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Revisiting industrial policy: Lessons learned from the establishment of an automotive OEM in Portugal☆

Anabela Reis *, Manuel Heitor, Miguel Amaral, Joana Mendonça

Center for Innovation, Technology and Policy Research, IN+, Instituto Superior Técnico, University of Lisbon, Av. Rovisco Pais, Lisbon 1049-001, Portugal

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ABSTRACT

This paper uses the establishment of Autoeuropa in Portugal, an automotive Original Equipment Manufacturer (OEM), as a case study to examine industrial policy aimed at stimulating technological innovation. The automotive industry, in particular Autoeuropa, represents an important socio-economic contribution to the Portuguese industrial production. We focus the analysis on Portugal due to its role as a small and peripheral economy, deprived of significant R&D capacity. The approach considered in this paper builds on the Triple Helix conceptual framework to examine how Autoeuropa's establishment has helped to promote technological innovation in Portugal. Data was collected from databases, interviews with experts in the field, and archival data. Our results indicate that the increasingly transnational business requires evolving from nationalistic approaches towards new collaborative policy frameworks. In this context, large international collaborative arrangements play an emerging role, and therefore should be promoted through new policy frameworks. Moreover, given the current context in which companies move their production activities to the most cost-effective location, it looks increasingly relevant to promote the role of research and technology organisations and technology-based firms as part of the industrialisation strategy.

1. Introduction

The combination of local public support with foreign direct investment (FDI) through an Original Equipment Manufacturing (OEM) establishment is expected to lead to job generation, capacity building and economic growth. Benefits arising from OEM establishment go beyond the obvious direct effects on employment and income tax collection. Evidence from examples such as Australia (Caves, 1974), Canada (Globerman, 1979) and Mexico (Blomström and Persson, 1983) show that FDI can enhance domestic manufacturing firms' performance through standards implementation and information sharing between the domestic plants and foreign firms. However, in some cases, such as Venezuela, technology spillovers from FDI are far from expected (Aitken and Harrison, 1999). Aitken and Harrison (1999) inferred that this might be the result of low foreign investment or because Venezuela's economy is not developed or diversified enough to benefit from foreign companies. Additionally, Borensztein et al. (1998) provided evidence that FDI benefits are dependent on the absorptive capacity of the host country, measured by human capital available in the host economy.

Processes related with diversification and industrial specialisation are complex and uncertain, involving the incorporation of knowledge and technology in people and organisations (Conceição et al., 1998; Conceição et al., 2003; Heitor and Bravo, 2010; Sheffi, 2005). Moreover, shifts towards modular production, associated with the entrenchment of global supply chains has added pressure to cut down costs, which represents challenging obstacles in the creation of higher-level local suppliers (Fine, 1998). This is particularly true in the automotive sector, where supply chains involve a large number of participants that must work together and coordinate their activities in order to ensure the successful final assembly of the automobile. Thus, creating and developing the necessary knowledge base to integrate this competitive industry takes several years of continued investment and cumulative capacity (Kim, 2001).

Governments' support and targeted policies might help to create, develop and accumulate technological capacity, fostering economic competitiveness and reducing socioeconomic vulnerability. Nevertheless, the boundaries and limits of public intervention remain a key issue in many political systems worldwide (e.g. Mazzucato, 2013). This is clearly a critical question in socio-technical research. Therefore, in this article, we explore the key conditions and agents necessary to foster technological spillovers through OEM establishment. The analysis carried out herein considers the automotive industry since it induces the development of high value-added chains with a multiplier effect on the economy, crosses several areas of knowledge, deals with a

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* Corresponding author.
E-mail addresses: anabela.reis@tecnico.ulisboa.pt (A. Reis), mheitor@ist.utl.pt (M. Heitor), miguel.amaral@tecnico.ulisboa.pt (M. Amaral), joana.mendonca@tecnico.ulisboa.pt (J. Mendonça).

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multiplicity of technologies, skills and organisational processes (Pavlínek and ŽiŽalová, 2014).

Motivated by the socio-economic contribution of the automotive sector to the Portuguese industrial production, this paper uses the establishment of Autoeuropa in Portugal as a relevant example for the study of industrial policy aimed at stimulating technological innovation. The reason for choosing Portugal is two-fold. First, as a Southern European country Portugal represents a relevant case study of a peripheral economy that has been integrated into global automotive production networks (Almodovar and Texeira, 2014). The other reason is that Portugal is small country with an industrial structure characterised by small firms, which rely on limited resources and therefore have a reduced bargain power to negotiate with OEMs or supplying multinationals (Veloso et al., 2000).

The paper is structured as follows. Section 2 presents a brief contextualisation of the automotive industrial production, discussing specificities of this sector. Section 3 outlines the conceptual approach. Section 4 provides the research setting and methodology. The results are presented and discussed in Section 5. Finally, Section 6 concludes with the final remarks and implications for industrial policy.

2. Automotive innovation dynamics

In recent years, manufacturing production has been shifting towards the most cost-effective location (e.g., Hepburn, 2011). As Spence and Hlatshwayo (2012) have shown for America, value-added grew across the economy, but employment in manufacturing declined substantially due to the relocation of low value-added activities, especially to rapidly growing emerging economies. Even though employment reduction has been mainly attributed to technological advances in automation and robotics, an additional important factor, which has been sometimes neglected, is the considerable increase in outsourcing functions in global supply chains (Berger, 2013). In Europe, there was an apparent spatial clustering of high value-added manufacturing activities in Central and Nordic countries such as Norway, Sweden, Finland, Germany and Austria (Reis et al., 2016).

Industrial production has generally been portrayed in the literature as crucial to economic growth. Indeed, it is shown that industrial production is associated with high productivity levels, higher income growth rates, and the ability to generate exports (Fingleton, 1999; Sirkin et al., 2011). Additionally, manufacturing requires the existence of a set of associated services, which leads to higher employment rates. Thus, FDI through the establishment of an OEM has been widely used as an instrument to foster employment.

Several studies have already provided evidence that FDI is of crucial importance to economies not only due to its direct effect of foreign capital application on national projects, but also through indirect effects as knowledge and information sharing, technological and human capital development and integration of local suppliers in global production chains (e.g., Caves, 1974). Nevertheless, the theoretical link between FDI and technology spillovers to local economy is not undisputed in the literature (Pavlínek and Žižalová, 2014).

As OEMs become more focused on design and assembly, they transfer production responsibilities abroad, changing the local industrial landscape (Locke and Wellhausen, 2014). This process undermines domestic competitiveness since it removes the majority of the private economy's R&D capabilities from the region (Tassey, 2014). This process has also effects on regional employment structure since it leaves regions with a specialised workforce without a job. But, on the other hand, it creates new job opportunities for regions receiving industrial production (Cowie, 2001). According to Ács and Naudé (2012), the process of structural change or industrialisation is not independent of the development stage of a particular country. Thus, it is expected that countries and regions with strong industrial bases profit the most from globalisation due to their ability to produce and use knowledge and technologies mostly developed in a wide network of organisations constituting a distributed knowledge base (Berger, 2013). Processes related with diversification and industrial specialisation comprise the incorporation of knowledge and technology in people and organisations (Conceição et al., 1998; Conceição et al., 2003; Heitor and Bravo, 2010; Sheffi, 2005). Thus, firms use R&D to gain understanding of new products and processes, which allows them to assimilate and exploit new knowledge (Cohen and Levinthal, 1989). By looking at OECD rankings for business expenditures on R&D (BERD) in the European Union (EU), as illustrated in Fig. 1, we notice that R&D expenditures in the EU are mainly concentrated in a small number of companies; and even though there has been an increase in R&D levels of investment in recent years, almost half of the investment is still made by the firms that figure in the ranking of top 20 R&D investors in Europe.

