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On the evolution of comparative advantage: path-dependent versus path-defying changes

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Abstract

The diversification of production and trade is widely considered to be a fundamental policy goal, particularly of developing economies with export baskets that are heavily concentrated in a few products. In what direction trade diversification ought to take place is subject to intense debate. The Product Space (PS) framework (Hausmann and Klinger, 2007; Hidalgo et al., 2007) is a recent contribution in the economic literature that has proved very influential in policy circles. It argues that the endowment of production capabilities (technologies, production factors, institutions, etc.) determines what countries produce today, but also restricts what they can produce in the future, as it is uncommon that countries develop a comparative advantage in goods that do not draw from the same pool of capabilities (unrelated products). Contributions along such lines argue that defying the initial comparative advantage can be a risky policy decision with high probability of failure. The main objective of this contribution is to use a novel methodology to investigate whether the patterns of diversification of a sample of 177 countries over the period 1995-2015 conform or not to the prediction of the PS framework. We find evidence of a high degree of path dependence but our analysis suggests also that a significant number of new products that entered countries' export baskets were unrelated to the initial productive specialization (path-defying changes). We shed light on the determinants of these 'radical' patterns of diversification and show they are associated with higher economic growth. The results of this study have important policy implications in particular for the design of industrial policies aimed at actively shaping countries' structural transformation.

Keywords: path dependence, product space, trade diversification, industrial policy

JEL Code: F1, O1, O3

Introduction

Governments around the globe are understandably preoccupied with 'what' their countries produce and export. Understanding how comparative advantage evolves over time is crucial for singling out its determinants and to subsequently inform effective policy measures. Accordingly, renewed interest in industrial policies has reignited the debate on the role of government in shaping specialization and driving structural transformation in specific directions.

New 'intellectual tools' to ground industrial policies (as well as to highlight their likely limits) have been provided by the Product Space (PS) framework, which was developed in the seminal works by economists and physicists (Hausmann and Klinger, 2007; Hidalgo et al., 2007). These authors apply network analysis to international trade data and assert that the evolution of export baskets is strongly characterized by path dependence. According to this framework, economies can be represented as sets of productive capabilities (technologies, factor endowments, institutions, etc.) that are combined in different ways to produce different products.[1] Countries progressively diversify the structure of their exports towards new products that reflect the country's current capabilities, and consequently the country's current production structure; relatedness between a country's current and its potential new products rests on a common set of productive capabilities. By contrast, the emergence of unrelated products in the export basket, i.e. of products that require productive capabilities that differ from those already being used in the current production of goods, is more unlikely as it occurs less frequently. This framework posits that acquiring a comparative advantage in radically different products—path-defying diversification—is a rare occurrence.

One important policy implication we can draw from these contributions is that policies that try to engineer diversification towards 'related goods' are more likely to succeed because countries already have a 'latent comparative advantage' in those products. The economic intuition behind such a 'smart specialization' strategy is straightforward: products that are closely related in the PS require a similar set of production capabilities. If an economy has a comparative advantage in a given product, then it is relatively simple for that economy—possibly with a little help from the government—to develop a comparative advantage in products that build on the same set of

[1] Differently from previous studies, the PS employs an 'agnostic' approach to the sources of comparative advantage and relies on the following intuition: if we observe—based on international trade data—that two products are produced and exported in tandem (i.e. the products are 'related'), then it is very likely that they use a similar/common set of production factors. By contrast, products that are rarely co-exported (unrelated products) are unlikely to be produced using a similar set of production capabilities. This outcome-based measure of comparative advantage has the advantage of abstracting from the exact identification of these productive capabilities (i.e. the true source of comparative advantage).

capabilities. By contrast, industrial policies aimed at promoting unrelated products are likely to lead to policy failure because 'large jumps' in the PS (which we refer to as 'path-defying' diversification in this study) require capabilities that are scarce and difficult to create. The PS analysis suggests that policymakers should follow a step-by-step approach, targeting products for which countries may have a latent comparative advantage ('small jumps in the PS') and therefore discourages as overoptimistic policy initiatives that defy their comparative advantage.

Despite the fact that these ideas have been widely disseminated in policy circles and that several countries have started applying lessons from PS analysis in the design of their policies, there is to the best of our knowledge no rigorous empirical test to date that determines whether countries' pattern of specialization follows such predictions.

We build on the novel methodology developed by Coniglio et al. (2018) to analyse whether the actual patterns of diversification were guided by the notion of relatedness as developed by the PS framework.[2] Using disaggregated international trade data, we specifically address the following research questions:

(i) Has the diversification of countries' export baskets followed a path-dependent pattern over the last 20 years?;

(ii) Under what circumstances can countries diversify towards areas of the Product Space that are unrelated with the initial production basket (radical changes)?;

(iii) Do countries that have successfully diversified to unrelated products have better economic performance?

Our contribution sheds light on the policy-relevant features that are associated with a country's ability to defy its initial comparative advantage and to specialize in new products that are unrelated with its current export basket.

In fact, new products that enter countries' export baskets and defy the hypothesis of path dependence are probably the most interesting from a policy perspective. Path-defying changes often require—and at the same time generate—breakthroughs that are the result of a new approach to combining knowledge and capabilities. Such changes have a strong potential to

[2] Coniglio et al. (2018) develop a 'dart-board' approach that allows thorough testing of the degree of path dependence in the development of countries'/regions' export baskets over time. The authors apply their non-parametric analysis to investigate the development of the export basket of Italian provinces (NUTS 3 classification) before (2002-2006) and during the global crisis (2007-2011). Their study reveals that despite the overall development of the provinces' export basket indicating a significant degree of path dependence—as predicted by the PS framework—more radical changes that defy the initial comparative advantage do in fact occur frequently.

influence the development of new technological trajectories and developments (see Dosi, 1982 or in the context of regional innovation, Castaldi et al., 2015).

The current debate has largely shifted from *whether* governments should influence the type of products/exports (i.e. their countries' current comparative advantage) to *which* types of goods/services their industrial policies should target[3]. The PS is increasingly being used as a 'map' to inform the direction of active policies, but its 'automatic' application might lead to undesirable outcomes. In several cases, countries successfully defeated their static comparative advantages. Notable examples include the rise of the aircraft industry in Brazil and the automotive and electronics industries in the Republic of Korea (Lin and Chang, 2009). These 'new product entries' are at odd with the PS framework and care should therefore be taken to avoid drawing narrow policy prescriptions from these important contributions.

In the first part of our analysis, we build counterfactual country-specific distributions of relatedness between new products that enter export baskets with a Revealed Comparative Advantage (RCA) *à la* Balassa larger than 1, and those products exported with an RCA larger than 1 five years earlier. Using non-parametric techniques, we test the hypothesis that these new products are unconstrained by the degree of their proximity, as measured by the PS. Our result of this general test rejects this hypothesis, thus confirming a significant influence of the capabilities accumulated in a country during its structural transformation. Two important results emerge from this general pattern. First, 'only' half of the new products can be considered statistically path-dependent.[4] This finding suggests that unrelated changes are far from rare. Secondly, we find a very large degree of cross-country heterogeneity in the degree of path dependence. While some countries experienced a process of diversification that was strongly constrained by the 'capabilities' available in the previous five years (*constrained diversification*), others were able to diversify away from their initial comparative advantage (*unconstrained diversification*).

In the second part of our analysis, we shed light on the determinants of these differences across countries. We find evidence that path dependence is less marked in advanced and larger economies with a high trade diversification in unrelated product variety. By contrast, countries with a large natural resource sector are less likely to diversify away from their current comparative advantage, suggesting another important dimension of the 'resource curse'. We

[3] See, for instance, Naudé, W. A. (2010).

[4] Coniglio et al. (2018) find a stronger degree of path dependence, approximately 70 per cent of new products, when looking at sub-national (NUTS 3) Italian data. The difference is likely to be due to the more limited set of production capabilities available on a small geographical scale, which implies a lower ability to make larger jumps over the production space.

show that better business and institutional environments are associated with a higher share of path-defying new entries. In other words, it is easier for countries with better institutions to diversify away from their current comparative advantage. In this respect, our results seem to suggest that an arm's length approach to certain policy dimensions—such as the direct intervention of governments in the credit market—is more likely to bear fruit in relatively wealthy countries where, as argued by Stiglitz (2002), market failures dominate government failures.

Finally, our results indicate that countries with a higher share of new products that are unrelated to their previous production basket—i.e. those countries showing a pattern of 'unconstrained diversification'—perform better that those that have a stronger degree of path dependence. According to our preferred estimates, a 10 per cent increase in the share of path-defying changes increases the average annual per capita GDP growth by 0.8 per cent in the subsequent 5-year period, which is a sizable contribution to a country's well-being.

Our paper is related to the recent contribution of Bahar et al. (2017), which examines how the emergence of new export specializations (extensive margin of trade) and the growth of export values (intensive margin of trade) are affected by relatedness with countries' pre-existing export baskets. They show that the probability of exporting a new product and demonstrating a clear competitive advantage in the ensuing decade increases between 80 per cent and 140 per cent when the new product's relatedness with the pre-existing export basket—measured, as in our paper, *à la* Hausmann and Klinger (2006)—is one standard deviation above the mean. Bahar et al. (2017) shed new light on the mechanisms behind the agnostic concept of relatedness developed within this framework. Using data from 144 countries over the period 1984-2014, they find that the emergence of new products is primarily driven by the use of related technological capabilities and by the existence of downstream industries (backward linkages).

While their paper contributes insights on the determinants of dynamic comparative advantages to the literature by exploring alternative measures of relatedness—from the general and agnostic measure of Hausmann and Klinger (2007) to measures related to specific demand and supply channels—we, in turn, analyse path dependence in the development of comparative advantage, its main determinants and its growth potential. Our methodology can be applied to an alternative definition of relatedness than that proposed Bahar et al.[5]

[5]The study of Bahar et al. (2017) has the merit of being the first to explore the black box of the concept of relatedness proposed in the literature. In fact, Hidalgo et al. (2007) use an agnostic measure that rests on the theoretical notion that if the same countries co-export any two products, there is a high probability that they are using a 'related' set of (undefined) production capabilities (technologies, factor endowments, institutions, etc.). Bahar et al. (2017) introduce

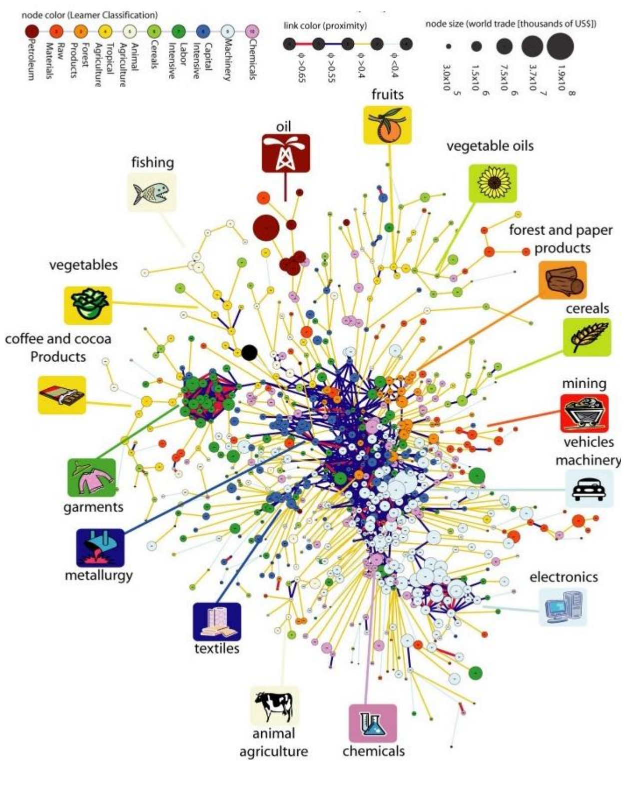
Our study is also closely related to a recent study of Pinheiro et al. (2018), which addresses the development of comparative advantage of 93 countries between 1970 and 2010. They find that the larger the share of 'unrelated' new product entries, the better the country's economic performance. To measure relatedness between the existing export basket and new entries, Pinheiro et al. use a novel concept of relative density: a new product is labelled 'related' if its proximity with the current export basket is higher than the average proximity of all those goods that can potentially be produced (option set). They find that unrelated activities are 'rare' (only 7.2 per cent of new products). One drawback of this approach—which our methodology aims to correct—is the inability to identify spurious (un)relatedness in the absence of a statistical counterfactual. We believe that our empirical approach is sounder in this respect.

