses due to their volatility, lack of market transparency and integrity, operational weaknesses as well as vulnerabilities in cryptoasset services and trading venues.

All of the above interventions indicate at least some concerns about the stability of the financial system. There are broader policy concerns, such as risks to consumer and investor protection and market integrity, money laundering, terrorist financing, sanctions' evasion, fraud, and other illicit financing risks, tax evasion, and circumvention of capital controls. These problems are exacerbated since cryptoassets live in their own digital, nationless territory and can largely function in isolation from existing institutional arrangements and other infrastructure. They are not backed by an accountable entity that can be bound by regulation and held responsible for potential breaches thereof. As a result, they can be regulated only indirectly.

31 Swiss Financial Market Supervisory Authority, "FINMA publishes ICO guidelines", press release of 16 February 2018.
32 European Banking Authority (2019), *Report with advice for the European Commission on crypto-assets*, January.
33 Financial Stability Board (2018), *Crypto-asset markets: Potential channels for future financial stability implications.*
34 Financial Stability Board (2018), *Crypto-assets. Report to the G20, on work by the FSB and standard-setting bodies.*
35 European Parliament (2018), *Cryptocurrencies and blockchain. Legal context and implications for financial crime, money laundering and tax evasion.*
36 Idem, *Virtual currencies and central banks monetary policy: challenges ahead.*
37 ESMA, EBA and EIOPA (2018), "ESAs warn consumers of risks in buying virtual currencies," February.

We will consider the implications for financial stability from three particular angles: (i) the risks involved; (ii) the prudential treatment of bank exposures to cryptoassets; and (iii) consumer and investor protection issues.

The BCBS has recently indicated that cryptoassets are an immature asset class which presents a number of risks,[38] the most important being market liquidity risk. Cryptoasset markets are illiquid and fragile, which limits the ability of participants to buy or sell the related instruments. The value of the tokens is intrinsic to the blockchain technology itself; thus it depends on the merits of such technology and on the extent of the network. If the value transfer system proposed by blockchain technology manages to attract several participants by showing its merits as a safe, efficient and fast system, then the associated token gains in value. The broader the network, the larger the secondary market, and if there are assurances about network maintenance against cyberattacks and bugs in its code, then the size of demand and the depth of the market may enhance the value. Against this backdrop, the value of the tokens exists not because some central agency serves as a liquidity backstop, but thanks to the merits of the technology and the network.

However, token ownership appears to be concentrated among relatively few market participants, whereas some platforms have exhibited operational issues, which further lead to the fragmentation of market structure. Besides, investors face counterparty risk, since the ICO organiser should perform its obligations in the real economy, but usually it takes no particular commitment to dedicate its effort and time to the proposed project. In the light of the above, illiquidity, concentrated ownership, fragmented market structure and counterparty risk make cryptoassets prone to price manipulation, market abuse and other misconduct.

The valuation issues are further exacerbated by occasional uncertainties in individual payments. The underpinning of trust in each cryptoasset is fragile, mainly due to "forking". This is a process whereby a subset of cryptoasset holders coordinate on using a new version of the ledger and protocol. Those that adhere to the new proposal take a different direction, while the rest remain with the original one. In this way, a cryptoasset can split into two subnetworks of users. There are episodes which may justify the lack of trust, leading to significant valuation losses.

Furthermore, operational risk issues may arise, in the form of controlling and monitoring risks. Controlling risk refers to the ability of token investors to assess whether a party is in a particular position to influence the public ledger and its performance. This requires a technical evaluation on whether a particular party or colluding parties can manoeuvre the functionality of the platform and divert values to themselves or an affiliate. The screening of digital assets is much harder than the screening of traditional corporations, where, at least, corporate governance codes and conducts are in place.

Monitoring risk refers to the ability of token investors to infer the merit of their investment ex ante, and assess its performance ex post. When there is no underlying asset, the source of value can be verified automatically and usually it is a built-in routine in the protocol, but if there is an underlying asset, the source of value is exogenous. In such circumstances, tokens as derivative products are subject to shifts and movements in the underlying market. Monitoring costs can be particularly high if the underlying asset is vague and sometimes prone to manipulation and misinformation (see Box 2).

Cyber risk is also important. Blockchain technology may be beneficial to many applications, but cryptoassets, especially those that are decentralised and operate with limited or no

38 Basel Committee on Banking Supervision, "Statement on cryptoassets", BCBS newsletter of 13 March 2019.

formal governance structure, present particular technological risks since they are subject to technological errors and limitations. Cryptoasset trading platforms can be, and in some cases have been, vulnerable to fraud, hacking, and other cyber incidents. In the past, a number of trading platforms with poor security have collapsed after cyber incidents, with real losses for customers.[39]

Cryptoasset trading platforms hedge against some risks and aggravate others. Since they rely on a network, there is no single point of failure, and any damage to a particular node does not disrupt the functioning of the public ledger. However, costly mistakes and hidden bugs may impede its performance. Traditional contracts are subject to legal appeal, but smart contracts are technically immutable. Their code enforces automatic execution without any possibility for ex post discretion. In contract theory, contracts that cannot address all possible contingencies and future events are described as incomplete contracts (see Box 2). Automation makes the property rights crystal clear, but exposes them to bugs and mistakes with no ex-post flexibility.

