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Macroeconomic divergence, structural polarization,
trade and fragility

**Claudius Gräbner, Philipp Heimberger, Jakob Kapeller
and Bernhard Schütz**

JƎU
JOHANNES KEPLER
UNIVERSITY LINZ

ICAE
INSTITUTE FOR COMPREHENSIVE
ANALYSIS OF THE ECONOMY

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Claudius Gräbner[a§], Philipp Heimberger[ab], Jakob Kapeller[ac] and Bernhard Schütz[c]

Abstract

This paper analyses macroeconomic developments in the Eurozone since its inception in 1999. In doing so, we document a process of divergence and polarization among those countries that joined the Eurozone during its first two years, which fits a typical 'core – periphery' pattern. We show how this polarization process first manifested in increasing current account imbalances, before it translated unto the level of general macroeconomic development after the crisis. Empirically, we demonstrate how this divergence is tied to a 'structural polarization' in terms of the sectoral composition of Eurozone countries: specifically, the emergence of export-driven growth in core countries and debt-driven growth in the Eurozone periphery can be traced back to differences in technological capabilities and firm performance. Pushing for convergence within Europe requires the implementation of three intertwined policy programs: macroprudential financial regulation, active industrial policies aiming at a technological catch-up process in periphery countries, and progressive re-distributional policies to sustain adequate levels of aggregate demand throughout the Eurozone.

Keywords: polarization, Eurozone, industrial policy, financial regulation, growth trajectories

JEL codes: E12, E6, F4, F6, O3

1. Introduction

Nearly twenty years after the introduction of the Euro in 1999 and about ten years after the outbreak of the financial crisis of 2007/2008, economic developments within the Eurozone remain remarkably uneven. Germany has turned from being the 1990s 'sick-man of Europe' to a dominant economic power of today: it has not only bounced back from the financial crisis but has also been able to accumulate large current account surpluses (Simonazzi *et al.*, 2013; Storm and Naastepad, 2015B; Stockhammer and Wildauer, 2016). Real output in Germany increased by 24.1% between 1999 and 2016, which stands in stark contrast to the developments in other Eurozone countries like Italy, where real output increased only by 4.6%, Portugal (+ 8.2%) or Greece (+ 1%).[1] Such a casual inspection of current macroeconomic statistics indicates that the Euro's alleged role as a "convergence machine" (e.g. Gill and Raiser, 2012) has been contradicted by a reality of accelerated divergence – at least for those countries joining the Euro during the first two years since its inception in 1999.

In this paper, we study the mechanisms underlying macroeconomic divergence in the Eurozone by focusing on the central role of differences in technological capabilities. We contribute to the existing literature in two major respects. First, we suggest an integrated framework for analyzing polarization in the Eurozone with a special consideration of the impact of the financial crisis to demonstrate crucial characteristics of the underlying polarization process during the pre-crisis and post-crisis period. Second, we relate the emergence of divergent macroeconomic development paths in the Eurozone to differences in terms of technological capabilities and firm performance.[2] Exploiting data on sectoral trade and economic complexity (Simoes and Hidalgo 2011), we assess their impact on future development paths.

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[1] Source: AMECO data on real GDP (Spring 2017); authors' calculations.
[2] Gala et al. (2018) have recently analyzed the relation between technological capabilities and convergence patterns between core and periphery countries in terms economic growth for a global sample of 149 countries over 1979-2011, finding that production complexity is significant in explaining convergence and divergence among countries.

These contributions are relevant for at least two reasons. First, we extend past works by Simonazzi *et al.* (2013), Botta (2014) as well as Storm and Naastepad (2015A, 2015B, 2015C), who emphasize that divergences in industry structures played a crucial role for the macroeconomic developments within the Eurozone. However, since these studies largely focus on pre-crisis years, they do not embed their analysis in a broader account of structural polarization in the Eurozone as a process that has continued in post-crisis years. This paper closes this gap in the literature by proposing a framework that allows for linking firm performance in core and periphery countries of the Eurozone to the macroeconomic literature on 'export-led' and 'debt-led' growth models (e.g. Stockhammer 2015; Baccaro and Pontusson, 2016; Stockhammer and Wildauer, 2016).

Second, our contribution lies in providing evidence on the distribution of technological capabilities during the pre- and post-crisis period, which is of relevance since structural industry characteristics are often essential for future developmental trajectories (Hidalgo and Hausmann, 2009; Cristelli et al, 2015). By demonstrating that the post-crisis Eurozone is characterized by non-convergence in terms of technological capabilities, we contribute to the broader policy debate: our results suggest that coordinated fiscal, wage and industrial policies will be needed to counteract the ongoing structural polarization process.

To identify the mechanisms underlying European polarization, we proceed as follows. First, we develop a framework that integrates macro- and microeconomic perspectives to arrive at a consistent view on European divergence in section 2. Section 3 provides empirical evidence illuminating the mechanisms highlighted within this framework. Section 4 summarizes our argument and discusses its policy implications.

2. Imbalances and macroeconomic fragility: A framework capturing structural polarization in Europe

This section provides a framework that identifies the major dynamics of structural polarization on both the micro- and macroeconomic level. In short, we argue that divergence among Eurozone countries before the financial crisis manifested itself in the emergence of two different growth trajectories – one trajectory '(private) debt-led', the other one 'export-led'. The structural ramifications arising from these two growth trajectories were hardly visible by inspecting typical macroeconomic indicators until the debt-led trajectory turned unsustainable with the unfolding of the financial crisis of 2007-2008. While the crisis has made obvious even to casual observers that European countries are diverging from a macroeconomic point of view, we argue that patterns of sectoral specialization already established before the advent of the crisis play a major role in the unfolding of imbalances within the Eurozone.

2.1 Main macroeconomic trends

The polarization process in Europe has hardly been visible before the outbreak of the financial crisis in terms of commonly used macroeconomic indicators; instead, interest rates, unemployment and GDP growth were all developing in a similar way in both core as well as periphery (Figure 1, Panels a, b, c). Before the crisis, only the increase in current account imbalances (Figure 1, Panel d) had directly indicated divergence between core and periphery countries: while the population-weighted average of the current account in the core rose from about 0.3% in 2000 to more than +6.5% of GDP in 2007, the weighted average of current account deficits in the periphery nearly doubled from -3.2% at the start of the Euro project to -6.3% before the financial crisis. Many economists and policy-makers interpreted these imbalances as a positive side-effect of an on-going convergence process triggered by the Euro (e.g.

Blanchard and Giavazzi, 2002; Giavazzi and Spaventa, 2010). While the risks of growing macroeconomic imbalances were largely neglected before the crisis,[3] the literature on the European debt crisis has pointed out that the macroeconomic management of correcting these imbalances after the outbreak of the financial crisis has faced severe problems: while the loss of monetary sovereignty is widely acknowledged as a source of fragility enabling speculative attacks on the sovereign bond markets against single Eurozone countries (e.g. De Grauwe 2012) and as a major institutional constraint on engineering an adequate monetary policy response to the crisis (e.g. Baldwin *et al.* 2015), the regulations of the EU's fiscal framework have played an essential role in restricting fiscal policy space that could have been used to accelerate the recovery from the Eurozone crisis (e.g. Koo 2015; Heimberger and Kapeller 2017).