This paper is organized as follows. In *Section 2*, we review contributions that focus on the determinants of trade diversification as well as selected studies related to the Product Space framework. We describe the data and methodology used to test our hypothesis of path dependence in *Section 3*. In *Section 4*, we perform an econometric analysis to study the main determinants of path dependence and to shed light on those country-level characteristics—including policy-relevant variables—that affect the ability to introduce new path-defying products in the export basket. The final step of our analysis is presented in *Section 5*, where we investigate the nexus between the share of path-defying changes and economic growth. *Section 6* concludes.

five specific measures of relatedness to assess the relative importance of different channels (technological relatedness, labour force relatedness, linkages with suppliers and with costumers). One important limitation of this approach is the way these specific relatedness measures are built. While generic measures of relatedness are built using world trade data, these specific measures were built using US data due to data limitations, with the underlying assumption that the US data can be applied to other countries as well. The potential bias in the measurement is likely to be significant as the sample includes many developing and emerging economies. For instance, 'labour relatedness' is measured on the basis of the US Current Population Survey regarding the "fraction of separating workers from each industry *i* that move to firms in each industry *j*". The assumption that this pattern of labour mobility applies to other countries is fairly strong. Similarly, backward and forward linkages and technological relatedness are also based on US input-output tables, R&D and patent citation data.

Box 1 The Product Space: a graphical representation

The Product Space (PS) was first presented in Hausmann and Klinger (2007) and Hidalgo et al. (2007) as a network of relatedness between 774 globally produced and exported products. The Product Space is effectively represented using a map (illustrated in the figure below) of global production in which each node represents a product and connections between nodes represent the degree of relatedness or proximity between them. Relatedness is measured as the conditional probability that any two goods (*i*, *j*) are co-exported by the countries that participate in global trade (*). The authors assert that the goods entering a country's export basket are highly connected with the set of products that were previously exported. The development of countries' comparative advantage can be represented in the PS as gradual 'jumps' from one node (product already in the export baskets) to the closest ones (products in which countries have a latent comparative advantage), as these products share the use of similar production capabilities.



In addition, Hidalgo et al. (2007) argue that where a country's export basket is 'located' in the Product Space matters for economic growth.

As new industries develop from existing ones, countries that produce goods that are more closely connected are more likely to develop more sophisticated goods. By contrast, countries specialized in goods that are located in the periphery of the Product Space are more likely to be trapped in development 'dead corners' and have more difficulty kick-starting new, more complex and sophisticated industries.

(*) The relatedness or distance in the PS between any two goods i and j is computed as the minimum of the pair-wise conditional probability of being co-exported with a revealed comparative advantage (RCA ≥1) applying the following formula $\varphi_{i,j} = \min\left\{P\left(x_i \mid x_j\right), P\left(x_j \mid x_i\right)\right\}$

2 On the development of comparative advantage: a selective literature review

This study on the development of comparative advantage contributes to the literature on export diversification. While studies on diversification generally focus on the determinants of ‘new entries’, we are interested in the relationship between ‘old’ and ‘new entries’ (i.e. the direction of trade diversification).

Several studies have emphasized the importance of trade diversification as a strategy for hedging against the risks of overspecialization (di Giovanni and Levchenko, 2009), for knowledge spillovers (Hausmann et al., 2007) and as an engine of structural change and economic growth (Agosin 2009; Cadot et al 2013; Gozgor and Can 2017). In particular, the nexus between trade diversification and growth has been the subject of scrutiny by several studies. One of the most comprehensive and rigorous analysis has been conducted by Mau (2016), who finds robust support to the hypothesis that trade diversification causes an increase in GDP per capita. The author also finds weak evidence of the reverse causality but GDP growth has more limited effects on trade diversification and, in addition, the effect takes time to emerge.

In what follows we firstly review some studies on the main determinants of trade diversification and then we discuss the evidence on path dependence in the inclusion of new products in export baskets.

2.1 What determines trade diversification?

2.1.1 Income per capita

Several studies have investigated the relationship between trade diversification and economic development proxied by income per capita. In the seminal theoretical paper by Hausmann and Rodrik (2003), economic development is compared to a ‘cost discovery’ process where entrepreneurs develop new products or processes by means of risky and uncertain investment activities. Grossman and Helpman (1993) show that economic growth is associated with an increase in diversification through innovation and the development of new products. While most theoretical contributions suggest a positive association between the degree of diversification and economic development, empirical studies report contradicting results.

Imbs and Wacziarg (2003) and Cadot et al. (2011) find evidence of an 'inverted U' relationship, with trade diversification increasing to a given level of development and subsequently declining.[6] According to the authors, when countries develop, market failures that limit the 'cost discovery' process are gradually mitigated and this leads to higher diversification *via* an expansion of the extensive margin of trade (number of goods and services produced and exported). As countries develop, a gradual dynamic process of elimination of less profitable varieties and specialization in goods and services that have a stronger comparative advantage leads to a lower degree of export diversification (re-specialization through growth at the intensive margin).

More recent evidence casts doubt on this conclusion. Using highly disaggregated trade data for 110 countries over the period 1998-2009, Mau (2016) finds evidence of a robust and positive correlation between income per capita and trade diversification, and rejects the hypothesis of an inverse U-shaped relationship. Using dynamic panel estimates, Mau shows that causality between income per capita and trade diversification runs both ways, but that the effect of trade diversification on countries' growth performance is stronger than the reverse effect.

De Benedictis et al. (2009) use relative rather than absolute measures of trade diversification to reject the hypothesis of re-specialization as GDP per capita reaches a certain threshold. This result is further supported by Parteka and Tamberi (2013) who also examine the potential endogeneity of GDP per capita and confirm a positive (but rather slow) effect of development on trade diversification.

2.1.2 Country size, human capital and geography

Population size and the quality of human capital are channels through which a country can add new products to its production and export basket (Hausmann et al., 2007; Parteka and Tamberi, 2013). Using data from a large panel of countries for the period 1962-2000, Agosin et al. (2012) find evidence of a positive effect of human capital accumulation on export diversification. They show that countries with a better endowment of human capital are more successful in expanding their trade baskets when a positive terms-of-trade shock occurs. This result suggests that a better endowment of human capital allows countries to respond more quickly and effectively to opportunities for diversification.

[6] Klinger and Lederman (2004) find evidence of a reduced pace of trade diversification for higher levels of income per capita. As argued by Mau (2016), this finding could be explained by the fact that new products might become indistinguishable from old ones using standard trade data classifications.

A recent study of Jetter and Ramirez-Hassan (2015)[7] concludes that the two most important predictors of export diversification among 36 possible determinants, including political, macroeconomic, cultural and geographical factors, are net enrolment in primary education and natural resource rents over GDP, with positive and negative effects, respectively. Secondary and tertiary education are found to be less relevant compared to primary education. This result suggests that in the medium to long term, an education pyramid with a large base is what matters most for promoting a well-diversified economy.

Geography may also play a role, as it affects the fixed as well as the variable costs of exporting a new product or service and, in turn, the number of export varieties.[8] Agosin et al. (2012) and Parteka and Tamberi (2013) find that distance from global markets—measured using proxies of remoteness or distance from key world markets—reduces the degree of trade diversification. Also, Basile et al. (2017), using a spatial dynamic model, show that proximity to large countries has a positive effect on trade diversification.

2.1.3 Trade policy and other policy or institutional determinants of trade diversification

Access to foreign markets is key to attaining a comparative advantage in new products and services. International trade costs are determined both by geography and economic policies; technological advancements in the transport sector have increasingly pushed the balance towards a greater relevance of artificial (policy-driven) barriers to trade. Mau (2016) finds evidence of an important impact of the dismantling of trade barriers on the degree of diversification, in particular in developing countries. Dennis and Sheperd (2011) identify a robust and positive effect of trade facilitation—i.e. the set of policy measures that reduce barriers to international trade, such as transaction and bureaucratic costs—on export diversification. They use Wold Bank data on export costs—the total official costs associated with the shipping of a standardized container—and on market entry costs[9]—the costs of starting a business—as measures of trade facilitation (Doing Business database). Using data on a large cross-section of countries in the period 1991-2003, Feenstra and Ma (2014) show that a 10 per cent bilateral improvement of their port efficiency measure—an important channel of trade

[7]Jetter and Ramirez-Hassan (2015) use a Bayesian Model Averaging approach, which averages all the possible combinations of 36 covariates (that is 2^{36} possible model combinations) to infer which of them are consistently good predictors of the dependent variable. This methodology allows to overcome the drawback of model uncertainty, which is widespread in the literature. The authors perform their analysis using a cross-section of 105 countries over the period 2000-2010.

[8]The theoretical mechanisms are well-captured by Melitz (2003) and later literature on heterogeneous firms in international trade with exporting activities incurring fixed entry costs as well as variable costs. In this class of models, trade costs—such as geographical barriers or trade policies—affect both the intensive and extensive margins of trade.

[9] Market entry costs are measured using a composite and standardized index which considers a wide variety of costs such as those related to administrative procedures, the transportation of goods to relevant sea ports, customs clearance and procedures, etc.

facilitation—has a sizable positive impact on export diversity (ranging between +1.5 per cent to +2.4 per cent according to model specifications).

In the last two decades, the proliferation of Regional and Preferential Trade Agreements (RTAs/PTAs) has been a driving force in the reduction of trade barriers. The findings on the role these agreements play in boosting the extensive margin of trade are not conclusive. Cook and Jones (2015) find evidence of a positive effect of the African Growth and Opportunity Act (AGOA)[10] on the diversity of exports from eligible sub-Saharan African countries to the US market while Dutt et al. (2013) using 6-digit bilateral trade data, estimate that WTO membership has increased the extensive margin of exports by up to 25 per cent. Contrary to the above-cited studies, Dingemans and Ross (2012) find no evidence that FTAs have promoted export diversification in Latin America. The authors argue that these important international trade infrastructures do not automatically have an influence on what countries produce and export. In this respect, they cite the emblematic case of Chile, where most diversification occurred in the 1970s-80s, before the surge of FTAs Chile signed. Similar evidence is provided by Buono and Lalanne (2011) for French firms trading in agricultural products, demonstrating that the implementation of the Uruguay Round Agreement actually had a negative impact on the extensive margin (and a positive one on the intensive margin) of trade.

Using country-level data, Helpman et al. (2008) show that ‘common approaches’ to gravity models used to assess FTAs’ effects on trade are significantly biased when omitting control for the extensive margin of trade. They find that when trade costs related to distance fall, the response of the extensive margin of trade is larger for less developed countries.

The study of Parteka and Tamberi (2013), using a panel of 60 countries in the period 1985-2004, finds that lower barriers to trade and RTAs have a positive effect on diversification.

Interestingly, type of political regime seems to play a role in shaping both the export diversification and sophistication of the export basket. Using data from a large panel of 116 countries over the period 1970-2005, Makhlouf et al. (2015) find evidence of an heterogeneous effect of trade openness on export specialization (the other side of the coin of diversification) and sophistication (proxied by the EXPY measure first introduced in Hausmann et al., 2007).