In addition, systemic risk can be a cause of concern as well. It is well known that price bubbles are a factor that leads to financial crises. Price bubbles depend on investor sentiment as well as investor capability to assess prices. Lack of informed market participants can increase noise in prices. Cognitive biases and heuristics have similar effects. Token markets are inherently structured to reflect such an environment. Although no empirical profiles of token investors exist, the lack of institutional representation implies that some of the above considerations are legitimate.

All these risks should be treated under the standard risk management paradigm. However, due to the technical complexity of cryptoassets, banks that engage in such instruments should enhance risk management practices by undertaking extensive due diligence, accessing appropriate expertise, ensuring appropriate incentives and mitigating conflicts of interest. The BCBS (see footnote 38) has indicated that banks with exposures to cryptoassets should as a minimum: conduct due diligence; have a clear and robust risk management framework; publicly disclose any material exposures; and engage in a dialogue with their supervisory authorities to provide assurance that all safeguards are in place.

A further issue is the handling of crypto-exposures, and their prudential treatment in particular. Bank exposures to cryptoassets imply accumulation of intangible assets which would be difficult to value in capital markets. Uncertainties are further heightened by the speed at which new cryptoassets come into existence. Bank exposures to cryptoassets have raised some interesting questions for bank supervisors in relation to diversification benefits, risk creation, risk mitigation, risk reallocation, and supervisory framework evolution.

The Basel framework does not provide for a separate exposure class for cryptoassets, but sets out minimum requirements for the capital and liquidity treatment of "other assets". Similarly, the Capital Requirements Regulation, which lays down the methodology for banks to assign their exposures to asset classes, does not provide for a cryptoasset class either. Instead, it envisages a broad and inclusive definition of "other non-credit obligation assets". The existing exposure classes were determined by the BCBS almost a decade ago and remain largely unchanged, with a few additions made in December 2017. With the growing prominence of cryptoassets in the financial world, it seems that regulators should explore whether the current regime is

39 The trading platform Coincheck was illegally accessed and lost JPY 58 billion (about USD 530 million). The customers of Mt. Gox, once the world's largest bitcoin trading platform, are still waiting for compensation more than three years after its collapse into bankruptcy in Japan. Confido, a start-up on the Ethereum platform, vanished from the internet after raising USD 374,000 from investors in an ICO fundraiser, having pitched itself as a blockchain-based application for making payments and tracking shipments. A few days after the offering, Confido deleted its Twitter account and took down its website, leaving the raised amount in the hands of its controllers. The case is dubbed as "exit scam".

adequate to address the specific risks of exposures to cryptoassets.[40]

Finally, another concern is consumer and investor protection, which is closely related to whether cryptoassets can be regarded as securities and are therefore covered by the existing securities regulation. The tokens issued in an ICO may or may not be considered as securities, depending on the underlying economic relationships involved. Two key characteristics of traditional securities are mandatory disclosure and standardisation, but since ICO issuances are not institutionalised, neither of them applies. Certainly, the terms of investment are typically embedded in the code, which is available for inspection. Theoretically speaking, investors can view the code, but are rarely in a position to assess its content due to the high complexity and technicality, as is typically the case with uninitiated investors. Transparency issues already daunt the traditional market, let alone the crypto-markets where literacy requirements are tremendous for understanding the underlying issues.

Alternatively, the ICO issuer can resort to voluntary disclosure, but standard economic theory has shown that voluntary disclosure leads to partial equilibria. If ICO issuances do not disclose full token information, then the absence of information about product differentiation may lead to the well-known lemons problem. When there is no possibility to distinguish product quality, only average quality products remain on the market. Is this also the case with ICOs?

Globally, regulators have so far tended to avoid making special rules or providing specific guidance to create a regulatory framework for operating cryptoassets. One of the first regulators to assess how cryptoassets should be treated (and not regulated) is the Securities and Exchange Commission (SEC), which oversees the US investment industry, and splits tokens into "fully regulated security tokens" and "lightly regulated utility tokens". In order for a token to be considered a "security" and therefore subject to securities regulation, the so-called Howey test[41] is applied. Four elements should be in place:

(i) the transaction is an investment of money;

(ii) the money is invested in a common enterprise;

(iii) there is a reasonable expectation of profits; and

(iv) profit comes from the efforts of a third party.

A token that ticks all of these boxes should be considered a security and covered by securities regulation, although sometimes it is difficult to make a fair assessment (see Box 2). In addition, due to their diversity, some cryptoassets and tokens may escape regulation and the transparency, governance and investor protection objectives that regulation pursues.

One specific issue is the use of cryptoassets for money laundering and terrorist financing purposes. The Financial Action Task Force (FATF) has issued a specific recommendation,[42] advising countries to conduct a coordinated risk assessment of virtual currency products and services, ensure cooperation between public and private sectors to assist competent authorities and assume the regulation of exchange platforms between convertible virtual currencies and fiat currency. It instructs countries to register or license natural or legal persons providing money or value transfer services, which would apply to entities providing convertible virtual currency exchange services. In addition, it advises countries to identify and assess money laundering risks surrounding new

40 The BCBS published a discussion paper on the design of a prudential treatment for cryptoassets and invited the interested parties for comments. See Basel Committee on Banking Supervision (2019), "Designing a prudential treatment for crypto-assets", Discussion paper, Bank for International Settlements, December.