Fig. 2 presents the R&D investment structure of the top 500 firms in the EU from 2003 to 2012, showing no significant changes during this period. It is noticeable that the automotive sector benefited the most from R&D investments. It is also worth noting that the investment in this sector is extremely concentrated in a small number of German companies, such as Volkswagen, DaimlerChrysler, Robert Bosch and BMW. In fact, these companies account for more than 60% of the R&D investment made in the automotive sector by the top 500 firms in EU, with no companies from Southern European countries in the automotive sector figuring in these numbers.

Despite the high importance of the automotive sector Europe, in terms of R&D investment, the respective dynamics taking place in the rest of the world are considerably different. For instance, the position of the firms on the top 20 changed noticeably throughout the years in the US and Asian countries. Indeed, the automotive sector has been changing worldwide due to a wave of merges, acquisitions and strategic alliances aiming at ensuring a global presence as well as the possibility to take advantage of economies of scale, reducing costs and increasing profitability. In an industry such as the automotive, which is marked by intense competition and dwindling business margins, this process leads to a standardisation of the automobile basic skeleton. Standardisation also allows plants to produce multiple and varied models simultaneously, which allows OEMs to respond more efficiently to sudden changes in demand and consumer preferences.

To cope with so many and ever-fast uncertainties, governments can stimulate innovation through effective regulation (Lee et al., 2011) or even through the provision of incentives that stimulate effective risk management, especially in fields of high technological uncertainty (Mazzucato, 2013). For instance, in the automotive sector several governments subsidised the development of electric vehicles over the years through the funding of research programmes, infrastructures and tax incentives. Globally, there is a growing tendency towards environmental friendly regulations, which means that technological transformative changes are on the way (Donada, 2013). Given the growing technological advances in the digital world, it is no surprise that the demand for interactive safety systems, vehicle connectivity and even self-driving cars will call for new expertise and attract new competitors outside the well established automakers (Gao et al., 2014).

Recent work suggests that sectorial policy tends to promote productivity growth and innovation, in particular when it enables competition (Aghion et al., 2011). The interplay of these forces would call into question whether and to what extent technological changes affect the automotive dominant design, which significantly impacts not only car components, but also the current product architecture and consequently, the entire supply chain. It is within this broader context that we need to analyse and understand the role of national industrial policies on automotive OEMs establishment, particularly in countries such as Portugal with comparatively low investments in R&D, as shown in Fig. 3.

3. Conceptual approach

Research on innovation systems (e.g. Ostry and Nelson, 1995) draw our attention to the relationship between the globalism of firms'

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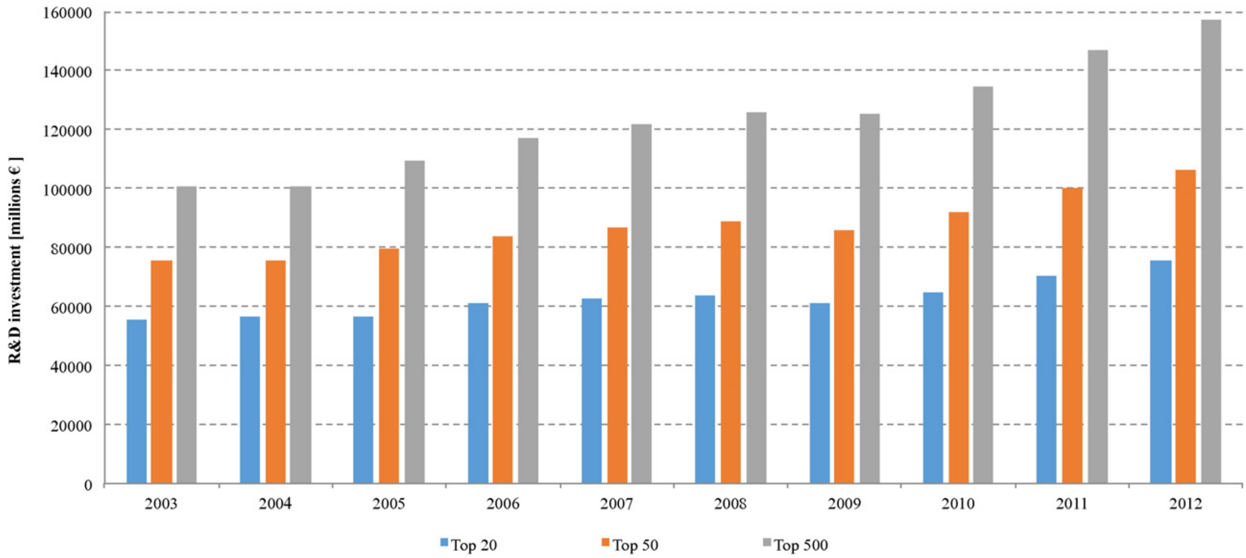

Fig. 1. R&D investment from top 20, top 50 and top 500 firms in EU. Authors' elaboration based on data from IRI (2014).

activities and nationalism of government policies, as well as to the associated interplay of cooperation and competition, which is characteristic of high technology and knowledge-based environments. Ostry and Nelson (1995) exposed a growing tendency of several industrialised countries towards direct intervention favouring domestic firms, intending to aid high-tech industries becoming more innovative, what has been called "techno-nationalism". It was within this context that the concept of "national systems of innovation" emerged in academia as a necessary condition for sustainable development (Lundvall, 1992; Nelson, 1993; Freeman, 1995). According to the national systems of innovation theory, innovation and technology result from a complex set of interactions, collaboration and knowledge exchange among enterprises, universities and government research centres at a national level.

The Triple Helix framework, which conceptualises university-government-industry relations as a dynamic driver of innovation, provides a conceptual approach of the structure and dynamics underlying the innovation system not geographically restricted (Leydesdorff and Zawdie, 2010). Many authors have discussed the benefits resulting from the Triple Helix model (Etzkowitz and Leydesdorff, 1995, 2000). Indeed, as argued by Leydesdorff and Meyer (2007), institutional arrangements based on university–industry–government relations may be considered as supportive structures for innovation in a knowledge-based economy. A notable example used to advance this model at an international level was introduced by Leydesdorff and Sun (2009) when investigating Japan. In their work, the international level was considered as a fourth dimension. Hence, we consider the Triple Helix framework to address the challenges and opportunities for fostering technological capabilities through an OEM establishment within an international supply chain.