[10] The AGOA is a PTA, which started in 2000 and provides preferential treatment to a wide range of products exported from a large pool of eligible African countries. Two provisions were designed. One is the AGOA Generalized System of Preferences, which extends the list of products that benefit from duty-free and quota-free access to the US market. The second is the AGOA apparel provision targeting apparel and textile products.

They furthermore show that trade openness only enhances both trade diversification and sophistication in democratic regimes while the opposite is found for autocracies. These results shed important light on the importance of institutional settings in shaping the effects of global interactions.

2.2 New export discoveries and path dependence

The development of 'new export products' depends on the existing export basket because new products can only originate from a re-combination of the current set of production capabilities. Current production capabilities are the key link between what a country produces today and what it will produce tomorrow, in other words, they are the essence of the mechanism of path dependence, which this study aims to investigate.

In recent years, an increasing number of studies based on the PS framework have investigated the existence of path dependence in the process of structural transformation. As in the original contribution by Hidalgo et al. (2007), these studies generally use trade specialization—measured by revealed comparative advantage—as a proxy of production specialization to analyse its development across the PS over time.

Hausmann and Klinger (2010) and Hidalgo (2012) demonstrate that the export baskets of Ecuador and of a pool of African countries (Kenya, Mozambique, Rwanda, Tanzania and Zambia) mostly consist of peripheral products[11], and highlight a relatively strong persistence of these countries' position across the PS over time.

Some studies have focused on the nexus between centrality in the PS and trade diversification. Minondo (2011) in a study on a set of 91 countries shows that the average connectedness of countries' export baskets (i.e. the degree of centrality in the PS) is a strong predictor of diversification levels. In a related study, Boschma and Capone (2016) analyse the process of trade diversification for the EU-27 and European Neighbourhood Policy (ENP) countries between 1995 and 2010. They find evidence of path dependence, with countries developing their revealed comparative advantage in products related to those in which they were already specialized. Bahar et al. (2017) determine that the probability of a product to enter a country's export basket increases by 140 per cent (from 1.9 per cent to 4.6 per cent) if its relatedness to the export basket of ten years earlier is one standard deviation above the mean value. They use the 'density' measure developed by Hidalgo et al. (2007) as main proxy for relatedness in their

[11] One regularity that emerges from the network analysis of trade data is the fact that while industrialized countries are primarily specialized in the production of 'central goods,' i.e. goods with higher average connections to others and higher sophistication, most of the export baskets of low income countries are located in the 'periphery' of the Product Space.

parametric analysis, which is computed as the average proximity (relatedness) of a new potential product to a country's current production basket. A positive and significant effect of these product-specific proxies of relatedness on the probability of a product entering a country's export basket is evidence of path dependence.

Despite their proposition of strong links between what is produced today and what will be produced tomorrow, these studies cannot be considered formal tests of the PS hypothesis of path dependence as they cannot discriminate between relatedness due to shared production capabilities (as the framework suggests) and spurious relatedness, which is the result of a random (unconstrained) process of diversification.

Our methodology allows us to test whether new products that enter a country's export basket are significantly related to those previously exported with a revealed comparative advantage. We can therefore measure to what extent the development of comparative advantage is path-dependent and, in turn, shed light on the characteristics that are significantly associated with big leaps or jumps across the PS (i.e. path-defying changes).

3 The pattern of structural change: path dependence versus path-defying changes

According to the PS framework, countries develop new products by following a path-dependent process, driven by the set of capabilities available in an economy. Thus, economies export goods with a revealed comparative advantage because they already possess sets of production capabilities that can be easily redeployed from 'related' production processes. Such relatedness between each set of products is proxied by the minimum of the pair-wise conditional probability of being co-exported. Relatedness represents a sort of inverse measure of distance on the PS.

Products that enter a country's export basket[12] should be those that share the most capabilities with—and therefore have the highest relatedness to—the previously exported goods and services. Following Coniglio et al. (2018), we test the validity of the path dependency hypothesis by observing whether the actual distribution of the relatedness of new products significantly differs from a randomly generated process (counterfactual distribution of relatedness).

[12] When referring to export basket, we mean the set of products exported with a revealed comparative advantage (Balassa, 1965) higher than unity.

3.1 Methodology

3.1.1 The general test of path dependence

The first step of our analysis requires us to define 'new entries' as those goods that are not part of the production basket at time t_0 (*option set*) and enter the country's export basket at time t_1. We recur to the standard definition of revealed comparative advantage (RCA) and define the set of goods in the export basket as those with a Balassa index larger than 1. Relevant new entries are represented by products with an RCA lower than 0.5 at time *t* and higher than unity at *t* + *T*.[13] For each country $c \in C$ and each time interval, we identify the set of new entries $n \in N_{c,t,t+T}$.

In the second step, we compute an *M x M* matrix containing the relatedness measures between any pair of goods *ij* exported in the world ($i, j \in M_t$ where *M* is the set of goods exported in each year *t*).[14] For each country in the world *c* and for each year, we denote x_{ict} as 1 if country *c* has an RCA in the production of good *i* at time *t*, and 0 otherwise:

$$x_{ict} = \begin{cases} 1 \text{ if } RCA_{ict} > 1 \\ 0 \text{ otherwise} \end{cases} \quad (1)$$

where RCA_{ict} is the standard Balassa index (1965) employed as a measure of export specialization. Thus, after creating the country-product matrixes of *RCAs* following Hausmann and Klinger (2007), we compute the proximity (or inverse distances) between each set of goods *i* and *j* as the minimum of the pair-wise conditional probability of being co-exported:

$$\varphi_{i,j} = \min\left\{P\left(x_i \mid x_j\right), P\left(x_j \mid x_i\right)\right\} \quad (2)$$

where $\varphi_{i,j}$ represents the proximity between any good *i* and *j*.

[13]Since this choice of *RCA* thresholds is inevitably arbitrary, we identify a new entry using two additional alternative thresholds for robustness. We use a less restrictive threshold ($RCA_t < 1$ and $RCA_{t+T} \geq 1$) and a more restrictive one ($RCA_t < 0.2$ and $RCA_{t+T} \geq 1$). For the time span, we use *T = 5* years. For robustness, time intervals *T=10* years is taken into consideration.

[14] We obtain a 1,241-by-1,241 matrix of products that are exported in the world economy in the period 1995 to 2010.

In the third step, we denote the set of goods being exported with $B_{c,t}$ with an *RCA* by country *c* at time *t* (pre-existing export basket). We then define $D_{c,t}$ an *M x C* matrix of relatedness between the new N_c products (entering the export basket between *t* and *t+ T*) and the pre-existing export basket for each country $c \in C$, as follows:

$$D_{ic} = \begin{cases} d_{ic}\left(\varphi_{ij}\right) = \max\left(\varphi_{ij}\right) \text{ when } j \in B_{ct},\ i \in N_c \\ \text{no value} \qquad\qquad\qquad\qquad \text{if } j \notin B_{ct} \end{cases} \tag{3}$$

where $d_{ic}\left(\varphi_{ij}\right) = \max\left(\varphi_{ij}\right)$ captures the proximity of new good *i* at time *t + T* with the most related good already in the Product Space of country *c* at time *t*.[15]

Our formal test is based on the notion that if new entries follow a path-dependent process, we should observe that the distribution of relatedness of the observed new entries ($n \in N_{c,t,t+T}$) statistically differs from that obtained by randomly generated counterfactual entries and, more precisely, that actual data are significantly more concentrated than random data for high levels of proximity. The intuition behind this test is that in a world where capabilities did not exert a significant constraint on the development of new products, we should observe a greater degree of diversification towards unrelated products, that is, products with lower levels of proximity.

We build a counterfactual distribution of relatedness for each country *c* and each time interval (*t, t + T*) by using 1,000 random draws of size equal to the actual number of new entries ($N_{c,t,t+T}$) from the option set, i.e. products not exported with a comparative advantage at *t*. We then reject the null hypothesis when the pattern of relatedness of actual new entries is statistically different from the randomly generated counterfactual.

The last step of our analysis consists of comparing the distribution of actual data with that of our counterfactual. Following Duranton and Overman (2005) and Coniglio et al. (2018), we perform

[15]We employ two alternative measures for robustness: i) *average proximity*, a measure of relative distance of each new product with all pre-existing products; ii) *weighted average proximity*, the relative distance of each new product with all pre-existing products weighted by the relative export share of the latter set of goods. These alternative measures provide qualitatively similar results (available upon request), but as argued in Coniglio et al. (2018), our measure of maximum proximity is preferable as it is more in line with the theoretical idea of relatedness in the Product Space due to the sharing of a common set of capabilities between any two products *i,j*.

the analysis by implementing a kernel smoothed density estimation of new entries' relatedness[16]. More precisely, for any level of proximity *d*, we estimate the smoothed kernel density function of relatedness as:

$$\overline{K}(d) \equiv \frac{1}{\left(\sum_{i=1}^{M}\sum_{t=1995}^{2010} I_{it}\right)h} \sum_{i=1}^{M}\sum_{t=1995}^{2010} f\left(\frac{d-d_{it}}{h}\right) \text{for all countries } c \qquad (4)$$

with densities calculated non-parametrically using a Gaussian kernel function with a bandwidth *h* set according to Silverman's optimal rule of thumb (Silverman, 1986). $d_{i,t}$ is measured using Equation (3) while $\sum_{i=1}^{M}\sum_{t=1995}^{2010} I_{it}$ is the total number of 'new' products in the considered time interval. The kernel density functions are computed for each country *c*.[17]

Finally, we build a counterfactual distribution of relatedness and compare it with the actual one obtained from Equation (4). The counterfactual density function is based on simulated relatedness computed from 1,000 random draws of size identical to the actual one (i.e. $\sum_{i=1}^{M}\sum_{t=1995}^{2010} I_{it}$) for each country in our sample.[18]

Plotting the distributions with proximity as the variable on the horizontal axis ranging from 0 (highly unrelated) to 1 (highly related), we can imagine three possible scenarios emerging from the comparison of the two kernel distributions. First, if the kernel distribution of proximities of actual new entries lies to the right of the counterfactual, we can reject the null hypothesis of randomness for any level of proximity in the actual data (*full path dependence*). A second possible scenario is when the kernel distribution of proximities of actual new entries lies below the counterfactual. In this case, we cannot reject the null hypothesis of randomness, as the two distributions of relatedness cannot be statistically distinguished (*no path dependence* in the development of comparative advantage). These two extremes can be interpreted as symmetrically opposed cases where the export basket's development is either fully constrained

[16] A vector of distances for each of the three definitions of new entries is created to ensure the robustness of our results with reference to the definition of this key element. In this paper, for the sake of brevity, we only present the results for one definition of a new entry ($RCA_{t+T} < 0.5$ and $RCA_{t+T} \geq 1$).

[17] I_{it} is a product by year matrix of size *M x S* which has a value of 1 for each new product entry for each country, and 0 otherwise, *M* being the number of products in the PS, and *S* the number of periods included in the analysis (i.e. 16 time periods when T=5 and 11 time periods when T=10).