41 Securities and Exchange Commission (2019), "Framework for 'Investment Contract'. Analysis of Digital Assets", April.

42 *FATF Report on Virtual Currencies: Key Definitions and Potential AML/CFT Risks*, 2014.

products, including virtual currencies, as well as to make sure that local financial institutions take appropriate measures to mitigate these risks before launching new products or developing new technologies.

Furthermore, the FATF urges countries to ensure that convertible virtual currency exchanges are subject to adequate regulation and supervision. Countries should also amend legal frameworks, as needed, to ensure effective anti-money laundering regulation of decentralised virtual currency payment mechanisms. Countries should mandate the licensing of virtual currency exchanges and the application of customer identification and record-keeping requirements at exchanges to overcome such challenges.

Box 2

THE DAO CASE[1]

The DAO was a virtual organisation, embodied in computer code and executed on Ethereum blockchain, which was created to sell DAO tokens to investors. Investors could send Ether to the DAO and receive DAO tokens in return. Each token represented voting power, and the investors were given the right to choose the portfolio of investments to be held by the DAO, which would serve as the underlying asset of the tokens. It was in effect an "automated investment fund" and the investors were entitled to a share of future profits made on these investments. For a project to be included in the portfolio, the proposal should be embedded in a smart contract deployed on the blockchain and its details should be posted on the DAO website. The projects were reviewed and approved by "curators" and were then brought for voting to DAO token holders. If a quorum of token holders accepted the project, then it was added to the portfolio.

The DAO platform was an enormous success and raised Ether worth approximately USD 150 million, but was then allegedly hacked by an unknown individual or group, who managed to transfer a third of the total amount raised by the DAO offering from the DAO's Ethereum blockchain to another Ethereum blockchain controlled by those hackers. They were able to do that by utilising a bug in the software of the DAO's smart contract. The bug was essentially a mistake in the code, an incorrect belief shared by both parties at the time of the offering about the contractual terms. Thus, some suggest that it was a bad business model rather than a bug.

The core developers of the Ethereum blockchain were able to overwrite the history of their blockchain and return all the funds to the investors. In effect, they created a "hard fork", which resulted in a split of the blockchain into Ethereum Classic and Ethereum. In the former case, the original blockchain is used and the individual or group have still access to the taken funds, which can be exchanged for fiat currencies, whereas in the latter they have no access. This demonstrates the complexity of blockchain technology applications in the financial services sector.

The DAO case also raised a philosophical issue. The Ethereum Classic supporters argue that the individuals rightfully exploited a bug in the smart contract and that the diverted funds should not have been returned to the investors. This points out the conflicting views about

1 Rodrigues, U.R. (2019), "Law and the Blockchain", *Iowa Law Review*, 104(2), 679-729.

the relationship between code and law, as well as about the appropriate governance mechanisms within the cryptoassets ecosystem. From an economic point of view, the DAO case is a typical example of an incomplete contract. Outside the blockchain universe, the parties would have dealt with the issue by advancing arguments before courts. On the blockchain, however, there is no such chance for legal intervention because by design the code is self-contained.

Finally, it should be mentioned that the US Securities and Exchange Commission (SEC) investigated the DAO token offering and concluded in its report that the DAO tokens were securities within the meaning of US securities law.[2] Thus, the investors were protected by the securities regulation.

2 Securities and Exchange Commission (2017), "Report of Investigation Pursuant to Section 21(a) of the Securities Exchange Act of 1934: The DAO", Release No. 81207, 25 July 2017.

5 CRYPTOCURRENCIES: A NEW FORM OF MONEY?

(a) What is money?

Cryptocurrencies[43] constitute the earliest and best-known example of cryptoassets. As mentioned above, they are based on a distributed ledger in order to avoid reliance on the traditional layers of formal institutions, such as central banks, banking authorities, and commercial banks, to process transactions and update ledgers. They are designed as a general-purpose medium with exchange across applications, in contrast with tokens which tend to be designed to support a specific condition in the distributed ledger technology. Among several cryptocurrencies created, bitcoin[44] is dominant and the most recognisable, accounting for over half of the market capitalisation.

With the emergence of cryptocurrencies, the academic community and policymakers started to reconsider the definition of money,[45] where the traditional discussion is complemented with current challenges posed by cryptocurrencies, as well as to revisit the ideas of Friedrich Hayek's theory of concurrent (private) currencies. From a financial stability point of view, it is important to understand whether cryptocurrencies can be considered as money or not, since this affects the functioning of the monetary system. A precondition for the system to work is trust and, given the nexus between monetary and financial stability, the question is of paramount importance.