Following this line of reasoning, this paper builds on this conceptual approach to bring evidence about the international dimension of supply chains. Also, it extends knowledge creation beyond academia to include vocational training since it plays a key role in the development of technological capabilities needed by firms. Therefore, hereafter this

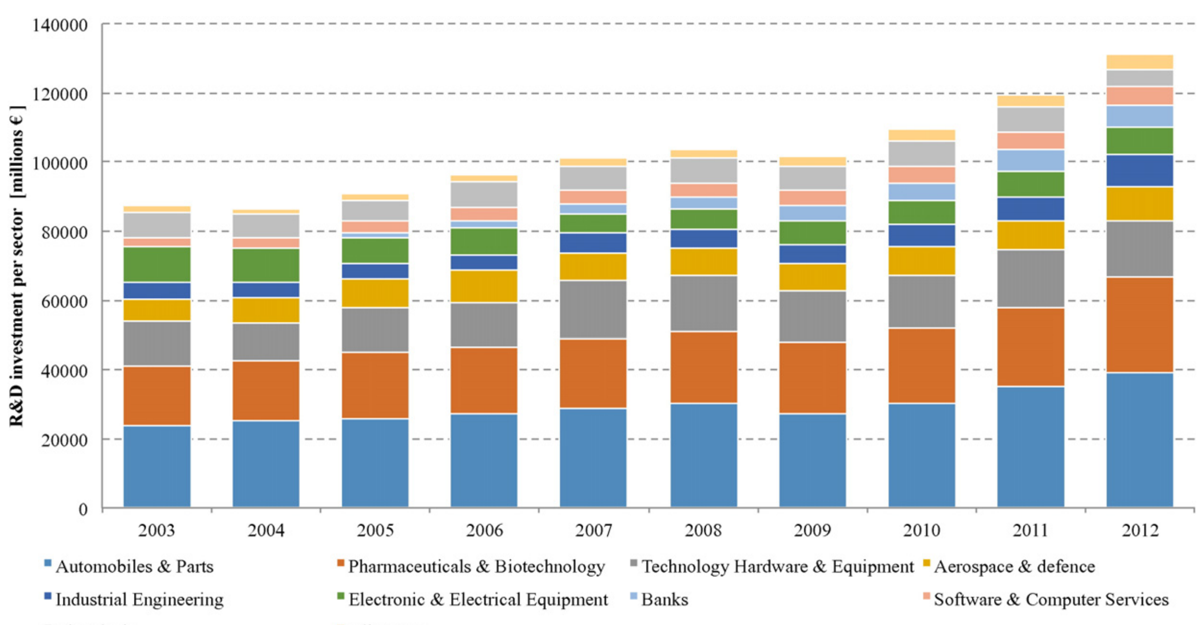

Fig. 2. R&D investment per sector in EU for firms in the top 500. Authors' elaboration based on data from IRI (2014).

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Ranking 2011	Firm	Sector	R&D Investment
1	Grupo Portugal Telecom	Telecommunications	208.225.166 €
2	BIAL - Portela & Cª, S.A.	Pharmaceuticals & Biotechnology	55.419.851 €
3	Nokia Siemens Networks Portugal, S.A.	Technology Hardware & Equipment	49.310.695 €
4	Empresas Sonae	Telecommunications	46.590.715 €
5	Banco Comercial Português, S.A.	Banks	40.330.000 €
6	Grupo José de Mello, SGPS, S.A.	Technology Hardware & Equipment, Health Care Equipment & Services, Personal & Household Goods, Utilities	31.232.657 €
7	Volkswagen Autoeuropa, Lda.	Automobiles & Parts	18.560.847 €
8	COBA - Consultores de Engenharia e Ambiente, S.A.	Construction & Materials	18.410.958 €
9	Grupo BPI	Banks	17.912.360 €
10	Grupo Unicer Bebidas de Portugal, SGPS, S.A.	Food and Beverages	14.883.503 €
11	Grupo SECIL	Construction & Materials	14.067.337 €
13	Barclays Bank, PLC	Banks	12.735.363 €
14	CTT - Correios de Portugal, S.A.	Industrial Transportation	12.447.389 €
15	Grupo Bosch	Automobiles & Parts, Personal & Household Goods	11.134.049 €
16	Grupo Porto Editora	Support Services	11.103.506 €
17	Grupo EDP	Utilities	10.464.164 €
18	Grupo Portucel Soporcel	Basic Resources	10.171.735 €
19	Hovione FarmaCiência, S.A.	Pharmaceuticals & Biotechnology	10.146.020 €
20	Grupo Galp Energia, SGPS, S.A.	Utilities	9.338.149 €

Fig. 3. R&D investment from top 20 Portuguese firms in 2011 (DGEEC, 2013)

dimension is mentioned as competence building. Leydesdorff (2010) positions patents as events in the three-dimensional space of triple helix interactions. The reasoning is that as a product of industrial competition, patents incorporate novel scientific knowledge that function at the interface of academia with industry, regulated through patent legislation (Leydesdorff, 2010).

By looking into the fast pace of technological change in the global competitive arena, we can consider competition as a matter of supply chain rivalry, where supply chain partnerships are a crucial element to the successful commercialisation of products (e.g., Fine, 1998; Hult et al., 2010). Given the growing technological complexity, supply chains rely more and more on different actors, such as universities, to generate novel knowledge (Berger, 2013). In addition, as mentioned earlier, government can stimulate innovation through regulation (Lee et al., 2011) or even through the creation of incentives (Mazzucato, 2013). In light of the foregoing, this triadic relationship between industry, competence building and government allow us to examine how to foster technological capabilities through an OEM establishment within an international supply chain. Therefore, we use that idea to argue that supply chains can be positioned in terms of three mechanisms: legislative control by government, wealth generation based on commercial activities by industry, and knowledge creation competence building, as illustrated in Fig. 4.

Academia, industry and government remain crucial players regarding the performance of science and technology (Etzkowitz, 2002). Nonetheless, the connectivity, links and associations with other organisations are no less important (Ivanova and Leydesdorff, 2014; Mazzucato, 2013). One of the main reasons for that is the set of complementary capabilities that companies can draw on to supplement their resources, which ultimately enhances the likelihood of new technologies come to life (Berger, 2013). These issues have indeed gained much relevance in the global political debate due to their importance for long-term economic competitiveness of nations (Locke and Wellhausen, 2014), which raises questions as to whether investments in human capital, R&D and technological competences are perhaps more important than short-term competitiveness. Investments in human capital, R&D and technology do matter and are perhaps the most important factor in explaining economic growth (Romer, 1994; Conceição et al., 2001; Lundvall, 1992; Nelson, 1993). However, technological change to growth is not immediate (Kim, 2001). Policies that

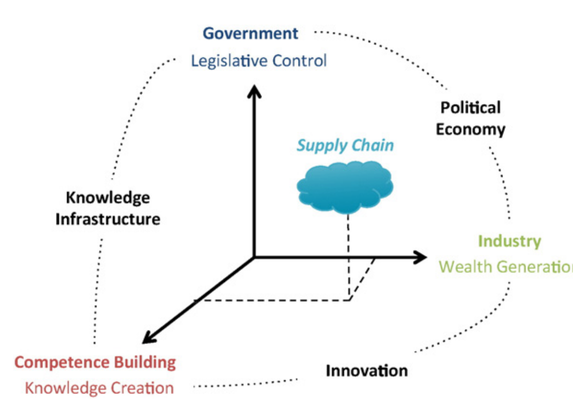

Fig. 4. Conceptual approach, adapted from Leydesdorff (2010).