[18] In every simulation for each country, we randomly draw a number of new entries from the products that are not in the export basket at time *t* which is identical to the number of effective products. In other words, our counterfactual exercise takes explicit account of the country-time-specific distribution of new entries, even though the time dimension is then pooled in the kernel estimates since in most countries—and mainly in the most industrialized ones—the number of new entries per period is quite low and mines the reliability of the non-parametrical analysis. The country-time peculiarities are then investigated using the Monte Carlo methodology, which is presented later, and which allows us to use them in the parametrical analysis.

or fully unconstrained by the initial set of productive capabilities. A third (more likely) scenario is a mix between the two reported above, whereby the kernel of actual data is partly to the right of the counterfactual. In this scenario, we can only reject the null hypothesis of random relatedness for those new entries for which the first kernel lies above the counterfactual, i.e. only for relatively high level of proximities which cannot be the result of a random process. This scenario would give general support to the hypothesis of path dependence, but it would also tell us that long distance and random jumps can occur across the Product Space.

3.2 A single product's test of path dependence

In addition to the test described above, we introduce a test of random relatedness for each new product that enters a country's export basket in a given period. This strategy allows us to measure how much path dependence (or path-defying changes) we observe in the data for each country in our sample, by computing the share of statistically path-dependent new entries over total new entries in a given period.

Our counterfactual distribution of proximities is built using the Monte Carlo method as follows. For each country $c \in C$ and for each 5-year time interval, we randomly draw a number of products from the option set at time t equal to the actual number of new export entries at time $t+T$, Jc, compute proximities using Equation (3) and generate an average value per draw. The random draw is carried out 1,000 times to compute a distribution of random average proximities that represent our country-time-specific statistical counterfactual. From these counterfactual distributions of proximities, we identify the 95th percentile value, which represents our threshold for detecting statistically path-dependent new entries. In other words, a new product is labelled (non-) path-dependent when its proximity with the pre-existing export basket is (lower) higher than the (5th) 95th percentile of counterfactual average proximities.

3.2.1 Data

We carry out our analysis using 4-digit Harmonized System exports data for the period between 1995 and 2015 (CEPII BACI database). Such disaggregation allows us to establish a (year-specific) Product Space composed of approximately 1,240 goods exported globally for up to 221 countries.[19] Export data are used to compute all countries' revealed comparative advantages and to then obtain the year-specific matrixes of relatedness between each set of goods as well as to identify the new entries for each country in every moving time interval. Since the length of

[19] Hidalgo et al. (2007) compute a network of relatedness, i.e. the Product Space, using SICT-4 digit trade data for the time interval 1998-2000; their matrix of relatedness includes 775 products.

our time periods of analysis is 5 years—10 years for the robustness check—our *t* covers 1995 to 2010 while $t + T$ spans from 2000 to 2015.

3.2.2 Results

Figure 1 presents the (kernel) distribution of proximities between new entries at time $t + 5$ and the pre-existing export baskets at time *t* for all countries in our sample for two time intervals (1995-2000 and 2010-2015, the first and last in our analysis, respectively). Distance is defined as the maximum proximity (Equation 3) and a new export is identified as a new entry when the RCA at $t + T$ is lower than 0.5 and the RCA at $t + T$ is higher than unity. The comparison between the kernel of the actual data (in blue) and the kernel of randomly generated data (counterfactual) is a general test on the (null) hypothesis of the unconstrained development of comparative advantage against the hypothesis of path dependence.

We can reject the null hypothesis (of unconstrained diversification) for any level of relatedness (horizontal axis *d* ranging from 0 (max distance or min proximity) to 1 (min distance or max proximity), when the actual data's kernel lies above the upper limit of the 90 per cent confidence interval.

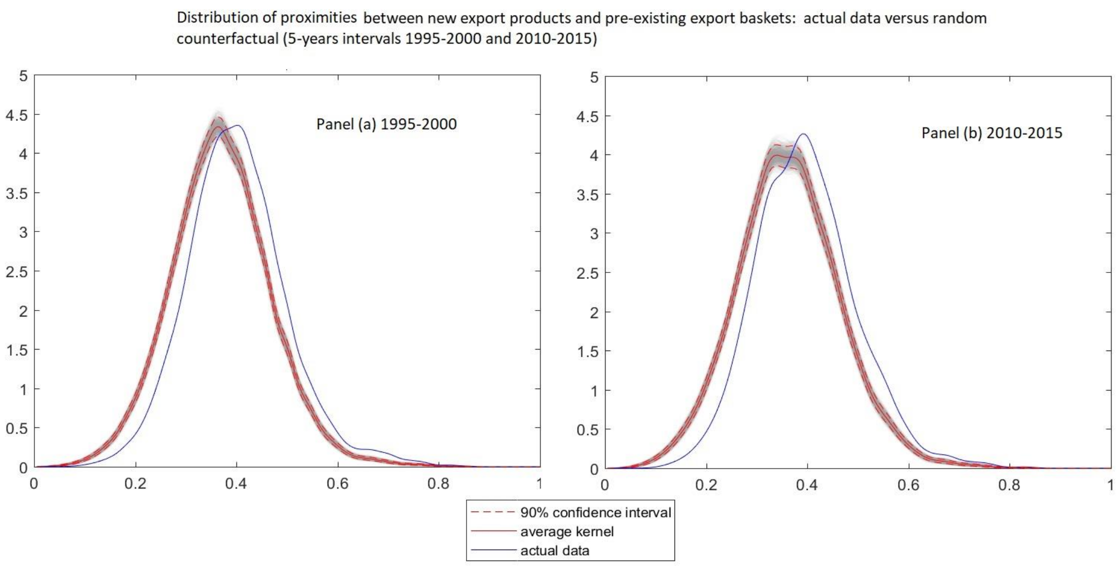
In both panels of Figure 1 we observe a non-random concentration of new entries above the proximity value of 0.4. Using the simile of the dart-board, we find that the actual darts (actual new products) tend to concentrate closer to the target (pre-existing export basket), which we would expect if they were not constrained by the initial set of capabilities (randomly generated new products). Evidence suggests that the pattern does not significantly change when shifting the focus to a different period and that path dependence drove the overall process of structural transformation in both the periods, 1995-2000 (Figure 1a) and 2010-2015 (Figure 1b).

The general pattern of path dependence is confirmed using two alternative definitions of relatedness between new entries at $t + T$ and the export basket at *t*, weighted average proximity and average proximity (see Appendix 1).[20]

[20] As alternative measures of relatedness, we use one-sided Kolmogorov-Smirnov tests for first order stochastic dominance where we compare the relatedness distribution of actual data with the randomly generated one. This parametric tests the null hypothesis that the two distributions can be generated by the same (random) process and that the relatedness of actual data are significantly more concentrated at higher levels of proximity (i.e. the cumulative distribution function of the actual data distributions lies below the mean values counterfactual). These tests were performed for all new entries in the world in 5-years time intervals. The results strongly reject the hypothesis of the two distributions and confirm that there is a significantly higher concentration of actual data at high levels of proximity. These results are available in Appendix 3.

Our finding support the 'mixed' scenario outlined above. Since the kernel distribution of actual new entries only lies above the counterfactual for relatively high levels of proximity, we cannot reject the null hypothesis of random relatedness for the entire distribution of relatedness. The results confirm the notion that diversification is generally strongly constrained by capabilities: what you export today strongly influences what you will export tomorrow (*constrained diversification*). Figure 1 also suggests that a non-negligible share of new products entering the export basket are concentrated at distance level where the actual data kernel lies under the counterfactual distribution; these products are evidence that *unconstrained diversification* occurs frequently, and that countries do in fact defy their initial comparative advantage.

Figure 1 Distribution of proximities between new exports and pre-existing export baskets



The results of the general test presented in Figure 1 mask large cross-country heterogeneity. The methodology discussed above can be used to test the general pattern of path dependence for each of the countries in our sample.[21]

Figure 2 illustrates the distribution of distances of actual new entries over the period 1995-2015 compared to the counterfactual for four economies: Cambodia (*Panel a*), the Republic of Korea (*Panel b*), the United States (*Panel c*) and Yemen (*Panel d*). The results highlight heterogeneous patterns. The development of Cambodia's comparative advantage shows a strong degree of path dependence; the South-Asian economy has a level of relatedness higher than 0.38, a non-

[21] We derive country-specific and year-specific counterfactual distributions, hence, our randomly generated distances account for the different pre-existing export baskets in terms of number of variety and their relative position in the Product Space. It is important to note that the frequency of new entries is also highly heterogeneous; for some countries, many new products enter the export basket in the 5-year intervals while for other countries—in particular, relatively more advanced economies—new export discoveries are observed less frequently.

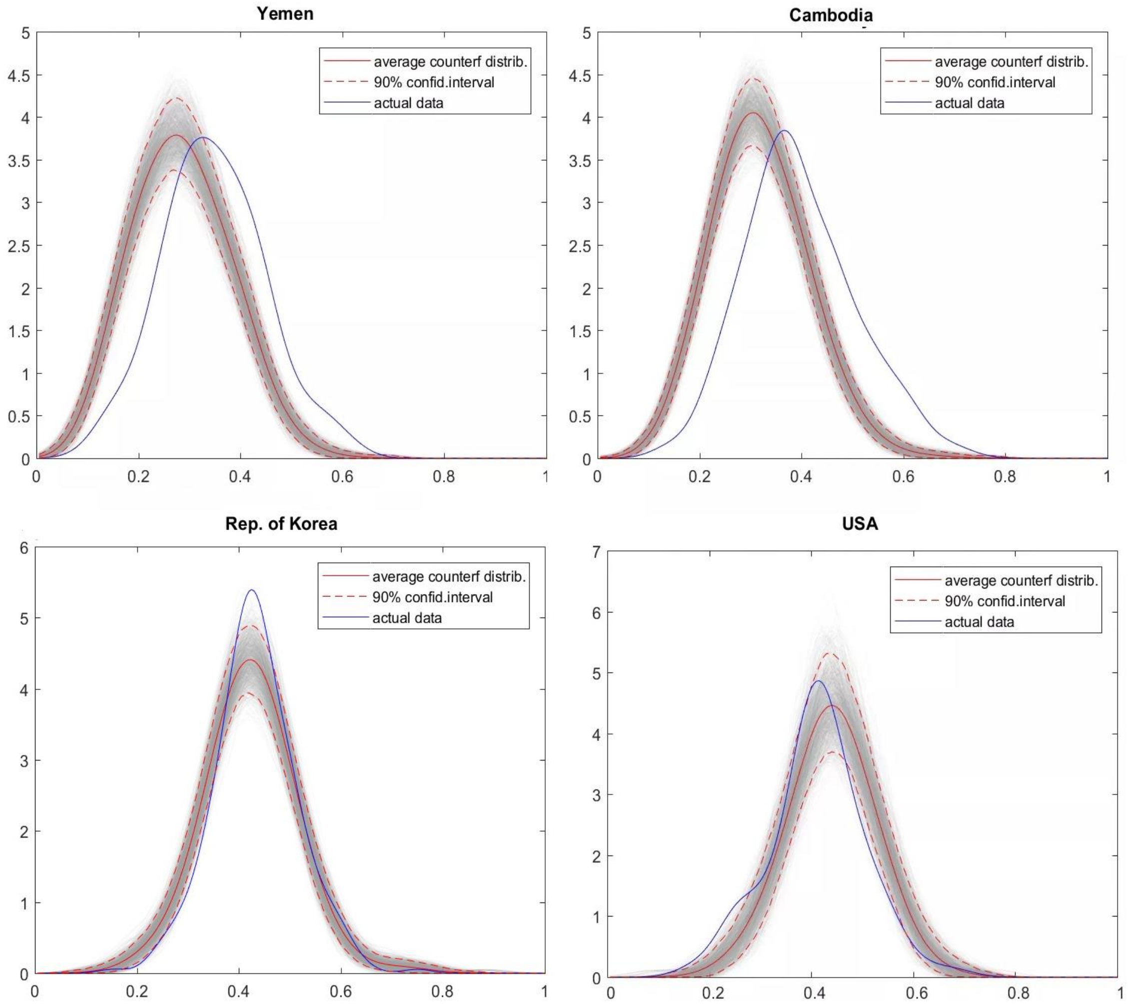
random concentration of actual data. A similar pattern is found in Yemen where the test of randomness is rejected at 95 per cent confidence for a level of relatedness higher than 0.35. *Panels a* and *d* indicate that the process of structural transformation involving developing economies such as Cambodia and Yemen are strongly influenced and constrained by the production capabilities available locally.