Money plays a crucial role in facilitating economic exchange. But what is money? The answer depends on the philosophical underpinnings of the responder. According to standard textbook analysis, money has three fundamental and complementary roles: it is (i) a unit of account; (ii) a medium of exchange; and (iii) a store of value. In order for money to perform these functions, people should have trust in the institutions and the institutional arrangements through which money is supplied. Around the world, the issuance of money is entrusted to centralised authorities, public or private. Over the ages, many forms of private

43 The architect of Bitcoin called it "electronic cash". The EBA and the ECB call the instruments based on blockchain technology "virtual currencies". The BIS refers to "digital currencies", whereas others use the terms "cryptocurrencies" or "altcoins" or "abstract currencies". The definition used has some connotations; for instance, the term "cryptocurrency" emphasises the cryptography, whereas the term "virtual currency" the lack of legal recognition.

44 Bitcoin consists of the Bitcoin protocol and the bitcoin (BTC) currency. By convention, the protocol name is written with uppercase B and is singular, while the currency name is written with lowercase b and may be plural.

45 European Central Bank (2015), *Virtual currency schemes – a further analysis*, February; European Central Bank (2015), "What is money?", explainer at https://www.ecb.europa.eu/explainers/tell-me-more/html/what_is_money.en.html; McLeay, M., A. Radia and R. Thomas (2014), "Money in the modern economy: an introduction", Bank of England, *Quarterly Bulletin*, Q1; "The future of money", speech by Masayoshi Amamiya, Deputy Governor of the Bank of Japan at the 2018 Autumn Annual Meeting of the Japan Society of Monetary Economics, Tokyo, 20 October 2018; "Money and private currencies – reflections on Libra", speech by Yves Mersch, Member of the Executive Board of the European Central Bank, at the ECB Legal Conference, Frankfurt am Main, 2 September 2019.

money have come and gone, mainly reflecting issuers' "incentives to cheat", but government-backed arrangements, which assure a centralised approach to trust, not always worked properly either. In effect, history demonstrates that "... money can be fragile whether it is supplied through private means, in a competitive manner, or by a sovereign, as a monopolist supplier".[46]

All economic textbooks mention Gresham's law, which is a monetary principle stating that "bad money drives out good". Good money requires a solution to the problem of a lack of trust. In almost all modern-day economies, money is provided jointly by central banks and private banks, with the central bank being at the system's core. Trust is generated through independent and accountable central banks. This means legal safeguards and agreed goals, e.g. commitment to price stability, together with democratic accountability to ensure society's economic and political interest in a stable currency.

Cryptocurrencies try to disrupt this paradigm. In the Bitcoin whitepaper there is a claim that "...the root problem with conventional currency is all the trust that is required to make it work. The central bank must be trusted not to debase the currency, but the history of fiat currencies is full of breaches of that trust". Somehow, this position finds support in economic theory. Nobel Prize-winning economist Friedrich Hayek considers that breaking the state monopoly on money is the best way to promote democracy[47] and ensure the stability of the official currency, quoting[48] "there is no answer in the available literature to the question why a government monopoly of the provision of money is universally regarded as indispensable, [...] what would happen if that monopoly were abolished and the provision of money were thrown open to the competition". He also argues that government monopoly prevents the discovery of better alternatives and he adds that "...it is not an exaggeration to say that history is largely a history of inflation, and usually of inflations engineered by governments and for the gain of governments".

Technological advances over the past few years have turned Hayek's proposal into reality, not as a result of any deliberate government policy but out of the inspiration of some individuals. Technology managed to question government monopoly over money issuance, enable competition between multiple private digital currencies and traditional fiat currencies, and eliminate the necessity of a central institution. In the cryptocurrency world, as long as the protocol implementation relies on an open-source code, the discussion about the issuer is not that relevant. What is warranted is to ensure a reliable support team in charge of the protocol code maintenance.

(b) Implications for financial stability

Financial stability issues revolve around whether cryptocurrencies can be considered "money", that is whether they can fulfil the basic functions of money. The unfortunate past experience with several private forms of money raises concerns as to whether the proliferation of cryptocurrencies is beneficial, desirable or sustainable. The question is whether at least some of them will survive in the long term or all of them will end up as short-lived oddities.

Cryptocurrencies aspire to be a new form of currency, unlike previous forms, promising to maintain trust through the use of technology. Being a blockchain technology instrument, cryptocurrencies consist of three elements: the protocol, the distributed ledger, and the consensus mechanism. The aim of the protocol is to align the incentives of all participants, so as to create a reliable payment system and estab-

46 Bank for International Settlements (2018), "Cryptocurrencies: looking beyond the hype", *BIS Annual Economic Report*.
47 Some view cryptocurrencies as "democratic currencies", as they pose no restrictions on financial transactions. This is however debatable since there is the obligation (thus restriction) to accept the blockchain protocol before requesting a transaction.
48 Hayek, F.A. (1976), "Choice in Currency: A Way to Stop Inflation", The Institute of Economic Affairs, *Occasional Papers*.

lish the instrument as a convenient means of payment. However, the share of cryptocurrencies in global payment transactions is tiny. According to the ECB,[49] "...on a daily basis, there are around 284,000 Bitcoin transactions globally, compared with 330 million retail payments in the euro area". One of the issues is the scalability problem, that is the growth of public ledger over time due to the requirement to download and verify the history of all transactions, which results to substantial delays in the completion of the transactions.[50]

Besides, being digital currencies, they acquire value only if the users are confident that the instruments are a safe store of value and that their ownership can be easily transferred to someone else. Since they cannot be physically owned, this means that property rights must be established through an efficient ledger system. Blockchain technology proposes the distributed ledger and the consensus mechanism, but the process is subject to forking. Forking a cryptocurrency is like debasing a fiat currency, which undermines trust. In this case, technology could not solve an age-old problem. Forking creates two new competitive cryptocurrencies, putting technological advancements at odds with trust.