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recognise innovation as a collective process are required to make this transition successfully (Mazzucato, 2013).

4. Research setting and methodology

Studying the automotive supply chain and the underlying dynamics of technological capacitation requires a research setting in which we analyse not only how technological knowledge was originally accumulated in the Portuguese automotive industry, but also how the existing technological knowledge has leveraged into new collaborations.

We chose the case of VW Autoeuropa for several reasons. First, we wanted to focus on one OEM establishment to explore the role of policy frameworks in fostering technological capacity. Second, Autoeuropa accounted in 2014 for 3.7% of all exports of the country and had an impact of 1% in the Portuguese GDP (Autoeuropa, 2016), which makes it a relevant example for the study of small and peripheral economies, deprived of significant R&D activities, and integrated into the global automotive production networks (Veloso et al., 2000; Almodovar and Teixeira, 2014). Also, due to OEM's reputation for enhancing domestic suppliers' performance through standards implementation and information sharing, we expected well-established routines and practises to shape the relationship with suppliers. Finally, Autoeuropa established its plants in 1995, which made availability of secondary data not an issue. In fact, we were able to complement our secondary qualitative data with interviews and press coverage.

We follow a longitudinal case study approach (Eisenhardt, 1989), developing a historical perspective to improve our understanding of the events as they unfolded over time. Data on Portuguese automotive parts[1] exports/imports was drawn from the Observatory of Economic Complexity—OEC (OEC, 2015). Data on human capital was drawn from Quadros de Pessoal (hereafter termed QP)—a Portuguese longitudinal matched employer–employee database built from mandatory information submitted by firms to the Portuguese Ministry for Employment and Social Security. It includes extensive information on private firms, establishments and workers in the Portuguese economy for the period 1985–2012. This study uses longitudinal data on employees to characterise the evolution of the automotive industry in Palmela. The task of identifying the automotive sector through the economic activity codes faced several limitations. Firms that contribute to the automotive supply chain do not have to be registered (through a NACE code—termed CAE code in Portugal) [2] in this sector of activity. The reason for this codification issue might result from several factors. For instance, if firms' current or past activities are not exclusively focused on the automotive sector, companies can be registered in a completely different sector. Also, during the period under observation, Portuguese standard industry classification codes underwent four changes[3], requiring correspondences between old and new ones. It is noteworthy that no data is available on the individuals (workers) in years 1990 and 2001. Also, data on companies for the years 1999 and 2000 could not be validated and therefore was discarded.

In order to prevent and overcome the previously mentioned limitations, we conducted semi-structured interviews, from June 2014 to March 2015, with 13 experts to gain a better comprehension about the automotive sector. Appendix C presents detailed information of the interviews we conducted, the titles of the informants, the estimated number of years that they have worked at each establishment, and finally the type and location of the organisation. The interviews ranged from 60 to 150 min and covered the context in which Autoeuropa emerged in Portugal, as well as the technical issues encountered in developing technological capabilities.

Overall, the process was highly iterative. We consulted multiple data sources that studied the automotive industry in Portugal. The collected information was not only internal (company reports and organisation charts), but also external (specialised technical papers, theses, books, newspaper articles, case studies and industry reports properly referenced throughout this article). This material provided a unique description of the environment and firm-specific conditions that favoured the development of technological capabilities in the Portuguese automotive sector. We also found historical and technical details on the automotive industry in Portugal and on the Autoeuropa case (Selada and Felizardo, 2002). This case provided a detailed, consistent chronology of the crucial events and factors that shaped the evolution of the automotive industry in Portugal, as well as the role that Autoeuropa played in that process.

The combination of several distinct data collections—databases, interviews, company reports, companies websites, academic literature—reduces the validation problems, as well as potential bias of historical analyses, while helping to identify converging lines (Yin, 1994). This combination allowed us to identify more accurately some factors that have favoured the accumulation of technological capability in the automotive supply chain, reducing the risk of giving importance to historical events based on the knowledge of outcomes. Furthermore, interviews helped to reconstruct more precisely how the automotive capabilities in Portugal have evolved over the last 20 years.

5. Autoeuropa establishment in Portugal

In 1991, the Portuguese government signed the agreement to establish Autoeuropa, an automotive plant, in Palmela (South of Lisbon). Autoeuropa opened as a joint venture between Ford and Volkswagen. Therefore, while *Ford brought the expertise in lean manufacturing practises into the plant layout*, *as well as the new supplier strategies based on modules and sequential deliveries*, *Volkswagen was responsible for the product development* (Interview A).

Autoeuropa started producing a multi-purpose vehicle (MPV) in 1995, commercialised as VW Sharan, SEAT Alhambra and Ford Galaxy. By 1996, the firm was already responsible for about 82% of all the passenger cars produced in Portugal (Conceição et al., 2003). In 1999, Volkswagen took over Ford's position and ceased the production of Ford Galaxy cars in February 2006. With the decision to produce the EOS at Autoeuropa, the firm started a new production line exclusively for this model, beginning its production in 2006. In 2008, Autoeuropa introduced the Scirocco sports model, and a year later, the original MPV line was dismantled to give place to multi-product plant. This change increased the plant's flexibility, which allowed manufacturing multiple models on the same production line. The second MPVs generation (VW Sharan and SEAT Alhambra) was introduced in 2010.

5.1. Government

Government intervention emphasis was placed on FDI attraction, as well as domestic technological capabilities enhancement. Therefore, policy instruments such as national and EU financial incentives, tax credit and indirect support were used. Among these, it is important to mention the specific programme for the development of the Portuguese industry (PEDIP), which provided incentives to companies regarding technology aspects, innovation, quality, training, management, and marketing among others (Selada and Felizardo, 2002). Indeed, State intervention dragged a substantial amount of foreign direct investment and several multinationals established facilities in Portugal. Several automotive component producers established plants at the industrial park in Palmela, ensuring *Just in Time* (JIT) deliveries, which means that production and delivery must happen at the appropriate time, allowing Autoeuropa to reduce significantly their stock level (Lima et al., 1996).

[1] Appendix A presents a description of the HS-4 codes used as automotive parts.

[2] NACE stands for Nomenclature of Economic Activities. CAE stands for the Portuguese Classification of Economic Activities.

[3] The CAE industry classification at QP was first revised in 1995. To enable the time-series analysis by manufacturing economic sector, we adopted the procedure presented in Appendix B.