By contrast, the Republic of Korea has a kernel distribution of actual data that is statistically similar to the one generated by the random process: the inclusion of new products in the Republic of Korea's export basket does not follow the PS predictions of path dependence. The pre-existing position of the US' comparative advantage over the PS does not seem to condition its development in the subsequent 5 years; the kernel densities for the period under scrutiny do not reveal a statistically significant concentration of new entries for relatively high levels of relatedness.[22] The results presented in Figure 2 are robust to the new entries' identification strategy and to the measure of relatedness taken into account.

Based on the results of the general test on path dependence it appears that small, least developed and resource abundant countries tend to confirm the prediction of the PS framework, and that their export baskets primarily (but not only) include goods that are strongly related to their initial export basket.

[22] Most kernel estimates of the actual data are drawn inside the 90 per cent confidence interval, and the only distances for which the distribution of observed relatedness lies above the 95th percentile of the kernel counterfactual's distribution are the farthest from the initial export basket, denoting a non-random concentration of new entries for very low levels of relatedness.

Figure 2 **New export products: distribution of actual and counterfactual distances in selected economies (all new entries, 1995-2015)**

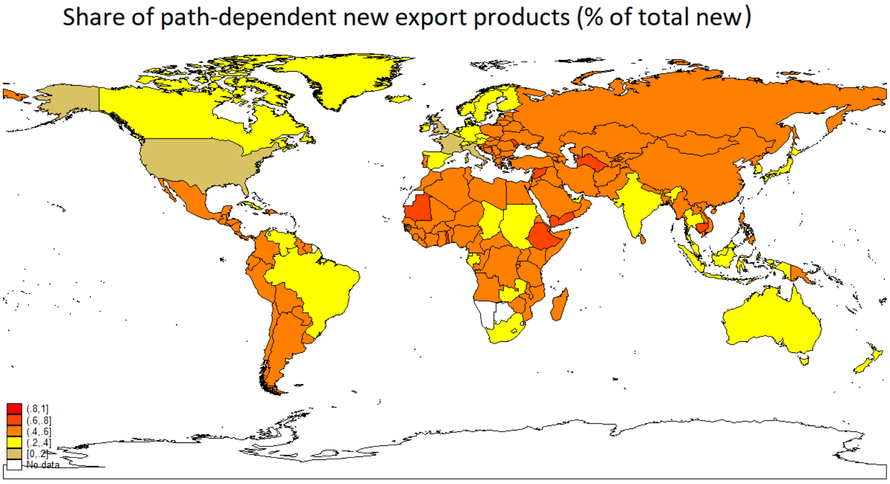


Notes: Kernel densities of actual and counterfactual distances

When considering the 'single product' test, we move from the analysis of the entire bundle of new exports to each single product. A new product is labelled path-dependent (path-defying) when its proximity with the pre-existing export basket is higher (lower) than the 95^{th} percentile (5^{th} percentile) of counterfactual proximities obtained using the Monte Carlo methodology described in Section 3.2.

Over the entire sample, approximately 49.2 per cent of the total number of new entries in the world between 1995 and 2015 were significantly related (path-dependent) to the initial export basket. The other side of the coin of this finding is that more than half of the new products that entered the export basket represented relatively more radical 'jumps' across the Product Space. This result suggests that we must take the normative implications stemming from this framework with a grain of salt.

Figure 3 **Share of path-dependent new export products (% of total new)**



Note: average values in the period 1995-2015

Figure 3 presents the average values of the share of path-dependent new entries in the period 1995-2015, with relatedness being measured as the maximum proximity between new entries and already exported products[23]. Among the countries in which we observe diversification to have been at least constrained by path dependence are developed countries such as the US, the UK, France and Italy. Most western European countries, as well as very different countries such as Japan, Canada, Brazil, Australia, India and South Africa, show very low path dependence in the relevant period. By contrast, economies whose diversification seems characterized by a high degree of path dependence include Yemen, Ethiopia, Mauritania, Syria, Turkmenistan and Cambodia. Most of these countries are developing economies with a high reliance on natural resources.

To more systematically analyse which characteristics drive the observed heterogeneity in the process of structural change—as well as its significance in determining economic growth—we perform a panel data analysis. These empirical exercises are presented in the two next sections.

[23] Maps with alternative definitions of distance are available upon request. Using an alternative definition of distance/relatedness does not substantially change the relative ranking of countries in terms of path dependence shares.

4 When does the apple fall near (or far) from the tree? The determinants of path dependence over the Product Space

In the previous section, we found evidence of a large cross-country heterogeneity in the degree of path dependence of new entries in the export basket. In this section, we analyse the country-level characteristics that drive these heterogeneous patterns. The emergence of new sectors that are unrelated to the pre-existing export basket signals countries' ability to effectively free themselves from the constraints posed by the initial set of production capabilities or, alternatively, to redeploy them with relative ease. This ability is essential to promote structural transformation and economic growth.

We estimate a *panel tobit model* in which our dependent variable, *path-dependent entries (PD share)* is the share of new entries in the export basket of country *i* at time *t*, which are statistically related to the country's pre-existing economic specialization at time *t – 5*. As in the previous section, we use *maximum proximity* (Equation 3) as our preferred measure of distance/relatedness, and define new entries as those products with an RCA≥1 at time *t* and an RCA<0.5 at time *t – 5*. In other words, new entries are products that enter export baskets in a statistically significant way.[24] Our empirical model is the following:

$$PDshare_{i,t} = \alpha + \beta X_{i,t-5} + \phi_i + \gamma_t + \varepsilon_{it} \qquad (5)$$

where $X_{i,t-5}$ includes our main country-level covariates that are measured five years earlier (*time t – 5*), ϕ_i includes time-invariant country level controls, γ_t time fixed effects and ε_{it} is the error term.

A full description and summary statistics of our dependent variable and of all covariates is reported in Table 6 available in the Appendix. As a proxy for the relative level of development, we use *GDP per capita (in log)*. We expect this variable, which reflects the degree of factors' productivities and competitiveness, to be negatively related with the dependent variable. More advanced economies have better endowments and a wider set of productive capabilities which, in turn, makes it easier for them to re-combine these capabilities and produce goods that are unrelated to their existing specialization. As described in Section 2, the existing literature emphasizes the existence of a positive relationship between GDP per capita and trade

[24] In this section, we only report the results based on our preferred measure of path dependence. For robustness, we used alternative definitions of the dependent variable using different criteria for measuring relatedness and for identifying new entries (i.e. alternative thresholds for the RCA index at time *t*; RCA<0.1, RCA<0.2 and RCA<1). The results reported using these alternatives are qualitatively similar and available upon request.

diversification. While these studies look at the 'quantitative' dimension of trade diversification (i.e. the number of new entries in the export basket), to our knowledge, ours is the first study that investigates the 'direction' the process of trade diversification takes.

We control for country size in terms of *population* since we expect that larger countries have, ceteris paribus, a higher potential to diversify away from their current comparative advantage. We expect a negative (positive) association with the number of path-dependent (path-defying) new entries for this variable as well.

Trade openness measured as the sum of total export and import over GDP (in log) is included among our covariates. The effect of this variable on the degree of path dependence is expected to be ambiguous. On the one hand, we expect that when controlling for other countries' characteristics such as size, more open economies are less likely to observe a path-dependent development as a higher degree of internationalization should facilitate access to a wider set of productive capabilities and to trade opportunities in unrelated industries. On the other hand, when countries have a large tradable industry, they might be less likely to attract the necessary resources (from the relatively smaller non-tradable industry) to kick-start a new line of exports. Export discoveries, in turn, are more likely to be related to those areas in which countries already have a comparative advantage (potential lock-in effect).

We include a measure of export diversification, *variety* (in log) that follows the definition of Frenken (2007). We expect that more differentiated export baskets—an indication of large and diversified sets of production capabilities—will allow an economy to diversify away from its initial production basket. We also expect that trade diversification in products that draw from the same pool of production capabilities will provide relatively less opportunities to diversify away from the current comparative advantage. We use two variables, *related variety* and *unrelated variety*, which measure the degree of trade diversification within a specific industry or across industries, respectively. While a higher number of unrelated varieties by enriching the portfolio of production capabilities might increase the ability to diversify in unrelated areas of the PS, a higher number of related varieties might induce a 'lock-in' effect which hampers diversification.[25]

Economic diversification is a compelling policy goal for resource rich countries which are often trapped in a 'resource curse' (Humphreys et al., 2007). Abundance in *natural resources* might negatively affect trade diversification through several channels; among the most debated in the literature are the negative effects of resource rents on institutional quality and real exchange rate

[25] Castaldi et al. (2015) use similar covariates in their analysis of the emergence of technological breakthroughs.

appreciation due to the 'Dutch Disease' effect. We expect that this variable is positively associated with our dependent variable as an economy that is strongly dependent on natural resources is less likely to diversify away from the current export basket.

Since foreign investors might be important agents of structural transformation, we include *FDI inflows* (net, share of GDP) and expect that countries attracting a relatively larger share of FDI are more likely to defy their static comparative advantage and diversify the economy, adding unrelated varieties to the export basket (we thus expect a negative effect on the dependent variable).[26]

Human capabilities are a crucial element for the 'cost discovery' process leading to the introduction of new export varieties. Given the notorious lack of panel data on formal education, and more generally on the stock of human capital, we use two proxies of human capital: the number of *scientific and technical journal publications* (a measure of output) and *educational expenditure* as a share of country GDP (a measure of input).[27]

Our specifications include two additional control variables. The total number of new entries in the export basket and the relative importance of new entries measured as their share in total exports; both variables are controls for size effects.

Finally, we include time dummies that account for common trends in the data (for instance, due to global economic shocks) and macro-area dummies which account for other time invariant characteristics like remoteness or participation in regional trading blocks.

In Table 1 we report the estimates of the random-effect tobit models on the determinants of the degree of path dependence in the development of countries' comparative advantage. We start from a parsimonious model which includes GDP per capita and population as well as control variables, and gradually include additional covariates in further specifications.

The coefficient of our proxy for level of development is always negative and highly significant, suggesting that more advanced economies experience a change in their export basket that is less path-dependent – a 1 per cent increase in GDP per capita at time *t* is associated with a decrease

[26] We also include FDI stocks as an alternative to inflows, and the results (not reported, but available upon request) are similar.

[27] Note that for those countries for which we have detailed information on the distribution of population by level of education, the number of scientific and technical articles in journals have a high level of correlation with the share of primary and secondary education that are found to be among the most important drivers of trade diversification (Jetterand Ramirez-Hassan, 2015).

(increase) between 2.3 per cent and 5.3 per cent in the share of path-dependent (radical) entries in the export basket five years later. A similar effect is related to the size of population, although this result is less robust.

Interestingly, we do not find evidence of a significant effect of the volume of international trade on the direction of trade diversification. As expected, when more trade varieties are present in countries' export baskets, it is more likely that diversification in the following five years would be unrelated, i.e. that countries would be able to 'jump' further across the Product Space (Table 1, Column 2). This result is entirely driven by unrelated variety while higher diversification within the same industry has no significant effect (Columns 3 to 7). A 1 per cent increase in our measure of unrelated trade varieties has a large negative (positive) effect on the share of path-dependent (radical) new entries (approximately 5 per cent in the specification reported in Column 3).