In this context, an introductory note on the definitions of country groups in the Eurozone should prove useful: In Figure 1 as well as throughout the paper, our distinction between core and periphery follows the recent literature (e.g. Simonazzi *et al.*, 2013; Baldwin *et al.*, 2015; Storm and Naastepad, 2015C; Iversen *et al.,* 2016; Johnston and Regan, 2016). Core countries include: Austria, Belgium, Finland, Luxembourg, Germany, and Netherlands; and periphery countries include: Greece, Ireland, Italy, Portugal, and Spain. Notably, our definitions of core and periphery countries include all Eurozone members, which joined during the first two years with the exception of France. The reason for excluding France is that this country remains on the edge, i.e. it is difficult to classify France as either core or periphery (Gräbner *et al.* 2018).[4]

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[3] Some economists and institutions, however, already had concerns about the technological divergences among the Eurozone countries before the European debt crisis of 2010. For example, the ECB (2008, p. 66) explicitly noticed differences in technological specialization of the EMU countries before the debt crisis.

[4] In the appendix we reproduce all the relevant figures with France included.
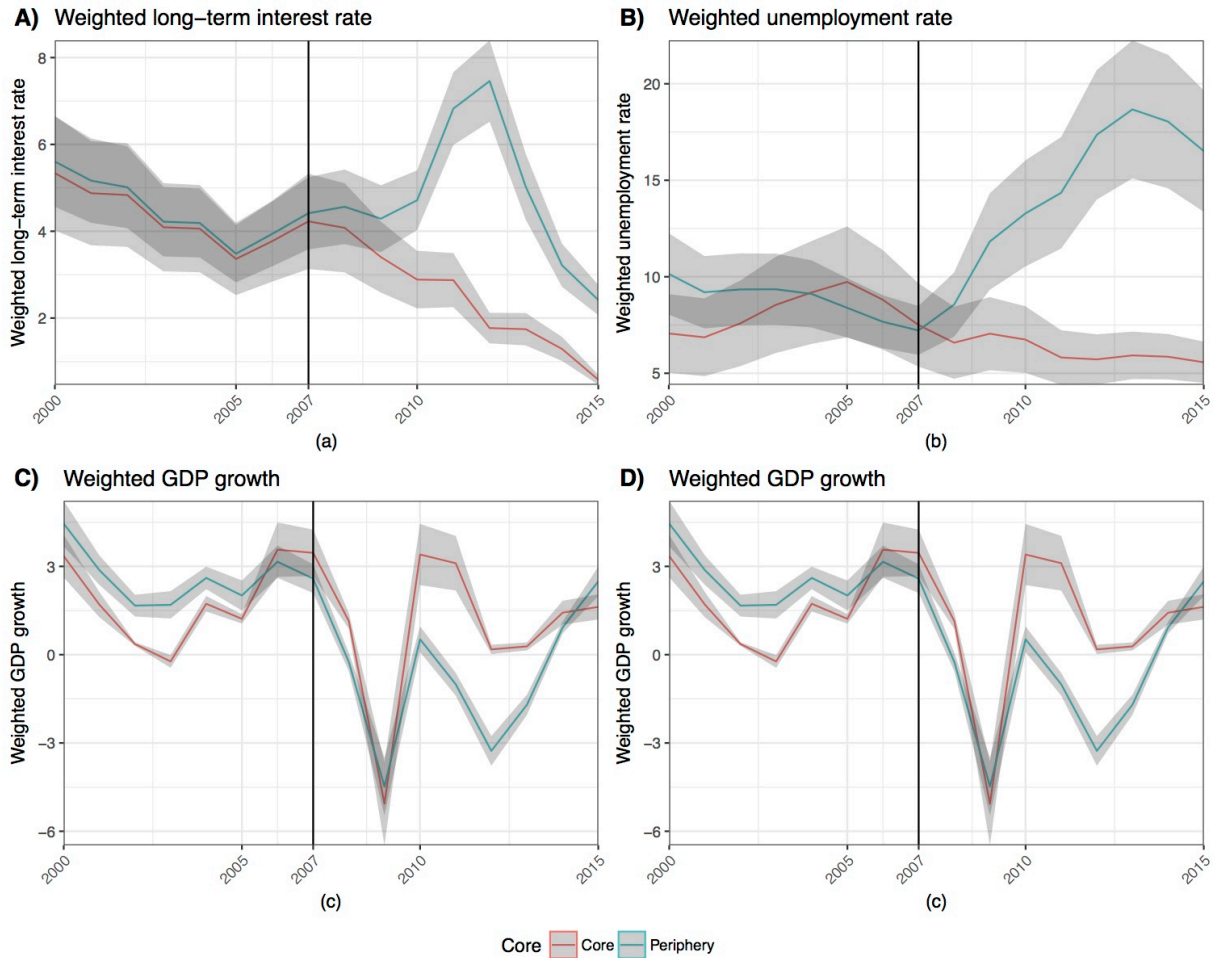
Fig. 1. *The hidden polarization in the Eurozone.*

*The plots show the population-weighted means with the area +/- 1 standard deviation around the weighted mean being shaded. Source: AMECO (for the economic indicators) and UN (for the population size); authors' own calculation. Core countries: Austria, Belgium, Finland, Luxembourg, Germany, Netherlands. Periphery countries: Greece, Ireland, Italy, Portugal, Spain.

Against the background of the macroeconomic developments in the Eurozone, we proceed with the generally accepted stylized fact that inequality has been increasing in most Western countries, including the EU's member countries (Atkinson *et al.* 2011). An increase in inequality leads to a decrease in effective demand, which weakens the economic outlook (Stockhammer, 2015). To what extent such a weakening impact on economic development depends on whether the other components of aggregate demand (as shown in equation (1)) increase correspondingly to compensate for the decline in consumption spending induced by increasing inequality.

$$Y^D=C+I+G+X-M \qquad (1)$$

For instance, one obvious possibility is that an increase in private investment *I* compensates for the decline in consumption spending *C*. While theoretically possible, such a scenario is not very plausible given that since the Euro's inception capital accumulation in the private sector has not been particularly strong within Eurozone countries, and private investment has fallen strongly since the start of the crisis with the most pronounced impact found in Southern Europe (e.g. Koo 2015; ECB 2016; Glötzl and Rezai 2017). Hence, in what follows we focus on alternative possibilities to compensate for the decrease in aggregate demand induced by increasing inequality aside from the channel of private investment.

First, the government could increase fiscal spending *G* to stabilize aggregate demand by compensating the decrease in private spending. However, in much of contemporary Europe the Stability and Growth Pact restricts expansionary fiscal policies. Hence, the pre-crisis roots in the Eurozone's countries can hardly be found in expansionary fiscal policies (e.g. Lane, 2012; Boyer, 2012) as prominently argued by some authors and policy-makers (e.g. Schäuble (2011). Most importantly, the claim that excessive fiscal deficit and government debt have led to the crisis is inconsistent with the empirical data, which show that the costs of the crisis (related to bailing-out the banking system, decreases in tax revenues and increases in unemployment-related spending) have created severe sovereign debt problems and not vice versa (e.g. Shambaugh, 2012; Baldwin *et al.*, 2015).