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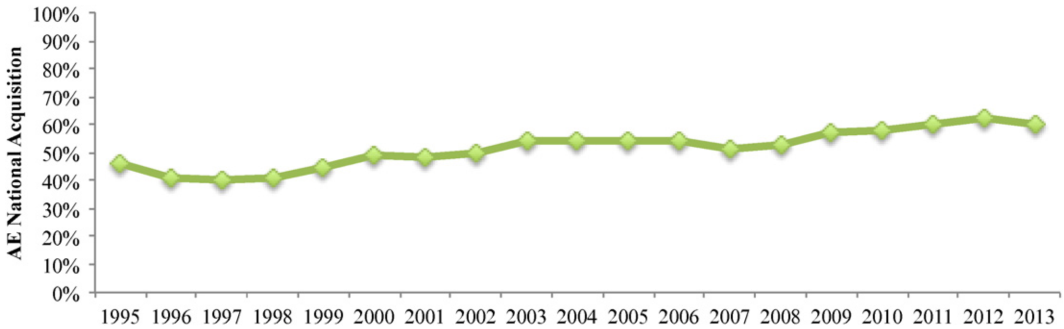

Fig. 5. Autoeuropa national acquisition. Authors' elaboration based on Autoeuropa's facts and figures (2016).

Moreover, in order to take full advantage of the Autoeuropa establishment, the Portuguese government established GAPIN, an organism responsible for the pre-selection of domestic companies with potential to supply Autoeuropa, as well as promoting joint ventures between Portuguese and foreign firms (Chorincas, 2002). Most of the foreign firms were German qualified suppliers of Ford and/or VW, which allowed the integration of domestic firms in the international network of automotive suppliers (Féria, 1999). Examples of joint ventures established at the time were: the TMG-Sommer Allibert, the PASFIL-Dynamit Nobel, the INAPAL-Menzolit, and the IBER-Ollef in the plastics field, the FAPOBOL–Diehl in the rubber field. Despite the commercial importance of these joint ventures, such partnerships were not limited to the production of automobile parts. For instance, in the logistics field there were: NAVIGOMES and Causse-Wallon, as well as PGS-Franz Maas. Fig. 5 presents the value of national incorporation in Autoeuropa's models from 1995 to 2013, which slightly increased throughout the years.

The Autoeuropa project was used to improve product quality in upstream activities throughout the supply chain, which led to the development of several Portuguese firms. As expressed by a Portuguese automotive supplier's CEO: *Autoeuropa completely changed the paradigm of several national firms, which then began to supply goods for the automotive industry* (interview K[4]). In fact, the Portuguese government established several initiatives aimed at quality and productivity improvement of automobile parts production companies (Veloso et al., 2000), which resulted in a substantial boost in the number of companies with the highest quality certification level (Q1) from Ford. From July 1991 to the Autoeuropa establishment in 1995, the number of companies with the Q1 certification increased from only four to fifty (Féria, 1999).

5.2. Industry

Autoeuropa was one of the most important foreign direct investments in Portugal and still has a significant importance for the overall economy, representing, in 2014, 1% of the Portuguese GDP, and 3.7% of Portuguese exports (Autoeuropa, 2016). Research has shown that the installation of Autoeuropa has played an important role in Palmela's economy. The overall manufacturing employment increased remarkably in the region since the agreement for Autoeuropa's establishment. Fig. 6 presents manufacturing employment in Palmela, which evidences this increase in employment, particularly significant in the manufacturing of transport equipment.

In Fig. 7 we present the manufacturing employment distribution by firm's capital origin. From this figure, we notice that by 1995 there were nine companies with foreign capital established in Palmela, accounting for approximately 70% of manufacturing employment in the region. After 1995, there was a slight increase of foreign manufacturing firms in the region, but with no major change in the employment distribution. On the other hand, there was a significant increase of domestic manufacturing companies, leading to a slight growth in the share of manufacturing employment. In other words, despite the increase in the number of domestic manufacturing firms in the region, foreign firms are the largest manufacturing employer in the region. This weakness of the Portuguese industrial production was already pointed out by Vale (2004). However, production end of the EOS model in 2015, which resulted in the closure of the company that manufactured the retractable hardtop and the dismissal of 300 workers (Pinto, 2015), highlighted the fragility of this industrial ecosystem. Moreover, given the current global context, in which companies shift their production to the most cost-effective location despite their national bounds, local suppliers and workers are more exposed than ever before to VW decisions.

The impact of Autoeuropa was not limited to Palmela. Evidence from interviews indicates that domestic firms improved their organisational and technological capabilities, leveraging on the knowledge acquired through the contact with Autoeuropa to escalate their production towards other automotive OEMs (e.g. interview E). Actually, from the 83 Portuguese firms that supply the VW Group, some do not supply Autoeuropa (Remmer, 2013). Therefore, by promoting a favourable environment of incentives, a substantial number of Portuguese firms were able to develop their capabilities and expand their operations worldwide. Fig. 8 shows Portuguese exports and imports of automotive parts from 1995 to 2013.

As can be seen in Fig. 8, both exports and imports increased considerably after Autoeuropa's establishment in Portugal. Although automotive parts exports surpassed imports in 2006, this trend was inverted afterwards until 2011. Worth mentioning is the fact that despite the stiff decrease of both exports and imports in 2009 (coincident with the aggravation of the global financial crisis), Portuguese automotive parts exports grew once again after this period. This trend reflects the heavily dependence of Portuguese production on the external market. It is also important to notice that several changes taking place at Autoeuropa, namely: the end of production of Ford Galaxy in 2006, the introduction of new models (EOS in 2006, Sirocco in 2008 and second MPV generation in 2010), and the implementation of the multi-product line (2009), which increased the plant's flexibility, allowing to manufacture multiple models on the same production line. Besides the four car models, Autoeuropa started a stamping business as another source of revenue in 2008. This unit produces stamped components, such as doors, side panels and hoods. After their production at Autoeuropa, service parts are sent to two companies in Portugal to receive an anti-corrosion treatment and then are sent to several other plants of the group, as well to a central warehouse, which later sells them to dealers (Remmer, 2013).

Data from the Portuguese automobile parts industry association shows that there were 188 firms in Portugal supplying automobile parts in 2014 (AFIA, 2014). In Fig. 9 we present the revealed comparative advantage (RCA) of exports and imports for automotive parts in

[4] All interviewees were assured confidentiality. Therefore, interviewees and organization names were masked in this study, as can be seen in the overview of the interviews, presented in Appendix C.

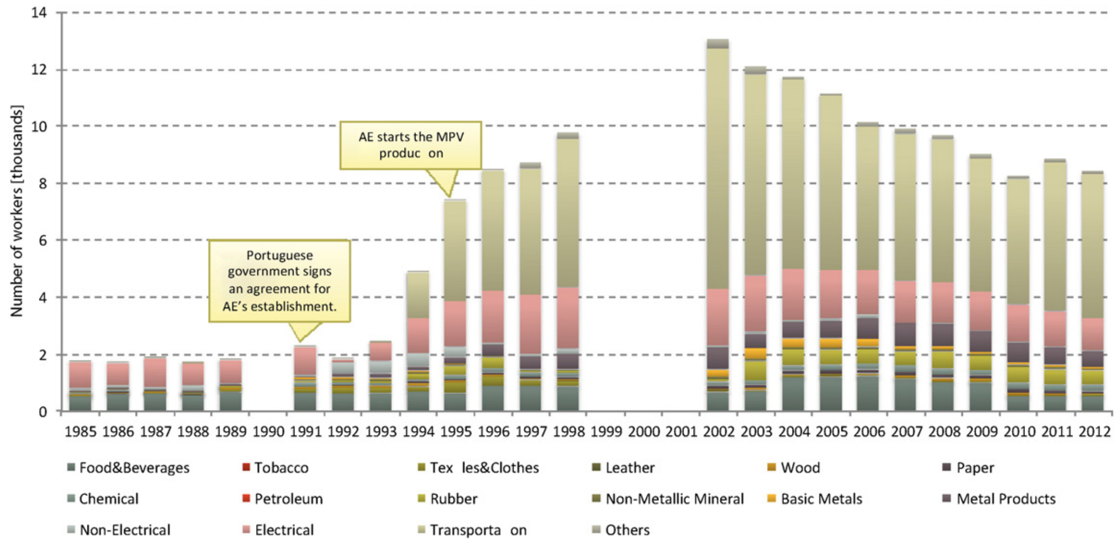

Fig. 6. Manufacturing employment in Palmela. Authors' elaboration based on QP data.