Furthermore, cryptocurrencies have no intrinsic value. Since their value is not backed by any government or organisation, their price is determined solely by expectations about their future price.[51] A buyer is willing to buy a cryptocurrency unit only if they assume that the unit will be sold for at least the same price later on. Its price, therefore, reacts highly elastically to changes in the expectations of market participants and is reflected in extreme price volatility. Against this background, some people seem very concerned about this lack of intrinsic value. Namely, Alan Greenspan in a December 2013 interview noted that: "It's a bubble. It has to have intrinsic value. You have to really stretch your imagination to infer what the intrinsic value of bitcoin is. I haven't been able to do it. Maybe somebody else can".

The price of cryptocurrencies is highly volatile and is affected by supply and demand factors. Regarding demand, there are two main sources, i.e. demand for mediating fiat currency transactions and demand for investment purposes. On the other hand, individual cryptocurrencies are usually in limited supply, as defined in the protocol. But this predetermined supply is undesirable from a monetary policy perspective, in the sense that it leads to an unstable currency. The price also depends on aggregate demand and, if a constant supply of money meets a fluctuating aggregate demand, the result is fluctuating prices. These fluctuations cannot be tamed, since the instruments are not backed by a commodity, such as gold, or by a government and they are not legal tender in any jurisdiction. In fiat currency systems, the central bank adjusts the money supply in response to changes in aggregate demand for money in order to stabilise the price level. In a decentralised network of cryptocurrency users, there is no central agent with the obligation or the incentives to stabilise the value of the currency. Whenever demand for the cryptocurrency fluctuates, so does its price. This, in the absense of a balancing mechanism, is very likely to be an inherent characteristic of these instruments.

Certainly, total supply can be modified with a fork or, if we consider all cryptocurrencies a homogeneous group, total supply is unlimited because there is always the possibility to create new cryptocurrencies. But then, the unlimited possibility to issue new money rarely brings sta-

49 Mersch, Y. (2018), "Virtual or virtueless? The evolution of money in the digital age", lecture, Official Monetary and Financial Institutions Forum, London, February.

50 A recent cryptocurrency conference stopped accepting payments in bitcoin because of the cost and time involved in processing the payments.

51 A new class of cryptocurrency is emerging, namely the stablecoins, which seek to stabilise the price of the "coin" by linking its value to that of a pool of assets. A typical example is the newly announced Libra, which has been presented as a stable cryptoasset (a "stablecoin") fully backed by a reserve composed of deposits of stable currencies and short-term government securities. See Bank for International Settlements (2019), *Investigating the impact of global stablecoins*, G7 Working Group on Stablecoins/International Monetary Fund/BIS Committee on Payments and Market Infrastructures. For some considerations on Libra, see "Money and private currencies – reflections on Libra", speech by Mr. Yves Mersch, Member of the Executive Board of the European Central Bank, at the ECB Legal Conference, Frankfurt am Main, 2 September 2019.

bility. That is the reason for the official warnings issued by policymakers: "Young people should use their many talents and skills for innovation, not reinventing money, [...] it's a fallacy to think money can be created from nothing".

In addition, experience suggests that it may be difficult to find a nominal anchor with privately issued currencies. Long-term investors are usually not prepared to bear exposures to rapid boom/bust cycles and some cryptocurrencies have been susceptible to a "cliff effect", that is a sudden steep decrease in price. Therefore, speculation obscures the effect of the fundamentals, if any, and thus makes it difficult for investors to anticipate future price dynamics.

For all these reasons, it seems unlikely that cryptocurrencies, without a particular issuer and not being denominated in sovereign currency units, will be widely used for payments and settlements, as long as sovereign currencies maintain their credibility and utility. They need to compete with the public's trust in central banks. This is easier in hard times, when people distrust established institutions, but much more difficult in good times. For the time being, the EBA rejects the use of the term "currency" and the ECB makes it clear that it does not consider cryptocurrencies or virtual currencies to be money. The Bank of England equally dismisses the view that cryptocurrencies are money. In contrast, the German Federal Financial Supervisory Authority (BaFin) classifies bitcoin as a unit of account comparable to foreign exchange without being a legal tender, and the Court of Justice of the European Union has ruled that the services of a bitcoin exchange in exchanging bitcoin for a traditional currency is exempt from VAT on the basis of the "currency" exemption. Similar steps are expected to increase cryptocurrency flow.