We find slight evidence that a higher share of natural resources in the economy is associated with a higher degree of path dependence in the subsequent five years. This result suggests that 'extractive' rents do not only limit a country's ability to diversify, but also 'lock' it into highly related diversification across the Product Space.

Countries with higher FDI inflows (or stocks) are more likely to 'defy' their static comparative advantage (Column 5); this result suggests that MNEs might play an important role as agents of structural change[28] and lead to the acquisition of a wide range of production capabilities. This can be considered an important (and new) channel of spillovers from foreign investments.

Human capital has a limited effect on our dependent variable. We find that the number of scientific and technical journal articles is positively related with the share of path-dependent new entries. It should be noted that the number of observations is significantly reduced when we include this variable, as some countries drop out of the sample.

It is interesting to note that most of the variance in the dependent variable is due to the cross-sectional difference between countries (more than 80 per cent of total variance) rather than the temporal variation.

[28]Neffke et al. (2014) show that firms with a higher degree of internationalization are crucial agents of structural change since non-local firms and entrepreneurs tend to diversify in industries that are less related to pre-existing regional production bundles.

Table 1 When does the apple fall near the tree? The determinants of path-dependent new entries in the export basket
Dependent variable: % share of path-dependent new entries over total new entries (5-year intervals)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP per capita (log)	-4.020***	-3.109***	-2.348***	-2.789***	-2.724***	-5.305***	-5.384***
	(0.727)	(0.751)	(0.806)	(0.834)	(0.838)	(1.405)	(1.891)
Population (log)	-1.126**	-0.364	0.227	-0.376	-0.381	-2.282*	-1.255
	(0.474)	(0.502)	(0.553)	(0.608)	(0.612)	(1.192)	(1.654)
Trade openness (log)	0.231	0.0203	0.442	-1.371	-0.820	-0.605	3.011
	(1.292)	(1.288)	(1.289)	(1.432)	(1.446)	(1.612)	(3.014)
Trade variety (log)		-7.615***					
		(1.730)					
Related varieties (log)			-0.290	0.849	0.508	2.153	1.589
			(1.290)	(1.326)	(1.337)	(1.622)	(2.367)
Unrelated varieties (log)			-4.992***	-4.185**	-3.892**	-5.551**	-8.420**
			(1.679)	(1.794)	(1.803)	(2.219)	(3.566)
Natural resources (% of GDP)				0.177*	0.162*	0.272**	0.00470
				(0.0910)	(0.0917)	(0.106)	(0.161)
FDI inflows (net, % of GDP)					-0.0777**	-0.0550	-0.0267
					(0.0383)	(0.0417)	(0.0551)
Scientific & tech. publications (log)						1.891**	1.925
						(0.921)	(1.262)
Educational expenditure (% of GDP)							-0.353
							(0.223)
Total new entries (last 5 years; log)	8.471***	10.47***	10.91***	11.34***	11.40***	11.19***	9.904***
	(0.931)	(1.024)	(1.050)	(1.086)	(1.098)	(1.341)	(1.781)

Share of new entries over total export value	-19.67***	-20.06***	-21.10***	-23.80***	-23.65***	-16.68**	-22.78**
	(4.826)	(4.811)	(4.822)	(4.900)	(4.968)	(6.652)	(9.167)
Constant	71.87***	59.50***	47.80***	61.71***	59.20***	101.7***	91.58**
	(14.44)	(14.59)	(15.21)	(16.01)	(16.07)	(27.14)	(39.34)
sigma_u	*7.650****	*7.581****	*7.599****	*8.083****	*8.057****	*8.062****	*9.318****
	(0.772)	*(0.762)*	*(0.763)*	*(0.786)*	*(0.789)*	*(0.951)*	*(1.197)*
sigma_e	*27.22****	*27.13****	*27.11****	*26.76****	*26.73****	*27.17****	*25.54****
	(0.393)	*(0.391)*	*(0.391)*	*(0.387)*	*(0.389)*	*(0.487)*	*(0.589)*
Observations	*2,715*	*2,715*	*2,715*	*2,696*	*2,657*	*1,827*	*1,137*
Macro-area and year dummies	*YES*	*YES*	*YES*	*YES*	*YES*	*YES*	*YES*
Number of countries	*177*	*177*	*177*	*177*	*177*	*173*	*154*

Note: Estimations using the panel tobit method; standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$

4.1 Business and institutional environment and path dependence

Path-defying changes in the export basket are the results of investments carried out by economic agents in risky and highly uncertain cost discovery activities. The quality of the business and institutional environment is fundamental in boosting incentives to undertake such potentially high yield but also high risk investments. In this sub-section, we analyse the role these policy-relevant factors play in shaping the degree of path dependence by using measures of countries' business and institutional quality developed by the Fraser Institute (2017).

Table 2 reports the results of our estimates testing the importance of a *general index of economic freedom* and its main sub-components. To test the relative importance of these institutional variables for countries at different levels of development, we interacted the covariates reported in each of the 7 columns with income level dummies based on the World Bank classification. Note that these indexes range from a maximum of 10 (highest level of freedom or lowest degree of government intervention) to a minimum of 0 (lowest level of freedom or highest degree of government intervention), hence, a higher variable implies reduced intervention or more 'economic freedom'.

Table 2 Determinants of path-dependent new entries in the export basket: the role of institutional environment
Dependent variable: % share of path-dependent new entries over total new entries (5-year intervals)

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
I_Var = Institutional variable reported in Column	**Economic Freedom Index**	**Size of government**	**Legal system and property rights**	**Sound money**	**Freedom to trade internationally**	**Regulation**
Institutional variable (baseline = high income country)	-5.611**	-1.008	-0.451	-3.15**	-2.151	-1.648
	(2.795)	*(1.229)*	*(1.536)*	*(1.435)*	*(1.949)*	*(1.739)*
Low income country * I_Var	5.453	0.451	2.129	1.754	2.122	5.655**
	(3.745)	*(1.880)*	*(2.359)*	*(1.832)*	*(2.767)*	*(2.614)*
Lower-middle income Country* I_Var	3.186	-1.653	-0.364	2.817	1.944	0.663
	(3.526)	*(2.044)*	*(2.268)*	*(1.808)*	*(2.499)*	*(2.734)*
Upper middle income Country* I_Var	5.732	-0.392	3.650	3.402**	3.464	0.427
	(3.639)	*(1.822)*	*(2.404)*	(*1.707)*	*(2.699)*	*(2.442)*
Obs.	*1,504*	*1,503*	*1,514*	*1,504*	*1,499*	*1,504*
No. of countries	*143*	*143*	*143*	*143*	*143*	*143*

The results suggest the existence of some degree of heterogeneity across income groups. A higher *Economic Freedom Index* is negatively (positively) associated with path dependence (path-defying) changes in the export basket five years later, but only for high income countries while the effect is insignificant for countries with lower levels of income. The *size of government* is negatively but not significantly associated with the dependent variable, but not for low income countries. This result lends some weak support to the hypothesis that an active role of the State can be less distortive in very poor countries where market failures are pervasive and probably more severe than government failures (Stiglitz, 2002, Bjorvatn and Coniglio, 2012). A similar pattern is found when introducing composite indexes of the quality of the *legal system and of property rights protection*, the *freedom to trade internationally* and *regulation*, although the estimated coefficients are not statistically significant (Columns 3, 5 and 6). The effectiveness and coherence of monetary policies seem to matter in shaping the likelihood of observing path-defying changes in wealthy countries, but not in relatively poor ones (index of '*sound money'*, Column 4).

Overall, the results suggests that less pervasive and distortive government intervention leads to a higher ability to dynamically move the comparative advantage away from the current one in relatively rich countries where market failures and barriers to entry in new industries are likely to be low. By contrast, we do not find strong evidence of these effects in less developed economies.

Table 3 Role of government and path-dependent new entries in the export basket: specific channels
Dependent variable: % share of path-dependent new entries over total new entries (5-year interval)

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
	Government consumption	**Transfers and subsidies**	**SOEs and investments**	**Top marginal tax rate**	**Non-tariff trade barriers**	**Credit market regulations**	**Ownership of banks**	**Business regulations**
Richest countries (top 35%)	-0.529	-1.085	0.682	-0.696	-4.537***	-3.058**	-1.711**	0.350
	(0.95)	(1.01)	(0.66)	(0.78)	(1.40)	(1.37)	(0.69)	(1.76)
Obs.	*578*	*571*	*570*	*572*	*530*	*573*	*570*	*544*
N. of countries	*64*	*60*	*59*	*61*	*60*	*62*	*59*	*62*
Poorest countries (bottom 35%)	2.23*	-0.532	-0.616	-2.21***	-0.0537	-0.0772	0.431	-4.196*
	(1.20)	(2.76)	(0.55)	(0.80)	(2.36)	(1.20)	(0.65)	(2.15)
Obs.	*425*	*331*	*444*	*279*	*272*	*418*	*383*	*333*
No. of countries	*52*	*46*	*52*	*39*	*42*	*51*	*46*	*49*

Note: Estimations using panel tobit method; Includes all covariates and controls included in Table 6 (model 6); Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3 presents the estimation results of more specific channels, with wealthy countries (top 35 per cent) and poor countries (bottom 35 per cent) being considered separately.[29] This exercise allows us to further explore the heterogeneity already emphasized in Table 2. When we consider the four sub-components of the aggregate index 'Size of Government' (Columns 1 to 4), we find—in line with Table 2—that the intensity of government intervention in the economy (for instance, via industrial policy) does not affect the direction of the development of comparative advantage. One exception is government consumption and the top marginal tax rate in poor countries. More precisely, a decrease (increase) in government consumption is associated with less (more) path dependence. By contrast, a lower top marginal tax rate in the poorest countries of the sample is associated with a higher degree of path-defying changes.

Overall, the results, as mentioned above, suggest that less pervasive government intervention is associated with a higher ability to dynamically move the comparative advantage away from the current one in relatively rich countries where market failures and barriers to entry in new industries are likely to be low. In wealthy countries, government intervention seems to hamper diversification in unrelated and new areas of the PS. By contrast, we do not find strong evidence of these effects in less developed economies, with one important exception: in relatively poor countries, improvements in business market regulations (bureaucratic costs, cost of starting a business, bribes and corruption, licensing restrictions and tax compliance) improve the ability to defy the static comparative advantage.

5 Path-defying changes and economic performance

In this section, we explore the following research question: do unrelated new entries in the export basket—those that defeat the static comparative advantage—lead to higher economic growth? We analyse this relationship in panel growth regressions using alternative estimation approaches following Hausmann et al. (2007).[30]

Table 4 presents the results of our growth estimates based on the full sample of countries. Our *dependent variable* is defined as *5-year average growth rate of GDP per capita*. We use non-overlapping periods in the time span 1995-2015 for a sample of 177 countries. The variables used in the model and the list of countries covered are available in Appendix 2.

[29] We employ sub-components of the more aggregated indexes reported in previous estimates.

[30] Given the proximity of our research question to the seminal paper of Hausmann et al. (2007) entitled 'What you export matters', which investigates the relationship between export complexity (measured by the variable ExpY) and economic performance using panel regressions, we follow their approach as much as possible in this section.