Portugal[5], which represents the advantage or disadvantage of a certain country in a certain commodity. A comparative advantage is revealed for values greater than one, whereas for values less than one, the country is said to have a comparative disadvantage.

As can be seen in Fig. 9, the RCA values for exports increased for values greater than one after 1999, meaning that the Portuguese economy has become much more specialised in the automotive parts through the years. Also, we can notice that RCA values for imports slightly decreased during this period, suggesting that Portuguese dependence on foreign automotive parts diminished. Nevertheless, from our interviews, it stood out that domestic firms still supply modules of low technological complexity, which integrate few components. Therefore, main challenges include moving up in the automotive value chain to become globally competitive. As an automotive supplier explained us, *there are very large investments that need to be made in order to move up in the automotive value chain. And generally, Portuguese firms are unable to make these investments. Thus, they continue to provide low-value-added parts and parts of low technological complexity. This is a vicious cycle and therefore, it is very difficult to move up the value chain* (interview E). Moreover, a business analyst went further on this subject, stressing that multinationals are in general much larger than domestic firms, with considerable more resources devoted to R&D, which ultimately allows them to absorb the costs when something goes wrong. Portuguese companies would probably close in a short period of time if something goes wrong and the OEM is not willing to bear that risk (interview D). Thus, it is difficult for domestic firms to move towards more technological complex parts, where better profit margins exist.

Profit margins for low value-added parts in the automotive sector are very small. For instance, some companies refuse to bid for volumes lower than 30,000 pieces because it is not competitive (interview C). But, as previously noted, moving up towards more technological complex parts is not an easy task, as established players can be more competitive due to their dimension, and in general, are better positioned to absorb the risk in new programmes. Perhaps, another option for domestic firms to consider is to address niche markets of low volumes, where big corporations generally do not enter. For example, this strategy was taken by the footwear industry in Portugal, which has become more focused on higher value-added products. Nevertheless, adopting this strategy requires identifying the niche markets of more sophisticated technologies, as well as surpassing the barrier between low and high value-added technologies, which is not straightforward (interview E).

5.3. Competence building

Much emphasis was placed on workforce training. A training centre equipped according to the existing standards and requirements in other European counterparts opened in Palmela's industrial park in 1993. The goal was to prepare the workforce for the needs of the firms that integrate the industrial complex, particularly Autoeuropa. Indeed, this training centre, called Formauto, was subsidised by both Autoeuropa and the Employment and Vocational Training Institute (IEFP) through FEDER and FSE funds (Lima et al., 1996). In 2003, after a reorganisation of the training competences, Formauto is extinct and ATEC emerges as a training academy to provide a technical education in several fields, such as welding, mechatronics, industrial maintenance, electronics, automation and control, amongst others. The former CEO of an automotive supplier installed in the industrial park, for example, told us that *it was to address the lack of Portuguese skilled technicians in electronics, pneumatics, and hydraulics that the ATEC was established in Palmela* (interview E). From our interviews, it also stood out that a high number of automotive companies located at the industrial park recruit people with a technical education from ATEC, and later on complement this training with on-the-job training at the firms' assembly lines (e.g. interview F).

Nonetheless, the technical training provided to the Portuguese workforce was not limited to the Palmela/Setúbal region. Several interviewees from other parts of the country also highlighted the important role of the IEFP in the training and qualification of the workforce. For instance, there are automotive suppliers that are developing training programmes in collaboration with the IEFP. Typically, the classes of trainees in these programmes are chosen according to several specificities, such as geographical proximity, educational level, and industrial culture. These requirements allow for a better matching of firms needs and the workforce. But, despite the improvement of the Portuguese vocational training, it is not comparable to the German reality. As the president of an industry association explained, *in Germany, there are people from various levels* (e.g., *technicians and engineers*) *involved in the product development since the beginning of the project. They are much more exposed to technological aspects from early on, which turns out to become part of their own culture.*

However, as the former director of an Autoeuropa supplier told us: *firms such as Autoeuropa do not have the autonomy to engage in product development and supplier selection processes. These processes are centralized at the OEM, which in the Autoeuropa case is in Wolfsburg.*

[5] Appendix D presents a brief description of this economic index, explaining how it was obtained.

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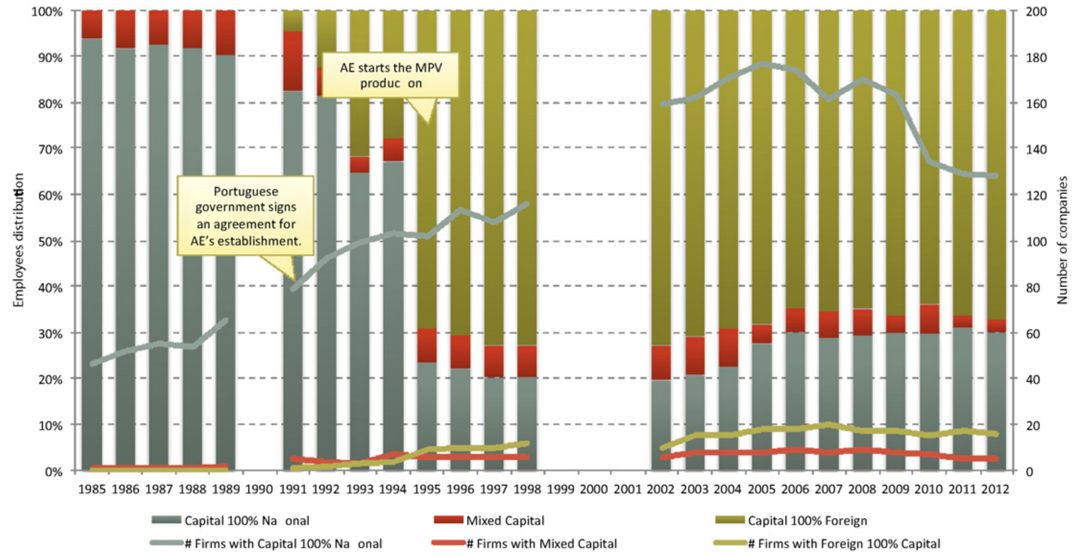

Fig. 7. Manufacturing employment distribution by firms' capital origin. Authors' elaboration based on QP data.