6 CONCLUSION, IF ANY

The financial sector, like society, is becoming increasingly digital, and there is considerable discussion on FinTech. The business model of firms offering FinTech solutions differs substantially from the traditional banking relationship model. It is unclear, however, whether FinTech will enhance or fundamentally disrupt banking, or perhaps lead to a combination of both. Most probably, it will increase competition but it is unlikely to replace banks in most of their key functions. Banks are more likely to adopt technological innovations, as they have done in the past, and find new solutions to existing problems.

Cryptoassets constitute a significant novelty, and several banks are taking or are considering taking positions. There is a big diversity of instruments and the market is evolving although it is far from settled. However, concerns have already been raised about financial stability, and the international financial community is exploring the appropriate prudential treatment of such assets.

Cryptocurrencies represent the best-known example of cryptoassets. They started almost ten years ago, and during that period they have multiplied in numbers. Are they investment or speculative instruments? Policy warnings by international organisations suggest the latter but, despite that, retail customers are increasingly investing in them. For the time being, it seems that their decentralised technology, however sophisticated, is a poor substitute for the solid institutional backing of money.

All of the above initiated a discussion about the implications of cryptoassets for financial stability. In conclusion, as aptly put by the FSB, "...it appears that risks to global financial stability are not significant at present, given the limited size of crypto-asset markets relative to other financial markets and the limited interconnectedness between crypto-asset markets and the regulated financial system. However, there is a need for vigilant monitoring in light of the speed of market developments". In a similar spirit, the IMF states that cryptoassets "do not pose systemic risks to financial stability, owing to their small scale [...] compared to the major credit card payments plat-

forms. [... Cryptoassets] may pose non-negligible financial risks to individual virtual currencies users and holders. [...] Large-scale use of virtual currencies and greater interconnectedness with other parts of the financial sector could in due course rise to systemic financial risks". However, it remains to be seen whether the widespread use of cryptocurrencies and related self-executing financial products (smart contracts) will give rise to new financial vulnerabilities and systemic risks. International organisations should be on alert and as *The Economist* wrote in August 2018: "Cryptocurrencies look like a solution in search of a problem".

7 FURTHER READING

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WORKING PAPERS (JULY – DECEMBER 2019)

This section contains the abstracts of Working Papers authored by Bank of Greece staff and/or external authors and published by the Bank of Greece. The unabridged version of these texts is available on the Bank of Greece's website (www.bankofgreece.gr).

CONTENTS

The dog that didn't bark: the curious case of Lloyd Mints, Milton Friedman and the emergence of monetarism

Working Paper No. 264
Harris Dellas and George S. Tavlas

Lloyd Mints has long been considered a peripheral figure in the development of monetary economics at the University of Chicago. The paper provides evidence showing that the standard assessment of Mints' standing in Chicago monetary economics —and in American monetary economics more broadly— is mistaken. In light of the originality and the breadth of his monetary contributions, and given the degree to which those contributions shaped part of Milton Friedman's monetary framework and were pushed forward by Friedman, the authors argue that, far from being a peripheral figure in the development of Chicago monetary economics, Mints played a catalytic role.

Central bank independence and inflation preferences: new empirical evidence on the effects on inflation

Working Paper No. 265
Louka T. Katseli, Anastasia Theofilakou and Kalliopi-Maria Zekente

On theoretical grounds, a clear distinction exists between central bank independence and inflation aversion. In the conduct of monetary policy, both contribute to lower inflation. This paper empirically re-examines the nexus between central bank independence and inflation for a large sample of advanced and developing countries over the 1992-2014 period by explicitly accounting for the effect of central bank inflation preferences on inflation developments. The evidence suggests that both features matter for mitigating inflationary pressures, in line with the relevant theoretical studies. Central bank independence alone seems not to be a sufficient condition to curtail inflation; the expected inverse relationship between central bank independence and inflation appears to hold when the (inflation) conservatism of the central bank is accounted for. At the same time, higher central bank conservatism seems to result in lower inflationary pressures in the economy. The results do not support the hypothesis of an interaction (either as substitutes or as complements) between the degree of independence and conservatism of the central bank.

Tonnage tax revisited: the case of Greece during a shipping crisis and an economic crisis period

Working Paper No. 266
Stelios Panagiotou and Helen Thanopoulou

The research investigates the relative position of the Greek tonnage tax system internationally. The authors point out that despite the regulatory framework remaining unchanged —since Greece was the first traditional maritime country to introduce this regime in the 1970s— total taxes paid by Greek shipping companies have increased by almost tenfold since the start of the Greek economic crisis. Next, they investigate the sources and mech-

anisms for this rise, pointing (a) at the impact of voluntary commitments undertaken by the Greek ship-owning community in the period of the economic adjustment programmes and (b) at the extension of the tax base. Further, they analyse the comparative tax burden on specified vessel types under the Greek, EU and non-EU tonnage tax regimes. The analysis reaffirms that while shipping tax regimes have converged internationally, there are still differences in the tonnage tax bill according to alternative principles. The paper concludes that while the Greek system is considered traditionally as favourable for companies, it has become less so in terms of international comparisons in recent years, favouring however state revenues through the shipping crisis since 2008. The authors suggest that tax incentives to ship-owning companies can vary according to whether maritime clusters, fleet competitiveness, short-term tax receipts or long-term tax receipts are selected as optimisation target and point to areas of further research.