Table 4 Do path-defying changes (non-)path-dependent entries) lead to higher growth?
Dependent variable: GDP per capita growth, yearly average (5-year panel; % change)

	Pooled OLS (1)	LSDV (2)	FE (3)	FE (4)	IV (5)	System GMM (6)
Path-defying new entries (log)	0.271***	0.279**	0.337***	0.354***	0.947*	0.301**
	(0.105)	(0.126)	(0.128)	(0.115)	(0.489)	(0.120)
Initial GDP per capita (log)	-0.344***	-4.04***	-5.88***	-9.85***	-10.9***	-3.77***
	(0.078)	(0.672)	(0.976)	(1.475)	(1.334)	(0.796)
Initial export sophistication, ExpY (log)			0.515 (0.575)	-0.338 (0.632)	-0.545 (0.556)	0.756 (0.305)
Initial Economic Freedom Index			1.003***	-0.275	-0.148	-0.500
			(0.234)	(0.417)	(0.356)	(0.468)
Initial scientific & tech. publications (log)				0.887***	0.0667	0.591
				(0.287)	(0.337)	(0.434)
Constant	2.51***	28.66***	39.59***	84.20***	84.29***	26.554***
	(1.166)	(4.712)	(9.062)	(11.40)	(9.279)	(7.931)
Observations	*692*	*692*	*504*	*384*	*384*	*383*
R2	*0.031*	*0.554*	*0.188*	*0.356*	*0.745*	
Number of countries	*177*	*177*	*143*	*141*	*141*	*141*

Note: Least Square Dummy Variable (LSDV) models in Column (1)(2) include country fixed effects; robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 *Panel IV regression:* path-defying new entries (log) are instrumented with the 5-year lag of the variable and the log of population. *GMM is the Arellano-Bond / Blundell-Bond system estimator and includes the lagged dependent variable and year dummies as suggested by Roodman (2009) / No. of instruments = 13).*

The *main variable of interest* is our measure of *the share of path-defying new entries* in countries' Product Space. This variable is defined following our original methodology presented in Section 3 and captures the share of products that enters a country's export basket with an RCA index ≥1 and which are unrelated to the pre-existing export basket. The main hypothesis we aim to test is whether a relatively better growth performance can be observed in those countries that have introduced new export discoveries in areas of the Product Space (statistically) that are unrelated to the pre-existing export basket. We expect a positive effect of this variable on economic growth as diversification in unrelated variety implies that a country has a wider set of productive capabilities that can be combined in an efficient way in order to boost productivity and in turn economic performance.

As Hausmann et al. (2007), we use a rather parsimonious growth model which includes the following covariates: the *initial (log of) GDP per capita* (a proxy of the initial level of development which is expected to be negatively related to subsequent growth, i.e. convergence hypothesis), the *initial level of export basket sophistication* measured as (log of) *ExpY* (the main covariate in Hausmann et al., 2007), a comprehensive measure of the quality of business environment (*Economic Freedom Index*) and a proxy for human capital (to raise the number of observations, we employ our 'output' measure used and described in the previous section, i.e. *the log of the initial number of scientific and technical journal articles*).

We find robust support for our hypothesis of a positive effect of path-defying changes in the country export basket and subsequent economic growth. In Columns (1) and (2), we use pooled OLS and Least Square Dummy Variable (LSDV) model, respectively. For both models, the effect of radical changes on growth is positive and significant. A fixed effect panel regression is used in Columns (3) and (4). As our main variable of interest could, in principle, be endogenous, we report the results of an IV regression and system GMM in Columns (5) and (6), respectively. In the IV regression we use the 5-year lag, as instrument for the share of path-defying new entries and country size proxied by population. As the theoretical hypothesis of scale effects in economic growth has not been robustly confirmed by the existing empirical evidence (see Rose, 2006 and a similar argument in Hausmann et al., 2007), we believe that our approach is not problematic.[31]

[31] It should be noted that when performing standard tests we reject the null hypothesis of endogeneity of our key co-variate. For completeness and given the well-known weakness of these tests we decided to include anyway the IV estimates.

Given the weak evidence of endogeneity of our measure of path-defying changes, our preferred specifications are those using fixed effects as these estimates allow us to control for time-invariant country effects and to better identify the impact of an unrelated development of the export basket on subsequent growth, netting out the within-country differences. The results reported in Columns (3) and (4) suggest that a 10 per cent increase in the share of path-defying new entries leads to a 0.78 per cent - 0.82 per cent increase in annual GDP growth per capita over the next five years; the growth effect is sizable. The results obtained with the system GMM estimator are in line with the FE model while the IV regression estimates suggest an even higher effect (although weakly significant).

As a final step of our analysis we estimate the same specification on a smaller sample which excludes high-income countries. The estimation results, reported in Table 5, confirm the findings highlighted above. The magnitude of the estimated coefficients is comparable to that obtained from the full sample when country time invariant characteristics are considered (see FE models in columns 3 and 4).

Table 5 Do path-defying changes (non-)path-dependent entries) lead to higher growth?
(excluding high income countries)
Dependent variable: GDP per capita growth, annual average (5-year panel; % change)

	Pooled OLS (1)	LSDV (2)	FE (3)	FE (4)	IV (5)	System GMM (6)
Non path-defying new entries (log)	0.361***	0.307**	0.324**	0.338***	0.0066	0.287*
	(0.124)	(0.146)	(0.140)	(0.125)	(0.498)	(0.159)
Initial GDP per capita (log)	-0.138	-2.905***	-4.086***	-8.512***	-10.98***	-7.451***
	(0.142)	(0.796)	(1.229)	(2.059)	(1.616)	(1.104)
Initial export sophistication, ExpY (log)			0.744	-0.0291	0.915	1.32*
			(0.773)	(0.833)	(0.740)	(0.771)
Initial Economic Freedom Index			0.933***	-0.639	-0.588	-1.326***
			(0.274)	(0.574)	(0.420)	(0.456)
Initial Scientific & tech. publications (log)				0.971***	-0.369	0.666*
				(0.349)	(0.343)	(0.398)
Constant	2.51***	21.59***	19.73*	65.26***	79.96***	51.52***
	(1.166)	(5.466)	(11.66)	(13.91)	(10.71)	(9.38)
Observations	*479*	*479*	*325*	*252*	*252*	*251*
R2	*0.0141*	*0.551*	*0.113*	*0.324*	*0.795*	
Number of countries	*122*	*122*	*96*	*95*	*95*	*95*

Notes: Least Square Dummy Variable (LSDV) models in Column (1)(2) include country fixed effects; robust standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$
Panel IV regression: Path-defying new entries (log) are instrumented with the 5-year lag of the variable and the log of population
GMM is the Arellano-Bond / Blundell-Bond system estimator

6 Conclusion

In this study, we examined the development of countries' comparative advantages in the period 1995-2015 to measure how this development conforms with the notion of path dependence, which is a cornerstone of the Product Space framework (Hausmann and Klinger, 2007; Hidalgo et al., 2007).

We find evidence that a large share of new products entering countries' export baskets is significantly related to the country's pre-existing comparative advantage or, in other words, that the extent of *diversification* was statistically *constrained*. Our study lends partial empirical support to the hypothesis of path dependence: we find that countries dynamically acquire a comparative advantage in products that require a set of productive capabilities that are already available or easily accessible. Our analysis, however, also reveals that a significant share of 'apples' (new products entering the Product Space of a country) did indeed fall far from the tree: nearly half of new products are not significantly related with those already present in countries' export baskets.

We used a novel methodology that allowed us to rigorously test the hypothesis of (non-random) relatedness, using non-parametric techniques. To our knowledge, this is the first study that moves beyond a simple description of the dynamics of change in the bundle of goods produced by countries over time or the use of measures of relatedness which can be the result of random processes (as in the recent work of Pinheiro et al., 2018).

Our findings have important implications for industrial and innovation policies. As governments around the globe are increasingly being drawn to the Product Space's notion of 'latent comparative advantage', policy efforts should prudently target products that are not yet in the country's export basket but that are related to it (i.e. small jumps over the Product Space are those that are likely to be effective). Our study shows that the development of comparative advantage of the world economy is characterized by significant jumps away from the diversification pattern postulated by the PS. Using such literature too narrowly as a map or guide to identify 'latent comparative advantage' might lead to undesirable results, as structural transformation has often taken very different and largely unpredictable directions. Furthermore—and this is of particular relevance for governments—we find that path-defying diversification, i.e. unrelated new entries, are associated with higher growth rates.

Our analysis of the determinants of the share of unrelated new entries reveals the importance of public policies: better regulatory and business environments and—although the evidence in this respect is less robust—better endowment of human capital allows countries to develop their comparative advantages in new areas of the Product Space.

Although this approach allows us to shed some light on the observed patterns, we are not able to fully control for the unobserved heterogeneity at the country and at the sectoral level. It would be interesting to analyse cross-country spatial spill-overs in the development of comparative advantage as international trade, capital mobility and migration are likely to affect the set of production capabilities that countries have and, in turn, their production baskets. These interesting aspects are left to future research.

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Table 6 Determinants of path dependence: variable descriptions and summary statistics

Variables	Description	Source	Obs.	Mean	St. Dev	Min	Max
(***Dependent variable***) Path-dependent new entries (% share over total new entries; 5-yearintervals)	Share of new entries (i.e. products exported with an RCA > at time *t* that were not exported or exported with an RCA<0.5 at time *t* - 5) that are 'path-dependent' (see Section 3) over total new entries	Own calculation based on CEPII-BACI database	2928	49.19	29.22	0.00	100.00
GDP per capita (log)	GDP per capita measured in constant US$ (year 2010; in log)	World Bank (WDI)	2867	8.30	1.53	4.75	11.46
Population (log)	Total population (log of)	World Bank (WDI)	2912	15.53	2.09	9.13	21.01
Trade openness (log)	Total value of export plus imports over GDP (log of)	World Bank (WDI)	2776	4.30	0.64	-3.86	6.28
Trade variety (log)	Herfindal Index measuring the degree of export diversification by means of an entropy measure at the 6-digit level (see Boschma & Iammarino, 2009). (log of)	Own calculation based on CEPII-BACI database	2902	1.43	0.59	-2.33	2.14
Related varieties (log)	A measure of diversification within industries. It is computed following Coniglio et al. (2017) as a Herfindal Index of export diversification and represents the weighted sum of the entropy indicator at the 6-digit level within each 4-digit industry (log of)	Own calculation based on CEPII-BACI database	2902	1.51	1.21	-5.13	2.99

Unrelated varieties (log)	A measure of diversification within industries. We use a Herfindal Index measuring the entropy of the 2-digit distribution of the HS trade classification. (Coniglio et al., 2017) (log of)	Own calculation based on CEPII-BACI database	2902	3.53	1.08	-1.77	4.83
Natural resources (% of GDP)	Natural resources rents (% of GDP)	World Bank (WDI)	2868	7.66	12.22	0.00	89.17
FDI inflows (net, % of GDP)	Net inflows of FDI as a share of the GDP	World Bank (WDI)	2828	5.26	16.20	-82.89	451.72
Scientific & tech. publications (log)	Number of scientific and technical journal articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology and earth and space sciences (log of)	World Bank (WDI)	1936	5.30	3.12	-2.30	12.89
Educational expenditure (% of GDP)	Public expenditure in education as a share of GDP	World Bank (WDI)	1517	14.83	4.91	2.92	44.80
Total new entries (last 5 years; log)	Number of new products that entered the country export basket with a Balassa RCA index higher than 1 from an initial Balassa RCA index lower than 0.5 in a 5-year interval (log of)	Own calculation based on CEPII-BACI database	2885	3.10	0.84	0.00	5.37