Second, aggregate demand for domestic goods might nonetheless increase if firms manage to increase their exports *X* relative to current imports *M* to substitute domestic demand with foreign demand, leading to net capital outflows as one side-effect (Hobza and Zeugner, 2014). Germany is the archetypical example for a country with an increasing export share and net

foreign wealth (Simonazzi *et al.*, 2013; Baccaro and Benassi, 2017), but the Netherlands or Austria also fall into this category. Because their current account is positive, these countries are called 'surplus countries' and, at least within the currency region, they are also creditor countries.

A third possibility is that the implied decrease in disposable income is compensated by an increase in the willingness of the private sector to incur debt in order to stabilize consumption spending *C* in the face of rising income inequality (Barba and Pivetti, 2009; Gu and Huang, 2014). If such a demand for credit is accommodated by a corresponding credit supply, this may temporarily mask the (potential) reduction in demand that would result from the drop in disposable income. However, it also comes at the price of increasing private sector debt and higher financial fragility (Kapeller and Schütz 2014). Examples for countries on this trajectory are Portugal, Spain or Greece (e.g. Drudy and Collins, 2011; Ruiz *et al.*, 2016; Heimberger and Kapeller, 2017).

Table 1. *A summary of potential reactions to a decrease in effective demand.*

Mechanisms compensating for decreasing demand	Expansionary fiscal policy	Substitution of domestic with foreign demand	Stabilizing demand via debt-let private sector expansion
Requirements	Creditors (could be central bank)	Competitive advantage, foreign import demand, capital outflows	Sufficiently de-regulated financial markets, capital inflows
Main Actor	Government	Firms	Households
Affected component of aggregate demand	Government spending (G)	Net exports (X-M)	Consumption (C)
Side effects	Increasing indebtedness of the national government	Net lending, currency re-valuation (not applicable in the Euro area)	Increasing indebtedness of private households
Examples in the EU	Legal institutions in the EU restrict this strategy.	Germany, Austria, Netherlands	Spain, Italy, Portugal
Implications for current account	Negative	Positive	Negative

Developmental paths throughout the EU have been shaped by these mechanisms to different degrees, with export-based expansion prevailing in some countries and private debt-led compensation in others (Stockhammer and Wildauer 2016; Storm and Naastepad, 2016). As indicated by Figure 2, this constellation of growth trajectories led to large current account imbalances and a division into *surplus* countries and *deficit* countries in pre-crisis times (e.g. Giavazzi and Spaventa, 2010). However, while current account deficits were mostly financed by capital flows from core countries to the periphery via intra-European financial linkages (Hobza and Zeugner, 2014; Storm and Naastepad, 2015C), the periphery countries' growing trade deficits were actually not primarily accumulated vis-à-vis-Eurozone countries but vis-à-vis the rest of the world (Chen *et al.*, 2013).

While European countries had already started to drift apart well before the financial crisis, the crisis has impacted the viability of debt-led private sector expansions. The political reaction of imposing fiscal austerity from 2010 onwards has reduced aggregate demand further, especially in Southern Europe, which led countries such as Spain, Portugal or Greece into a debt-deflationary cycle due to deficient demand. Their governments lack viable instruments to counteract the vicious cycle of increasing debt, low growth and high unemployment (Heimberger and Kapeller, 2017).

So far, we have articulated the main macroeconomic trends underlying polarization in the Eurozone, but remained silent on the question of why some countries got on the path of debt-led compensation, while others produced an export-based expansion. In order to identify possible reasons for this divergence and to better explain its unfolding in the pre-crisis period, we next focus on analysing the underlying polarization process on the micro and meso level.
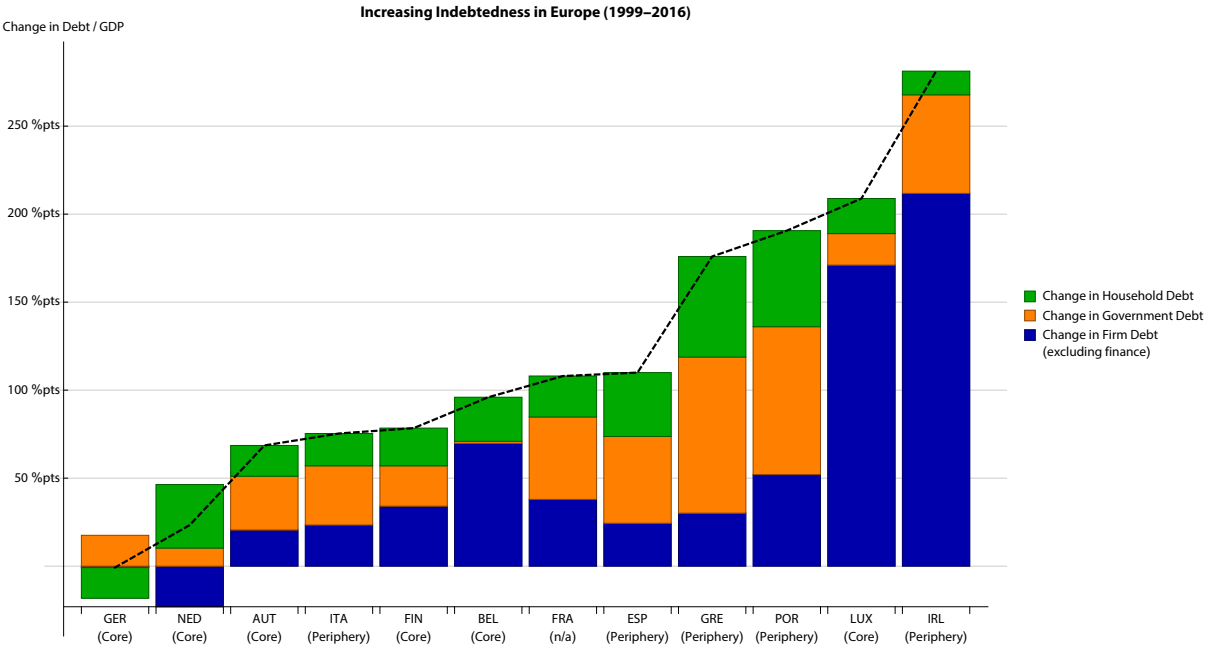
Fig. 2. *Change in debt relative to initial GDP between 1999 and 2016. Source: OECD, data set 'FIN_IND_FBS', retrieved July 2017; author's own calculation.*

2.2 Debt-driven growth and export-led growth

The EU has witnessed a liberalization period with deep structural changes in the financial sector, which allowed for increasing credit supply that contributed to the emergence of debt-driven growth trajectory in a number of countries. Financial deregulation allowed financial institutions already present in one member country to open affiliates in other member countries, leading to a significant increase in the size of the financial sector, going along with a rise in the supply of credit (Chmelar, 2013). Financial sector integration also facilitated the cross-border movement of capital, implying that sectors with above-average rates of return experienced a steep rise in capital inflows. During the pre-crisis period, some industrial sectors in the Southern European periphery experienced rates of return exceeding those in the core countries (e.g. the Spanish construction sector). As capital became available to these sectors, it spurred economic expansion driven by foreign credit (Haldane 2011; Baldwin *et al.*, 2015; Storm and Naastepad 2016). In the periphery these capital flows and financial interlinkages between core and periphery countries contributed to debt-led booms and corresponding asset-bubbles (Chen *et al.*, 2013; Hobza and Zeugner, 2014). Low real interest rates in the Southern periphery were also a consequence of the monetary union. Having a common interest rate set by the ECB meant that countries with above average inflation rates (mostly the countries of the Southern periphery) nonetheless experienced declines in real interest rates (Baldwin *et al.*, 2015; Storm and Naastepad, 2015C) and corresponding inducements to increase private sector debt. Similarly, low real interest rates on mortgages stimulated real estate booms, most notably in Ireland and Spain (Storm and Naastepad 2016).