This means that firms such as Autoeuropa end up devoting few resources to R&D activities and are more oriented towards production. Therefore, industrial partnerships with universities end up reflecting this same reality, in which *industrial partnerships with universities exist, but they are not done in a structured way* (interview F). In order to change this situation, the Portuguese government established some industrially linked programmes, such as the MIT Portugal Program. These cross-national partnerships were aiming at strengthening Portuguese science and technology knowledge base at an international level (Heitor, 2015). In particular, the Engineering Design and Advanced Manufacturing programme affiliated with a set of leading companies in the automotive sector, including Autoeuropa and major automobile component manufacturers.

Another important feature critical for the enhancement of suppliers' innovation and absorptive capabilities in Portugal were the local supplier organisations, most remarkably the Research and Technology Organizations (Almodovar and Teixeira, 2014). For instance, the technological centre for the moulds, special tools and plastic industry—CENTIMFE—has played a major role in the development of the automotive component segment in the central region of Portugal. Nevertheless, the interviews revealed that although significant progress has been achieved in terms of industrial collaborations, this network is not yet large enough to leverage product design and development, leaving great room for improvement. Current main challenges include the adaptation of current industrial policy mechanisms towards the consolidation of these long-term triple relations for collaborative research.

6. Concluding remarks and implications for industrial policy

Prior work has documented the need for industrial policies to go beyond “national systems of innovation”. Ostry and Nelson (1995), for example, reports that as firm's activities have become increasingly global integrated, national government policies have less control over economic markets. However, these studies have not focused on countries that have become part of global supply chains, despite their relatively low R&D capacity, such as Portugal. Although our work focuses on the promotion of technological innovation through OEM establishment in the automotive sector, we expect that lessons concerning industrial policy are relevant to other sectors like, for example, aeronautics.

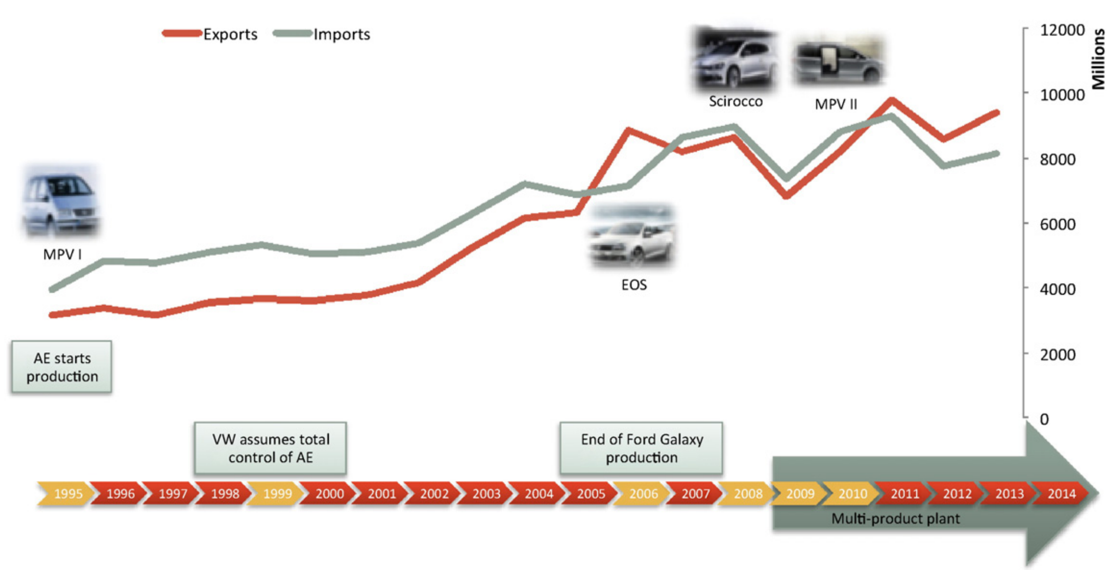

Fig. 8. Portuguese Automotive Parts Exports/Imports from 1995 to 2013. Authors' elaboration based on OEC data.

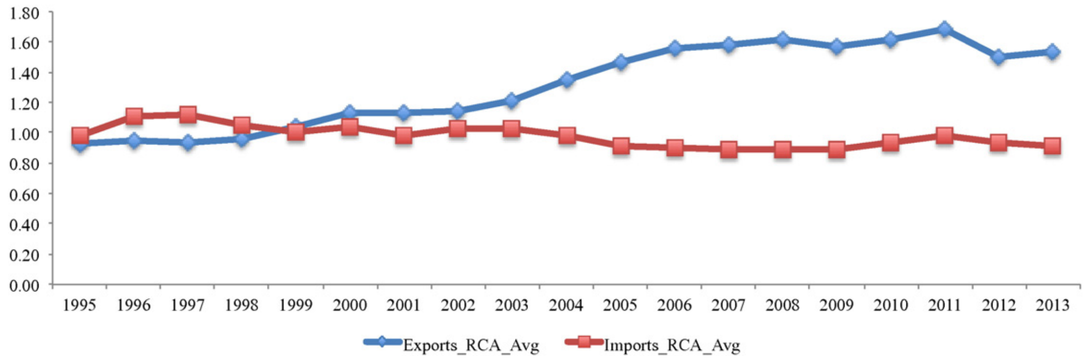

Fig. 9. Evolution of RCA average values for automotive parts in Portugal. Authors' elaboration based on OEC data.

Based on the literature (Leydesdorff, 2010), we argue that supply chains can be positioned in terms of three mechanisms: legislative control by government, wealth generation based on commercial activities by industry, and knowledge creation competence building. Therefore, the approach considered in this paper builds on the Triple Helix conceptual framework (Etzkowitz and Leydesdorff, 1995, 2000) to examine how Autoeuropa's establishment has helped to promote technological innovation in Portugal.

Following this line of reasoning, we argue that governments can put mechanisms in place that stimulate technological spillovers to domestic firms through OEM establishment. Such mechanisms include the development of the national industry through information sharing about quality requirements needed to enter a regulated industry, as well as the promotion of the dialogue between domestic firms and international contractors. Regarding, industry we found that despite the significant growth in Palmela's manufacturing employment, most of this work is largely concentrated on foreign companies. These findings extend those of Vale (2004), confirming that given the current context in which companies move their production activities to the most cost-effective location, local suppliers and workers are more vulnerable than ever before. In addition, improvements in the competitiveness of automotive component producers noted in our study clearly benefited from the establishment of Autoeuropa in Portugal. However, despite the positive role of Autoeuropa in promoting Portuguese automotive parts exports, technological spillover effects remained relatively small. Products supplied by domestic companies are still confined to low value-added products of low technological complexity. In what concerns competence building, we have shown that capacitation strategies should promote vocational training since it plays a central role in the development of technological capabilities needed by firms. Moreover, despite the important role of large knowledge networks in promoting an internationalisation and specialisation path, they have not been effective in promoting technological change. Network competitiveness depends on many factors, and requires increasingly focused partnerships that should be promoted through new regulatory frameworks. Therefore, this work supports the need for opening up science and industrial policies to multiple public and private agents, promoting global research networks towards socio-economic resilience. Future industrial policies would therefore require fostering and promoting a network of technology suppliers and skill-intensive employers.