The effects of climate change on a small open economy

Working Paper No. 267
George Economides and Anastasios Xepapadeas

This study investigates the impact of climate change on the macroeconomic performance of a small open economy. The setup is a new Keynesian dynamic stochastic general equilibrium model of a small open economy without monetary policy independence, in which a climate module that interacts with the economy has been incorporated. The model is solved numerically using common parameter values, fiscal data and projections about temperature growth from the Greek economy. The results suggest that climate change implies a significant output loss and a deterioration of competitiveness. Moreover, it seems that the loss of monetary policy independence is not a big loss, when the short- and long-term implications of climate change for a small open economy are investigated.

Oil and pump prices: is there any asymmetry in the Greek oil downstream sector?

Working Paper No. 268
Zacharias Bragoudakis, Stavros Degiannakis and George Filis

The aim of this study is to assess whether fuel prices in Greece respond asymmetrically to changes in global oil prices. To do so, the authors depart from the current practice in the literature that focuses on fuel prices. Rather, they consider the mark-up of both the refineries and the retailers. Furthermore, unlike the bulk of the existing literature, they take into consideration the whole supply chain, i.e. both the refineries and the retail fuel sector. Hence, it is first assessed whether the refineries' mark-up responds asymmetrically to global oil prices and subsequently whether the retailers' mark-up shows an asymmetric behaviour relative to changes in the refineries' fuel prices. The findings show that Greek fuel retailers do not change their mark-up behaviour based on changes in the refined fuel price. By contrast, the asymmetric behaviour is evident in the refineries mark-up relative to changes in global oil prices, which is then passed through to retailers and consumers. Finally, the analysis convincingly shows that weekly and monthly data mask any such asymmetric relationship. Thus, the authors maintain that unless the appropriate data frequency, fuel price transformations and the whole supply chain are considered, misleading findings could be revealed.

Financial system heterogeneity and FDI flows: evidence from OECD economies

Working Paper No. 269
Kostantinos Dellis

Foreign direct investment (FDI) has grown dramatically as a major form of international capital transfer over the past decades. The unprecedented growth of cross-country FDI flows has been attributed to a rich set of economic, geographical and institutional factors. This paper examines the role of financial system heterogeneity as a potential detrimental factor to FDI flows across OECD economies. To do so, the author uses a panel dataset of the most recently updated bilateral FDI data at the country level according to OECD BMD4 definition and constructs measures of financial distance using a broad set of financial indicators. The econometric approach consists of a gravity-style model, estimated according to the latest advancements in econometric techniques in order to avoid omitted variable bias. The results indicate that financial system similarity is associated with increased bilateral FDI flows, a conclusion that is robust across different estimation strategies and financial distance measures. The insightful policy implication for advanced economies is that a restructuring of the financial system and harmonisation to best practices can contribute to economic recovery through the FDI channel as well. Finally, the results highlight the importance for the full implementation of the Banking Union and the Capital Markets Union in the EU.

On the effects of the ECB's funding policies on bank lending and the demand for the euro as an international reserve

Working Paper No. 270
Heather D. Gibson, Stephen G. Hall, Pavlos Petroulas and George S. Tavlas

The euro area financial crisis that erupted in 2009 was marked by negative confidence effects that had both domestic and international ramifications. Domestically, bank lending declined sharply. Internationally, the demand for the euro as a reserve currency fell precipitously. The authors investigate the effects of ECB policies on banks' lending, taking account of national and regional spillovers. They also assess the effects of ECB policies on euro reserve holdings. The results suggest that those policies were important for rebuilding confidence, thus supporting both bank lending and the use of the euro as a reserve asset.

Non-performing loans in the euro area: does market power matter?

Working Paper No. 271
Maria Karadima and Helen Louri

As consolidation in the banking sector has increased impressively in the wake of the global financial crisis, the question of the impact of market power on bank risk has become topical again. This study investigates empirically the impact of market power, as evidenced by concentration (CR5 and HHI) and (lack of) competition (Lerner indices), on the change in NPL ratios (ΔNPL). The authors use an unbalanced panel dataset of 646 euro area

banks over the 2005-2017 period. Since the distribution of ΔNPL is found not to be normal but positively skewed, they employ a penalised quantile regression model for dynamic panel data. The authors find conflicting results, which are in line with the argument that more concentration does not always imply less competition. The results suggest that competition supports stability when NPLs increase, but concentration enhances faster NPL reduction. In addition, the authors find that the effect of bank concentration is stronger in periphery euro area countries, while the effect of competition is enhanced in banking sectors with higher foreign bank presence. Finally, bank competition is more beneficial for commercial banks in reducing NPLs than for savings and mortgage banks, while commercial banks are more prone to creating NPLs than the other two bank types. A tentative conclusion of the study could be that post-crisis consolidation facilitates the faster reduction of NPLs, while as the situation normalises, competition discourages the growth of new NPLs. Policy makers should take such findings into account by encouraging consolidation, especially in periphery countries, but also by inserting competition in the banking sector through either regulating anti-competitive behaviour or inviting new and/or foreign entrants.