In contrast to the debt-led growth model followed by periphery countries in the pre-crisis period, the export-led model builds on compensating losses in aggregate demand by increasing exports instead of expanding private credit. However, such an increase in net exports can hardly be realized by all European countries at the same time as increases in net exports in some countries

require corresponding increases in net imports elsewhere. Hence, as long as the rest of the world does not fall into a frenzy of buying European goods, expectations of an overall export-based growth pattern for Europe are misguided. In what follows, our contribution to the existing literature is to show that countries populated by firms lacking in international competitiveness in producing complex products will find it more difficult to mitigate inadequate domestic demand by generating additional revenues from exports (see Table 1). We therefore hypothesize that these firm characteristics have contributed to the emergence of debt-driven and export-led growth models in the Eurozone.

What determines competitiveness of firms in the first place? The macroeconomic literature mostly focuses on the role of (unit) labour costs for explaining competitiveness (e.g. Stockhammer, 2011; Gabrisch and Staehr, 2014), while others emphasize the importance of regulatory issues (Kapeller *et al.* 2016) and natural endowments (Dicken, 2014), especially in a global context. The focus on labour remuneration is somehow surprising, since it has been shown that changes in unit labour costs have a negligible impact on gross output prices for internationally marketed goods (Storm and Naastepad 2015B).

On the sectoral and firm level, technological capabilities and innovativeness are generally found to be more important than differences in factor costs (Dosi *et al.* 2015, echoing Kaldor 1978), especially in sectors characterized by higher degrees of technical sophistication (e.g. Carlin *et al.* 2001; Storm and Naastepad, 2015B). In these circumstances, relative unit labour costs only play a minor role in determining *current* export performance in comparison to technological capabilities. The role of low unit labour costs is rather to attract foreign investment and, hence, to facilitate technological upgrading.

In sum, the competitiveness of a country's population of firms is determined by its relative technological capabilities rather than by its relative unit labour cost (Dosi *et al.* 1990; Dosi *et al.* 2015). This result is largely supported by evidence for the countries that joined the Eurozone in the first two years since its inception:[5] Germany's export success, for instance, is not primarily a consequence of relatively low wages; instead, it is due to superior 'non-price competitiveness' by German firms in some sectors, while the Eurozone's periphery countries have stayed behind in terms of their technological capabilities (Simonazzi *et al.*, 2013; Storm and Naastepad, 2015A, 2015C). The role played by wage restraint for developed countries is important in a different way: it has been crucial in terms of keeping consumption demand and thereby import demand in check. Thus, low wage growth has indeed contributed to Germany's 'current account success', but without providing much of a boost to exports (Simonazzi *et al.*, 2013; Storm and Naastepad, 2015B).[6]

3. Dimensions of structural polarization in the Eurozone

We now turn to the empirical dimensions of divergence between core and periphery. We empirically illustrate the role of private-debt dynamics (section 3.1), then turn to an analysis of production and export structures in the Eurozone (section 3.2), and, finally, investigate the relationship between technological capabilities and changes in sectoral industry structures (section 3.3).

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[5] This present argument applies to technologically more advanced economies such as the countries considered in the present article. The extent to which wage restraints are important for developing countries in order to attract foreign investments and the resulting spill-over effects might be different and is not the subject of this paper.
[6] Our emphasis on the technological priority for determining international competitiveness may not be appropriate for a more heterogeneous country sample than the Eurozone, in particular if developing countries are taken into account.

3.1 Diverging trends in private debt

Since the introduction of the Euro, the observable increase in debt has been shared unequally across Europe. Considering the development of debt held by the real sector, i.e. excluding the financial sector, we see that from 1999 until 2016 several countries (Ireland, Luxemburg, Portugal and Greece) saw their non-financial sector debt rise to more than 170% of GDP, whereas Germany more or less managed to keep its level of debt at the 1999 level (see Figure 2). Moreover, despite the heavy emphasis in the public discourse on the rise in government debt as the alleged root of the crisis, it was instead private sector debt of households and non-financial firms that contributed substantially to the rise in debt in nearly all Eurozone countries. Additionally, while the major part of the increase in government debt occurred post-crisis (due to financial sector bailouts, unemployment benefits, tax losses and fiscal stimulus programs), the rise in household debt materialized before the crisis (Figure 3).

Figure 3 shows that, beside the fact that the levels of household debt peaked around the crisis, the rise in household debt was much more pronounced in the periphery compared to the core and was concentrated in the pre-crisis phase, while non-financial corporate debt does not show the same pattern, but rather increases constantly across time (in both core and periphery).
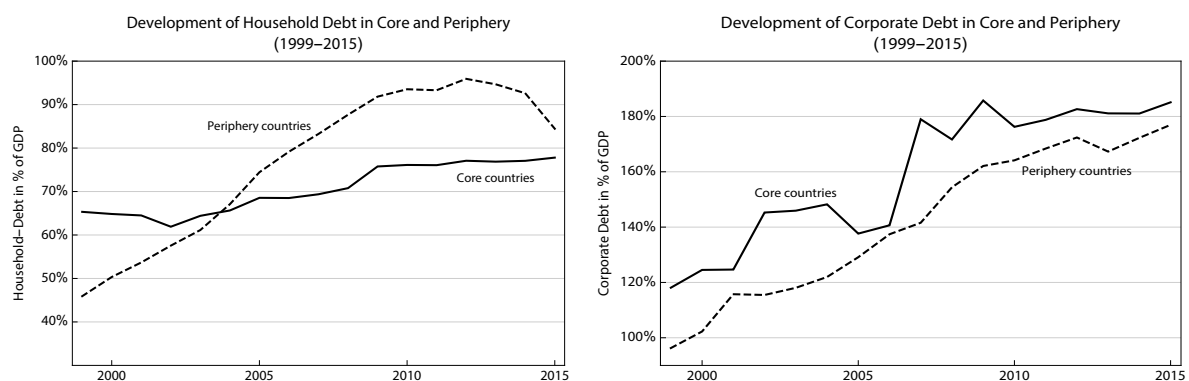
Fig. 3. *Average evolution of household-debt as a percentage of GDP among core and periphery countries. Source: OECD, data set 'FIN_IND_FBS', retrieved July 2017; authors' calculations. Core countries: Austria, Belgium, Finland, Luxembourg, Germany, Netherlands. Periphery countries: Greece, Ireland, Italy, Portugal, Spain.*

While periphery countries initially started out with significantly lower levels of household debt, they surpassed core country levels in 2005; the periphery never surpassed the core in terms of corporate debt. In this view, household indebtedness emerges as a prime indicator for detecting unsustainable debt-based growth models, which marked pre-crisis developments in the Eurozone. With household debt at historically high levels and a financial sector unwilling to lend during crisis-times, the sharp decline in private demand was a next to inevitable consequence in the periphery during the post-crisis period (Koo, 2015). In conjunction with the limitations of fiscal policy scope due to the EU's fiscal regulatory framework, the policy options for avoiding deep recessions and economic stagnation in the periphery were essentially blocked.