Furthermore, research and technology organisations as well as technology-based firms seem to have an increasingly significant role in the industrialisation process, but require continuous incentives to diversify their activities beyond a single market. The related implication is the need for public policies actively promoting the internationalisation of those players. Indeed, the automotive sector has been consistently based on international relations, not only in terms of the suppliers' selection, which is done at the OEM's headquarters, but also because automotive component suppliers export their products worldwide. Moreover, training is not only provided within the national borders, but also abroad. These factors contribute for knowledge and financial flows that go beyond national boundaries. Therefore, sustainable development requires a new phase of industrial policy that gives priority to new collaborative policy frameworks within the increasingly transnational business, technology and science. In other words, we have identified the need to promote new forms of FDI, which clearly break traditional boundaries of "national systems of innovation".

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Appendix A. HS-4 codes for Automotive Parts (U.S. Commercial Service, 2014)

4009 Rubber Piper;
4011 Rubber Tires;
4012 Used Rubber Tires;
4013 Rubber Inner Tubes;
4016 Other Rubber Products;
6813 Friction Material;
7007 Safety Glass;
7009 Glass Mirrors;
7320 Other Glass Articles;
8301 Padlocks;
8302 Metal Mounting;
8407 Spark-Ignition Engines;
8408 Combustion Engines;
8409 Engine Parts;
8413 Liquid Pumps;
8414 Air Pumps;
8415 Air Conditioners;
8421 Centrifuges;
8425 Pulley Systems;
8426 Cranes;

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8431 Excavation Machinery;
8482 Ball Bearings;
8483 Transmissions;
8507 Electric Batteries;
8511 Electric Ignitions;
8512 Electric Lighting & Signalling Equipment;
8517 Telephones;
8519 Sound Recording Equipment;
8525 Broadcasting Equipment;
8527 Radio Receivers;
8531 Audio Alarms;
8536 Low-voltage Protection Equipment;
8539 Electric Filament;
8544 Insulated Wire;
8707 Vehicle Bodies;
8708 Vehicle Parts;
8716 Trailers;
9029 Revolution Counters;
9194 Dashboards;
9401 Seats;
9403 Other Furniture.

Appendix B. Correspondence between CAE revisions for the manufacturing sector

First, we constructed a correspondence table between 3-digits CAE Rev. 1 codes (in place until 1994) and 2-digits CAE Rev. 2 codes (in place from 1995 to 2002). Second, we find no differences between 2-digits CAE-Rev. 2 and 2-digits CAE Rev. 2.1 (in place from 2003 to 2006) for the manufacturing economic sectors considered herein. Finally, we made the correspondence between 2-digits CAE Rev. 2.1 and 2-digits CAE Rev. 3 (in place after 2007). Table 1 summarises this correspondence between CAE revisions.

Appendix C. Overview of interviews

Table 2
Overview of interviews.

ID	Interview date	Position	Estimated years in the organisation	Type	Location
A	04-06-2014	Supplier manager	9	Industry	Setúbal, Portugal
A	04-06-2014	Engineer	3	Industry	Setúbal, Portugal
A	04-06-2014	Purchase Analyst	22	Industry	Setúbal, Portugal
B	15-07-2014	Business Analyst	12	Consulting	Lisbon, Portugal
C	30-07-2014	President	2	Industry Association	Porto, Portugal
D	31-07-2014	Board member	14	Consulting	Lisbon, Portugal
E	22-08-2014	Former director	10	Industry	Setúbal, Portugal
F	27-08-2014	Logistics manager	9	Industry	Setúbal, Portugal
G	03-10-2014	Full professor	32	Academia	São Paulo, Brazil
H	10-10-2014	Researcher	2	Academia	São José dos Campos, Brazil
I	09-12-2014	Business director	12	Industry	Lisboa, Portugal
J	13-02-2015	CTO	13	Industry	Setúbal, Portugal
K	16-03-2015	CEO	13	Industry	Braga, Portugal

Table 1
Correspondence between CAE revisions for the manufacturing sector.

	Rev1	Rev2 & Rev2.1	Rev3
Food & beverages	311, 312, 313	15	10, 11
Tobacco	314	16	12
Textiles & clothes	321, 322	17, 18	13, 14
Leather	323, 324	19	15
Wood	331	20	16
Paper	341, 342	21, 22	17, 18
Chemical	351, 352	24	20, 21
Petroleum	353, 354	23	19
Rubber	355, 356	25	22
Non-metallic mineral	361, 362, 369	26	23
Basic Metals	371, 372	27	24
Metal Products	381	28	25
Non-electrical	382	29, 30	28
Electrical	383, 385	31, 32, 33	26, 27
Transportation	384	34, 35	29, 30
Others	332, 390	36, 37	31, 32, 33

Appendix D. Revealed comparative advantage

The term revealed comparative advantage (RCA) is used as an international economic index of trade specialisation (Balassa, 1965). RCA can be defined as:

$$RCA_{ij} = \frac{x_{ij}/\sum_i x_{ij}}{\sum_j x_{ij}/\sum_i \sum_j x_{ij}}$$

where x_{ij} are the exports (imports) of sector i from country j. Therefore, the numerator represents the percentage share of a given sector in national exports (imports), and the denominator represents the share of that sector in world exports (imports).

We used the RCA data computed through the Observatory of Economic Complexity project, disaggregated according to the Harmonized System at the four-digit level (HS-4), available at http://atlas.media.mit.edu/en/resources/data/. With these data, we calculated for Portugal the average RCA value of automotive parts.

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Anabela Reis is a Doctoral student in Engineering and Public Policy at Instituto Superior Técnico, University of Lisbon. She holds a PhD fellowship from the Portuguese Science and Technology Foundation, FCT through the research network “International Risk Governance Council—Portugal, IRGC-Portugal”.

Manuel Heitor is Professor at Instituto Superior Técnico, University of Lisbon, and Director of the Center for Innovation, Technology and Policy Research, IN. He served as Secretary of State for Science, Technology and Higher Education in the Portuguese Government, 2005–2011.

Miguel Amaral holds a PhD in Industrial Engineering and Management from the Instituto Superior Técnico (IST), University of Lisbon. Miguel also holds an MSc in Engineering Policy and Technology Management, an advanced training diploma in Communications Science and a degree in Economics. Presently works as Assistant Professor at the Engineering and Management Department from IST and as a Research Associate at the Center for Innovation, Technology and Policy Research, IN+/IST, where he directs the Laboratory of Technology Policy and Management. His research interests and teaching focus mainly on Technological Change and Entrepreneurial Dynamics.

Joana Mendonça is a researcher at the Center for Innovation, Technology and Policy Research (IN+), and a senior researcher at International Risk Governance Council Portugal (IRGC). Her research focuses on industrialisation and innovation processes, looking at new business creation, with a special focus on the role of people, skills and competences, having published a number of articles on entrepreneurship and innovation processes. She was deputy director for the science, technology and higher education statistics department, and an assistant to the Secretary of State for Science, Technology and Higher Education. She is the national representative on the SGHRM working group on monitoring and indicators for DG Research.

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