Stranded assets and the financial system

Working Paper No. 272
Andreas A. Papandreou

There has been a burgeoning interest and literature on the risks associated with stranded assets. This paper aims to present an overview of this literature, with a focus on the risks to the financial system associated with stranded assets and why these risks need to be a concern to central banks. It considers various definitions of stranded assets and its expanding scope, while focusing more narrowly on climate-related risks and how these affect the financial system. Two main channels of climate-related risks are discussed in depth: risks of physical impacts from climate change and risks associated with the transition to a low-carbon economy. Reasons why the financial system may inadequately account for these risks are presented along with corrective policies on the part of investors and central banks. The paper also considers the special challenges and threats to financial stability associated with the historically unique sustainability transition needed to achieve the targets set by the Paris Agreement.

A reconsideration of the doctrinal foundations of monetary-policy rules: Fisher versus Chicago

Working Paper No. 273
George S. Tavlas

There has long been a presumption that the price-level-stabilisation frameworks of Irving Fisher and Chicagoans Henry Simons and Lloyd Mints were essentially equivalent. The author shows that there were subtle, but important, differences in the rationales underlying the policies of Fisher and the Chicagoans. Fisher's framework involved substantial discretion in the setting of the policy instruments; for the Chicagoans, the objective of a policy rule was to tie the hands of the authorities in order to reduce discretion and,

thus, monetary-policy uncertainty. In contrast to Fisher, the Chicagoans provided assessments of the workings of alternative rules, assessed various criteria —including simplicity and reduction of political pressures— in the specification of rules, and concluded that rules would provide superior performance compared with discretion. Each of these characteristics provided a direct link to the rules-based framework of Milton Friedman. Like Friedman's framework, Simons's preferred rule targeted a policy instrument.

Asymmetric price adjustment and the effects of structural reforms in a low income environment: the case of the gasoline market in Greece

Working Paper No. 274
Zacharias Bragoudakis and Dimitrios Sideris

The pricing mechanism in the gasoline market has often been the subject of public debate in Greece during the crisis years. Inefficient pricing could imply oligopolistic practices in the market and losses to consumers' welfare in a period characterised by a dramatic fall in consumers' income and standard of living. A way to test whether pricing is efficient in the market is by testing for asymmetries in the adjustment of domestic gasoline prices to world oil price changes. The paper has two aims: (a) the first is to investigate the existence of asymmetric adjustment of gasoline prices to oil price variations in the Greek market, thus contributing to the relevant literature; (b) the second is to examine whether the structural reforms that took place in the gasoline market and the large fall in income, which characterised consumers' behaviour in the recent period, had any impact on the pricing dynamics in the market. To this end, the analysis: (i) applies the TAR-ECM threshold cointegration technique, which assumes asymmetric adjustment towards the long-run equilibrium; (ii) makes use of observations at the highest frequency available; and (iii) uses the most recent data. The results provide evidence in favour of symmetric behaviour just for the crisis period. This may reflect competitive behaviour by suppliers who had to interact in a low demand environment and under a new institutional framework following the reforms, along with a change in the search behaviour of consumers, who had to deal with a severe fall in their income.

Financial literacy and its influence on consumers' internet banking behaviour

Working Paper No. 275
Panayiotis C. Andreou and Sofia Anyfantaki

This study examines the level and antecedents of financial literacy and investigates its influence on consumers' internet banking behaviour. The focus is on Cyprus, a country that experienced an unprecedented financial crisis in 2013, which caused an enormous shrinkage of its banking sector. Ever since, banks have been investing in financial innovations such as internet banking (i-banking), aiming to enhance customer service and efficiency in the age of financial digitalisation. Notwithstanding, the results show that financial literacy is yet too low in Cyprus, whereby only 37.33% of the adults surveyed in the study have a good financial knowledge proficiency level. The results indicate that financially literate consumers show a strong preference for frequent use of i-banking, whereby the odds of using i-banking frequently

increase by more than 64% for one standard deviation increase in the respondents' financial knowledge score. The findings highlight the crucial interplay of digital and financial sophistication, and their positive influence on consumers' usage of digital financial services. The evidence from Cyprus also points to policy directions, according to which digital financial education programmes should be a central element in national financial literacy strategies.

Fiscal distress and banking performance: the role of macroprudential regulation

Working Paper No. 276
Hiona Balfoussia, Harris Dellas and Dimitris Papageorgiou

Fiscal fragility can undermine a government's ability to honour its bank deposit insurance pledge and induces a positive correlation between sovereign default risk and financial (bank) default risk. The authors show that this positive relation is reversed if bank capital requirements in fiscally weak countries are allowed to adjust optimally. The resulting higher requirements buttress the banking system and support higher output and welfare relative to the case where macroprudential policy does not vary with the degree of fiscal stress. Fiscal tenuousness also exacerbates the effects of other risk shocks. Nonetheless, the economy's response can be mitigated if macroprudential policy is adjusted optimally. The analysis implies that, on the basis of fiscal strength, fiscally weak countries would favour and fiscally strong countries would object to banking union.

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