3.2 Divergence of product diversification and trade flows with the rest of the world

In this section, we show that there are two main channels of polarization in terms of production and export structures: one related to the destination of exports, the other to the kind of products being exported.

3.2.1 Polarization in terms of export markets

In our next step we ask whether and to what extent polarization is also visible in trade data. Figure 4 is based on bilateral trade flows of Germany, Ireland, Italy, Portugal, Greece and Spain from 1999 to 2016. The data depicted in Figure 4 clearly indicate a polarization process between Germany and the periphery countries (excluding Ireland).[7] Several points are worth highlighting. First, the periphery countries' trade balances were already on a path of deterioration well before the outbreak of the crisis, mainly due to rising imports (e.g. Chen *et al.*, 2013). Second, the periphery countries' trade balances improved from 2007 to 2016, but this development is to a large extent due to the slump in imports, caused by fiscal consolidation and deflationary wage

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[7] Note that the line for the periphery countries in Figure 4 excludes Ireland, as Ireland's model of attracting large multinationals by introducing low corporate taxes comes with a spike in exports that should be contrasted with a corresponding rise in income attained by foreign firms and individuals. However, this latter task cannot be performed with the data at hand.

policies after the crisis (e.g. Stockhammer and Sotiropoulos, 2014). Third, Germany's trade surplus was already increasing before the start of the crisis; the increase was mainly achieved vis-à-vis the rest of the world (and not the Eurozone). In fact, Germany's trade balance vis-à-vis the Eurozone has declined by more than 2 percentage points since reaching a high in 2007 and has recorded values close to zero since 2012. At the same time, however, Germany's trade balance vis-à-vis the rest of the world has continued to grow since the start of the crisis, standing at 7.8% of GDP in 2016. Hence, an important part of Germany's growth story seems to be that over the last 20 years, German firms have managed to diversify their export markets, thereby recording strong export growth in regions outside of the Eurozone. At the same time, the periphery countries have clearly not managed to do the same: their trade balance with the rest of the world has improved since the start of the financial crisis, but in 2016 it was still in deficit.
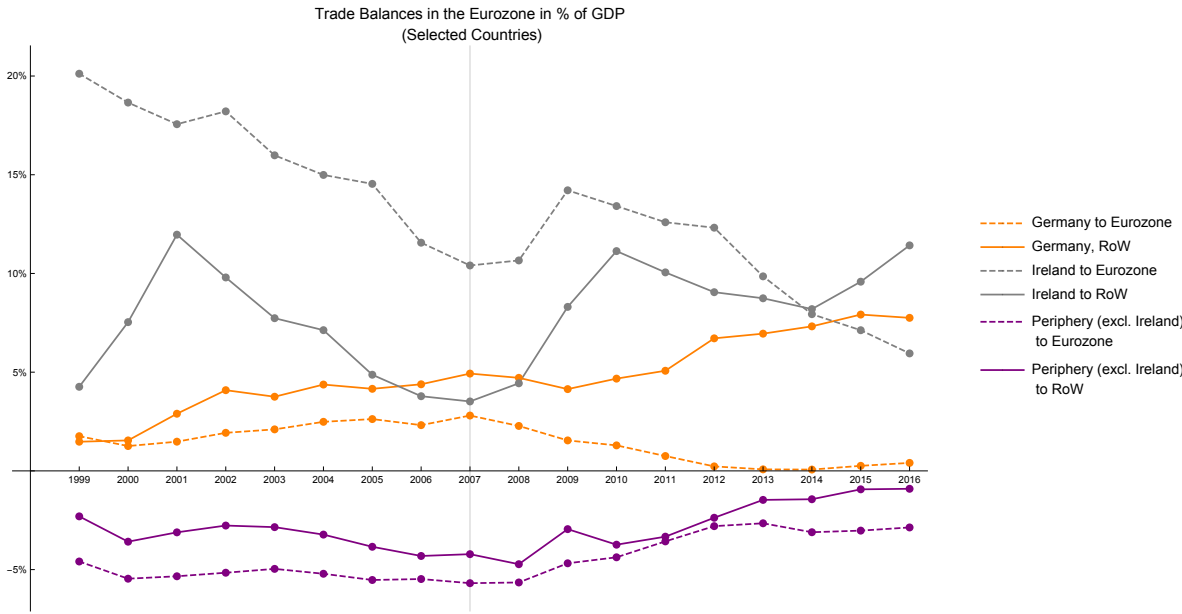

Figure 4. *The evolution of trade balances in Germany and in the periphery of the Eurozone (in % of GDP). Source: Direction of trade (IMF), World Economic Outlook (IMF); own calculations; ROW: Rest of the world. Data includes only goods and no services. Periphery countries (excluding Ireland): Greece, Italy, Portugal, Spain.*

3.2.2 Polarization in terms of exported products

The previous section has highlighted that while the periphery countries' trade balance had already started to deteriorate well before the financial crisis, German firms have managed to diversify their export destinations over the last 20 years: a significant share of German trade relationships are with emerging, fast-growing economies, particularly in Asia. But we do not only observe polarization with respect to export destinations, but also a persistent difference with regard to the kinds of products exported by core and periphery countries. This is important because "what a country exports matters" (Hausmann *et al.,* 2007, p. 1). More specifically, quantitative measures such as indices of economic complexity (Hidalgo *et al.*, 2007, Hidalgo and Hausmann, 2009, Tacchella *et al.*, 2012) suggest that countries that are able to produce and export more complex products generally enjoy a favourable development in terms of rising incomes (Hidalgo *et al.*, 2007, Hidalgo and Hausmann, 2009, Cristelli *et al.*, 2015). Figure 5 is based on import and export data for the period 2000-2015; it illustrates that the capabilities to produce complex products is distributed very unequally among European countries, a persistent fact that we suggest to be a major root of the polarization patterns we observe at the macro level. In an accompanying appendix, we provide detailed explanations on how the economic complexity data used in sections 3.2 and 3.3 of this paper are constructed; we also discuss the advantages and potential shortcomings of using this data to proxy technological capabilities.

If the path to macroeconomic success in times of increased economic openness in Europe heavily relies on the production of very complex products, while the capabilities to produce such products are distributed unevenly, not all countries will manage to take this path. To make this argument more precise, we compare the export baskets of various countries and measure the diversity of producers associated with goods of a given degree of complexity by means of a Gini index. We observe that the export capacities for products with very low and very high complexity are distributed rather unevenly among the countries, whereas the export of products of medium

complexity is more equally distributed. This finding implies that while virtually all Eurozone countries export products of medium complexity– represented by a low Gini index for products with a product complexity index (PCI) between -1.5 and 0.5 –, the export of very simple products (PCI below -1.5) and very complex products (PCI above 1.0) is more concentrated. Given that such inequality cannot be observed with regard to imported products as demand for complex products is distributed much more evenly than their supply, technological distinction should typically materialize in export success and an increase in international competitiveness. Specifically, this asymmetry not only explains why high degrees of technological capabilities come with competitive advantage (fewer competitors, but constant demand), but also allows to align volatile macroeconomic trends with persistent differences in technological capabilities: the emergence of some form of economic polarization comes as no surprise in an economic regime that relies on fostering international competitiveness when one main source of competitiveness (technological capabilities) is distributed so unequally.
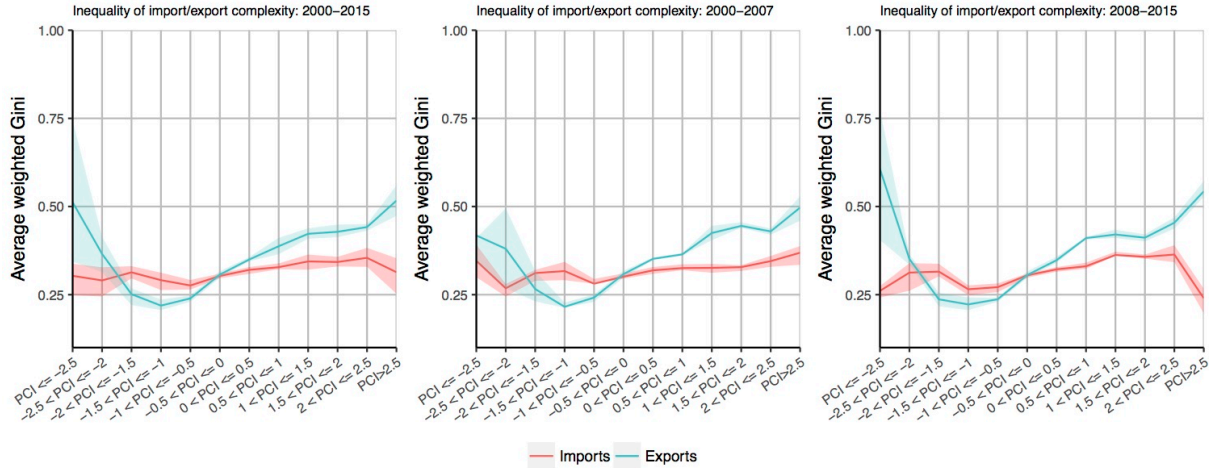
Fig. 5. *Inequality in terms of the complexity of the products exported and imported by the Euro countries between 2000 and 2015. Inequality is measured by the Gini index, which has been weighted by the total exports of the countries. The shaded area indicates the 25 and 75 percentile of the yearly Ginis. Source: Simoes and Hidalgo (2011) in its 07-2017 version; authors' own calculation. For details on the advantages and shortcomings on using the economic complexity data see the accompanying appendix.*

In order to gain a more nuanced view of these persistent level differences we now look at the differences between countries more explicitly. On the y-axis in Panel a) of Figure 6, we plot the difference between actual exports of products with complexity greater than some product

complexity threshold (specified on the x-axis) and the hypothetical share of exports that would prevail if the capability to produce all products would be distributed evenly across countries. The lines for the Eurozone countries illustrate their respective deviation of actual from expected exports for different thresholds of product complexity; the mathematical derivation of the deviations plotted on the y-axis of Figure 6 as well as general information about the distribution of products with regard to their complexity can be found in the supplementary appendix.
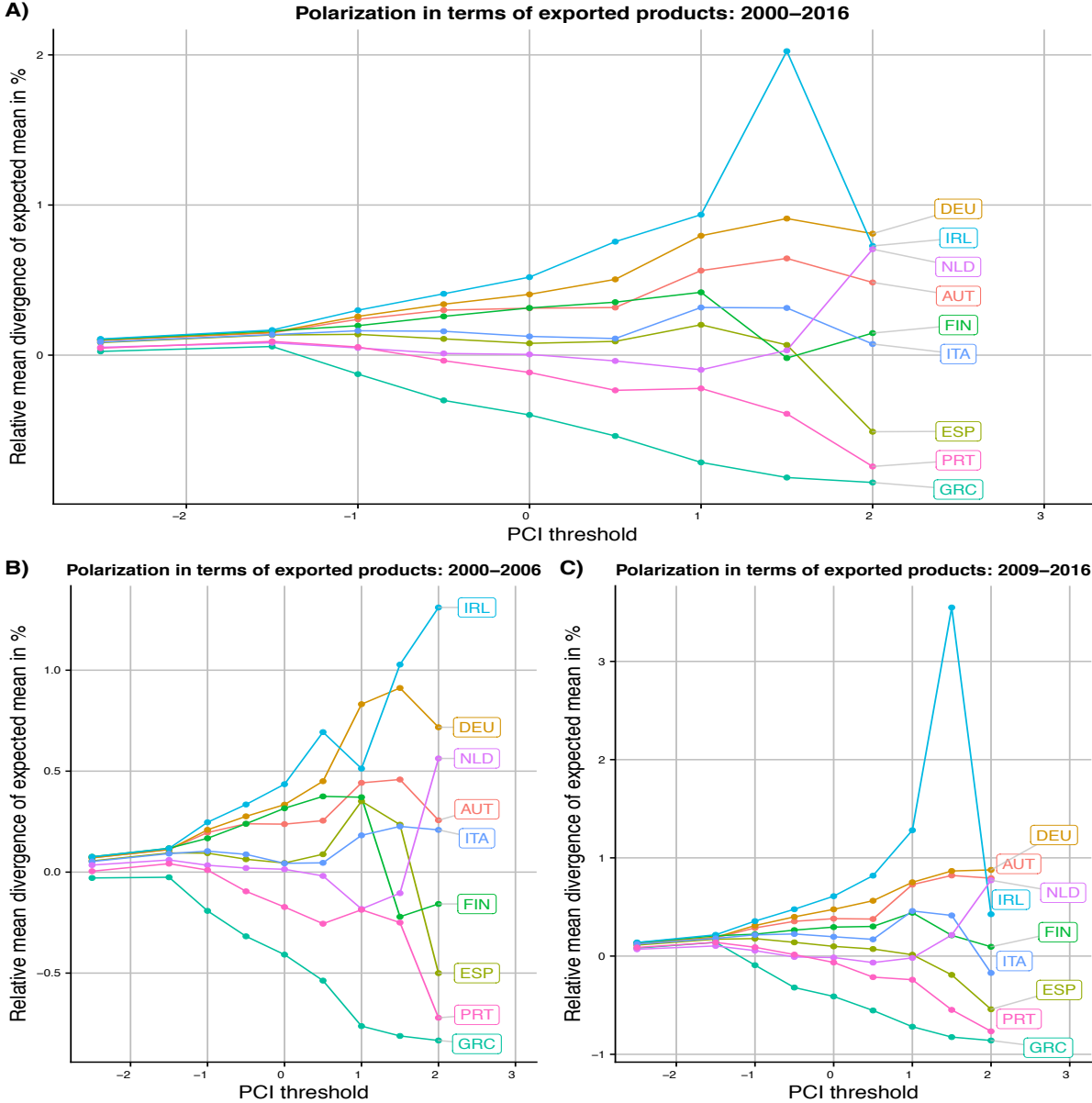
Fig. 6. *Deviations from the export volume of countries with a product complexity index (PCI) of various thresholds (on the x-axis) that would be expected based on the total export share of the countries. Source: Simoes and Hidalgo (2011) in its 07-2017 version; authors' own calculation. More details on the derivations are available in the appendix.*

Several observations can be drawn from Figure 6. First, in addition to the difference in the *amount* of goods exported – in the period 2000-2015 about 9.1% of total exports in the world came from Germany, only 1.8% from Spain –, there is an important difference with regard to the *kind* of products exported. For instance, during this period the share of German exports for products with a complexity index above 1 was much larger than 9.1%. With regard to more complex products, Germany's exports were about 80% higher than expected based on the share of Germany in total world exports, while for Spain they are just 20% higher than expected.[8] Second, Figure 6 provides clear evidence for a polarization in terms of exported products: while the periphery countries increasingly move into negative territory as the PCI threshold increases – which implies that there is a negative deviation of actual exports from expected exports –, the inverse does hold for the core countries. This positive deviation of core countries provides further evidence that the core is much more successful than the periphery in exporting complex products. Third, Ireland is the only country that has managed to challenge the dominance of Germany in the category of the most complex products. This point becomes evident in the increasing deviation of Ireland's actual exports from expected exports for higher PCI thresholds. Overall, the main driver of export growth in Ireland has been the pharmaceutical sector (Barry and Bergin 2012). The technological upgrading of the Irish economy is due to the creation of a business cluster specialized on complex information telecommunication products, the Irish "Silicon Docks" (Brazys and Regan 2017, Regan and Brazys 2018), which was made possible due to state-led enterprise policy aimed at establishing links with the tech industry in the Silicon Valley, low corporate taxes and the migration inflow of highly skilled labour from other European countries (Brazys and Regan 2017, Regan and Brazys 2018). Finally we observe that the financial crisis has not had a large impact on these relationships: panels b) and c) of Figure 6 indicate that the polarization of exported products has proven very persistent in the pre-crisis (2000-2006) and post-crisis period (2009-2016).

The observation that a persistent gap on the level of production structures causes a growing polarization on the macro structure is consistent with the evidence discussed by Hidalgo and Hausmann (2009), who conclude that "countries tend to approach the level of income associated with the capability set available in them" (p. 10570). In total, these developments illustrate the

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[8] When considering only EU trade, about 38.9% of total exports in the period 2000-2015 in the EU came from Germany and only 7.9% from Spain, with the German export for products with a complexity greater one was about 30% higher than expected base on the share of Germany in total EU exports, while we observe the opposite pattern for Spain

persistent level differences in the manufacturing structure across European countries, with Germany dominating as a highly diversified export economy. As indicated by our empirical analysis, structural polarization is rooted in an unequal distribution of technological capabilities that manifests in striking core-periphery patterns in terms of the product complexity of exported products.

3.3 Technological capabilities and structural change

To further investigate the issue of polarization in industrial structures and its path dependent nature, we study the structural change of industrial sectors in the Eurozone's economies since the introduction of the Euro. We use a measure for the directedness of structural change proposed by Gräbner *et al.* (2018), which is based on assessing the average complexity of all changes in a countries' export baskets on a sectoral level.

The intuition behind this approach is to measure how the directedness of technological change in the Eurozone's economies has evolved over time. In particular, we calculate the weighted average complexity associated with the decline and growth of individual sectors over two time windows: first, the 'pre-crisis directedness measure' looks at structural changes from the pre-Eurozone (1995-1999) to the pre-financial-crisis period (2003-2007); second, the 'post-crisis directedness measure' captures structural changes from the pre-financial-crisis period (2003-2007) to the post-crisis period (2010-2014). The measure indicates for a given Eurozone country whether export values improve more markedly for more complex products (in which case the value of the directedness measure is positive) or for less complex products (in which case its value is negative; more information on the derivation and estimation of the variable is available in the appendix).

The upper panel in Figure 7 plots the directedness of technological change against the initial economic complexity position of the respective Eurozone country for the two time-spans introduced above. Thereby, the arrows indicate the relative shift in position from the pre- to the post-crisis period. Several observations can be made from the upper panel in Figure 7: first, it

shows that periphery countries typically occupy lower ranks in terms of complexity as compared to core countries, but show greater variation in terms of their technological directedness. These observations hold for both phases. Second, we find a general and inverse relationship between a country's starting position in terms of complexity ranks and the directedness of technological development. This result aligns well with the classic Kaldorian claim that success breeds success (Kaldor 1980), which suggests that countries with a more favorable starting point in terms of technological capabilities gain further structural advantages over time, while relative laggards tend lose even more technological ground. Finally, the arrows indicate that the major commonality between periphery-countries lies in their structural development since the onset of the crisis as their position has deteriorated in terms of both their complexity ranks as well as their technological outlook. The core countries, in contrast, show more heterogeneity in their behavior after the financial crisis and exhibit quite different development paths. To better illustrate this aspect, the lower panel of Figure 7 shows the changes in position for all countries anchored in a common vantage point; in doing so, we can identify more clearly the homogenous development of periphery countries, which have witnessed both declines in complexity ranks as well as in their technological outlook. Consequently, the periphery countries are the only, and lonely, inhabitants of the lower left quadrant, where not a single core country can be found.
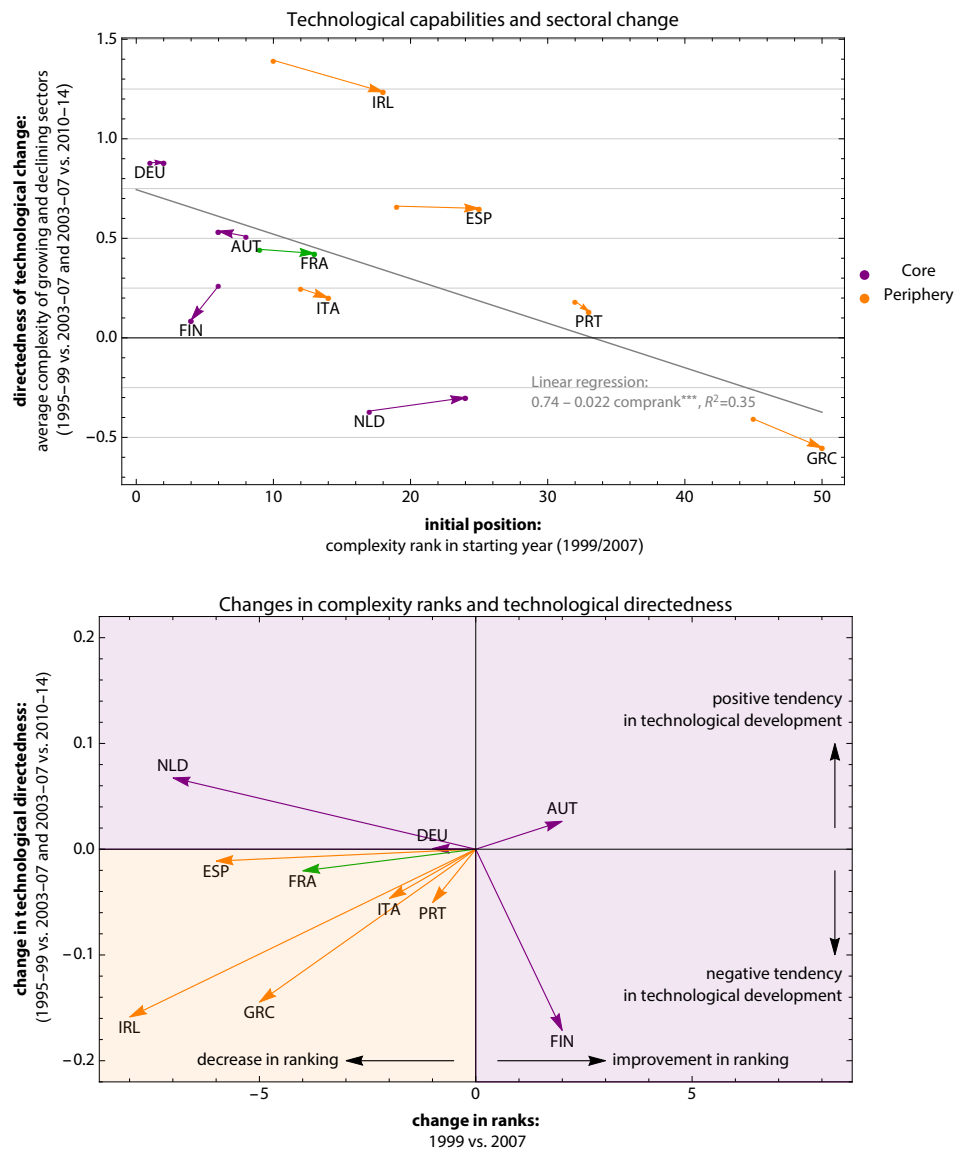
Fig. 7. Technological capabilities and structural change. Data: Eurostat; Simoes and Hidalgo (2011); own calculations. The calculation of the directedness of technological change variable on the y-axis is based on our own calculations of changes in average complexity derived from changes in export-composition. For details, see the text as well as the accompanying appendix.

As already indicated, the results in Figure 7 point to considerable heterogeneity among the core countries: while some are struggling to hold on to their initial position, Germany has clearly sustained its technologically dominant role, which led to an increasing distance towards the periphery countries. Hence, technological divergence is clearly visible if one considers that all of the Southern periphery countries have lost ground relative to their pre-crisis position. This observation also holds for the special case of Ireland, which was affected by the crisis in a similar

way as the remaining periphery countries (see lower panel in Figure 7), but of course enjoys a favourable general trend due to its specific development model discussed in the preceding section (Regan and Brazys 2018).

Considering the central role of technological capabilities for the assessment of future economic developments (Hidalgo and Hausman 2009; Cristelli *et al.* 2015), our results suggest that one cannot expect a natural convergence process to materialize in the Eurozone. The problem is that the emergence of a structural competitive advantage in terms of technological capabilities (e.g. in Germany's case) rests on increasing returns to production, which itself have their roots in – *inter alia* – geographic specialization (Fujita *et al.* 1999), the presence of business communities and social ties among entrepreneurs and managers (Banerjee and Munshi 2004), and trust and innovation clusters (Elsner *et al.* 2015). All the mentioned factors have been at the heart of the classical arguments on circular cumulative causation and backwash effects (Myrdal 1958), and cumulative causation and export-led growth (Kaldor 1970; Thirlwall 1980; Boggio and Barbieri 2017). Our empirical findings based on Figure 7 clearly point to the presence of such path dependent, Kaldorian developments. Hence, the current trajectory very likely represents a 'lock-in' in terms of industrial specialization and, thus, economic development, which cannot be broken without coordinated policy intervention.

4. Conclusions

We have introduced a framework that sheds light on the mechanisms underlying the polarization in the Eurozone by integrating micro and macroeconomic perspectives into a coherent view. In doing so we have shown how macroeconomic divergence between core and periphery countries is driven by the co-existence of two different growth trajectories (export-led vs. demand-driven models), which themselves can be traced back to a 'structural polarization' in terms productive capabilities and technological sophistication. The emergence of export-driven growth in the core

and debt-driven growth in the periphery is linked to the micro level of technological capabilities and firm performance. By examining this relation empirically, our findings also carry implications for future analysis, e.g. by pointing to the exceptional character of the Irish development or by documenting that the privileged position in terms of income and prosperity currently enjoyed by core countries might not be stable in the future as some core countries might have difficulties in reproducing their superior technological capacities.

A number of important policy implications follow from our findings. First, as long as core and periphery countries remain mired in structural polarization and follow two different growth trajectories, macroeconomic divergence in the Eurozone will continue. Second, a set of active policy interventions is required to change the underlying export-led and debt-driven growth patterns. Against the background of our framework, such policies should *simultaneously* address (i) the lack of financial regulation through macro-prudential policies, (ii) the divergence of production structures and export regimes through European industrial policies, and (iii) the increasing inequality in European economies through a macroeconomic policy program based on public investment and redistribution.

With regard to the financial sector, our framework suggests the promotion of macro-prudential regulation based on limiting the diversity of financial instruments and the introduction of a corresponding financial transaction tax to constrain speculation and promote real investments. Regarding the issue of financial stability (e.g. Fischer 2014), we suggest improving the international cooperation of national supervisors, ensuring an interdisciplinary approach to financial supervision and increasing the regulation of insufficiently regulated financial institutions (e.g. investment funds).

To overcome polarization in terms of production structures in Europe requires an active industrial policy that aims at fostering a catching-up process in terms of innovative activity and technological capabilities for firms in the European periphery (Mazzucato, 2013; Bahar *et al.,* 2014; Cimoli and Dosi 2017; Noman and Stiglitz 2017). These policies must pose incentives, so that technological capabilities diffuse more freely from the European core to the periphery. In addition, they must entail investments into knowledge policies that support technological, organizational and institutional innovations in the periphery. Such policies could, for example, subsidize entrepreneurs, which are the players that help an economy to discover its cost and opportunity space (Hausmann and Rodrik 2003). Since this discovery process leads directly to public knowledge and production techniques that can be imitated by others, entrepreneurial activity in the face of true uncertainty represents a social learning process that should be facilitated by government policies. Finally, macroprudential regulation of the financial sectors and industrial policies should be accompanied by public investment and redistribution policies (Noman and Stiglitz 2017) to counteract the rise in income inequality, which is the main root of deficient demand in Europa that underlies current processes of economic polarization.

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