Share of new entries over total export value	Share of exports of total new entries over the value of total exports (log of)	Own calculation based on CEPII-BACI database	2928	0.10	0.17	0.00	0.99
East Asia and Pacific	Dummy equals 1 if the country belongs to East Asia and Pacific	World Bank (WDI)	2928	0.17	0.38	0.00	1.00
Latin America and the Caribbean	Dummy equals 1 if the country belongs to Latin America and Caribbean Islands	World Bank (WDI)	2928	0.17	0.38	0.00	1.00
North America	Dummy equals 1 if the country belongs to North America	World Bank (WDI)	2928	0.02	0.13	0.00	1.00
Middle East and North Africa (MENA)	Dummy equals 1 if the country belongs to the Middle East and North Africa	World Bank (WDI)	2928	0.11	0.32	0.00	1.00
South Asia	Dummy equals 1 if the country belongs to South Asia	World Bank (WDI)	2928	0.04	0.20	0.00	1.00
SSA	Dummy equals 1 if the country belongs to sub-Saharan Africa	World Bank (WDI)	2928	0.22	0.42	0.00	1.00
Europe	Dummy equals 1 if the country belongs to Europe	World Bank (WDI)	2928	0.26	0.44	0.00	1.00
Low income country	Dummy equals 1 if the country belongs to the income categories defined by the World Bank	World Bank (WDI)	2895	0.15	0.36	0.00	1.00
Lower-middle income country	Dummy equals 1 if the country belongs to the income categories defined by the World Bank	World Bank (WDI)	2895	0.26	0.44	0.00	1.00

Upper-middle income country	Dummy equals 1 if the country belongs to the income categories defined by the World Bank	World Bank (WDI)	2895	0.28	0.45	0.00	1.00
High income country	Dummy equals 1 if the country belongs to the income categories defined by the World Bank	World Bank (WDI)	2895	0.30	0.46	0.00	1.00
Economic Freedom Index - EFI	Composite Index that measures the degree of economic freedom present in five major areas: [1] Size of government; [2] Legal system and security of property rights; [3] Sound money; [4] Freedom to trade internationally; [5] Regulation. The index ranges from 10 (max freedom) to 0 (min freedom)	Fraser Institute (2017) Economic freedom of the world (online database)	1540	6.64	1.04	2.93	9.19
Size of government	Sub-component of the EFI. It measures the degree of government intervention in the economy. The sub-index is composed of several elements. Countries with low levels of government spending as a share of total spending, a smaller government enterprise sector, and lower marginal tax rates earn the highest ratings in this respect. The index ranges from 10 (max freedom) to 0 (min freedom)	Fraser Institute (2017) Economic freedom of the world (online database)	1538	6.40	1.38	1.75	9.90

Legal system and property rights	Sub-component of the EFI. It measures the degree of protection of citizens and property rights and the efficiency of the judicial system. The index ranges from 10 (max freedom) to 0 (min freedom)	Fraser Institute (2017) Economic freedom of the world (online database)	1550	5.31	1.82	0.99	9.28
Sound money	Sub-component of the EFI. It measures the degree of consistency of monetary policy (or institutions) with the goal of long-term price stability, as well as the freedom to use foreign currencies. The index ranges from 10 (max freedom) to 0 (min freedom)	Fraser Institute (2017) Economic freedom of the world (online database)	1540	7.76	1.75	0.00	9.89
Freedom to trade internationally	Sub-component of the EFI. It measures the degree of freedom to trade internationally (for instance, tariff and non-tariff barriers to trade) and to move capital across borders (FDI and speculative investments). The index ranges from 10 (max freedom) to 0 (min freedom)	Fraser Institute (2017) Economic freedom of the world (online database)	1532	7.02	1.40	0.00	9.72
Regulation	Sub-component of the EFI. It measures the burden associated with bureaucratic procedures and regulations. The index ranges from 10 (max freedom) to 0 (min freedom)	Fraser Institute (2017) Economic freedom of the world (online database)	1540	6.70	1.13	2.70	9.38

Government consumption	Sub-component of the ‘Size of government’ index. The measure is based on government consumption as a share of total consumption	Fraser Institute (2017) Economic freedom of the world (online database)	1558	6.03	2.15	0.00	10.00
Transfers and subsidies	Sub-component of the ‘Size of government’ index. The measure is based on transfers and subsidies as a share of GDP	Fraser Institute (2017) Economic freedom of the world (online database)	1404	7.65	2.13	0.84	10.00
SOEs and investments	Sub-component of the ‘Size of government’ index. The measure is based on the extent to which countries use private investment and enterprises rather than government investment and firms (State Owned Enterprises) to direct resources	Fraser Institute (2017) Economic freedom of the world (online database)	1578	6.00	3.23	0.00	10.00
Top marginal tax rate	Sub-component of the ‘Size of government’ index. The measure is based on the top marginal income and payroll tax rate and the income threshold at which these rates begin to apply	Fraser Institute (2017) Economic freedom of the world (online database)	1341	5.97	2.44	0.00	10.00

Non-tariff trade barriers	Sub-component of the ‘Freedom to trade internationally’ index. The measure is based on the extent of non-tariff barriers to international trade	Fraser Institute (2017) Economic freedom of the world (online database)	1217	6.02	1.44	1.83	9.69
Credit market regulations	Sub-component of the ‘Regulation’ index. The measure is based on a set of conditions reflecting the extent of government intervention in the domestic credit market (bank ownership, interest rate controls and other restrictions to private credit	Fraser Institute (2017) Economic freedom of the world (online database)	1544	8.07	1.68	0.00	10.00
Ownership of banks	Sub-component of the ‘Regulation’ index. The measure is based on the extent to which the banking industry is privately owned	Fraser Institute (2017) Economic freedom of the world (online database)	1482	6.96	3.19	0.00	10.00
Business regulations	Sub-component of the ‘Regulation’ index. The measure is based on a set of regulations and constraints that increase the cost of doing business for private firms (bureaucratic costs, cost of starting a business, bribes and corruption, licensing restrictions and tax compliance)	Fraser Institute (2017) Economic freedom of the world (online database)	1327	6.03	1.26	2.18	9.50

Path dependence, radical changes and growth: variable descriptions and summary statistics

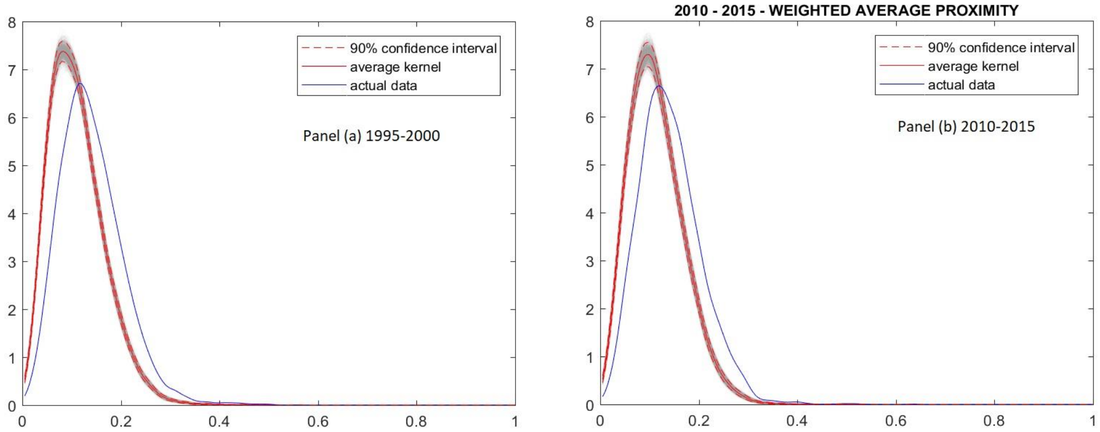
Variables	Description	Source	Obs.	Mean	St. Dev	Min	Max
Dependent variable: GDP per capita growth, annual average (5-year panel; % change)	5-year average growth rate of GDP per capita (constant 2010 US$)	World Bank (WDI)	694	2.54	3.08	-8.21	17.12
Non path-dependent new entries (log)	Share of new entries (i.e. products that are exported with an RCA > at time *t* that were not exported or exported with an RCA<0.5 at time *t* - 5) that are 'non-path-dependent' (see Section 3) over total new entries (i.e. radical new entries)	Own calculation based on CEPII-BACI database	714	3.66	0.96	-2.05	4.61
Initial GDP per capita (log)	GDP per capita measured in constant US$ (year 2010; in log)	World Bank (WDI)	699	8.32	1.53	5.14	11.39
Initial export sophistication, ExpY (log)	Measure of sophistication level associated with the country's export basket. *See details in Hausmann et al. (2007).* (in log)	Own calculation based on CEPII-BACI database	710	9.27	0.33	8.17	10.53

Initial Economic Freedom Index	Composite Index that measures the degree of economic freedom present in five major areas: [1] Size of government; [2] Legal system and security of property rights; [3] Sound money; [4] Freedom to trade internationally; [5] Regulation. The index ranges from 10 (max freedom) to 0 (min freedom)	Fraser Institute (2017) Economic freedom of the world (online database)	513	6.54	1.13	2.93	9.11
Initial scientific & tech. publications (log)	Number of scientific and technical journal articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology and earth and space sciences (log of).	World Bank (WDI)	515	5.37	3.13	-1.61	12.89

Appendix 1 Kernel estimate with alternative measures of relatedness

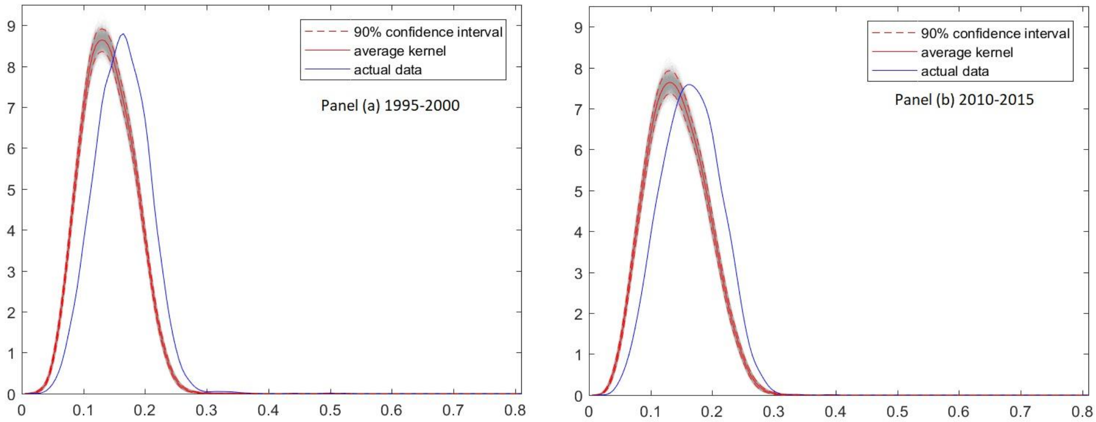
WEIGHTED AVERAGE PROXIMITY

Distribution of proximities between new export products and pre-existing export baskets: actual data versus random counterfactual (5-years intervals 1995-2000 and 2010-2015)



AVERAGE PROXIMITY

Distribution of proximities between new export products and pre-existing export baskets: actual data versus random counterfactual (5-years intervals 1995-2000 and 2010-2015)



Appendix 2 List of countries included in growth regressions (Tables 5 and 6)

Low and middle income countries		High income countries
Algeria	Madagascar	Australia
Angola	Malawi	Austria
Argentina	Malaysia	Bahamas
Armenia	Mali	Bahrain
Bangladesh	Mauritania	Belgium-Luxembourg
Belize	Mauritius	Brunei Darussalam
Benin	Mexico	Canada
Bolivia	Mongolia	Chile
Brazil	Montenegro	China Hong Kong SAR
Bulgaria	Morocco	Cyprus
Burkina Faso	Mozambique	Czech Rep.
Burundi	Myanmar	Denmark
Cabo Verde	Nepal	Estonia
Cambodia	Nicaragua	Finland
Cameroon	Niger	France
Central African Rep.	Nigeria	Germany
Chad	Pakistan	Greece
China	Panama	Hungary
Colombia	Papua New Guinea	Iceland
Congo	Paraguay	Ireland
Costa Rica	Peru	Israel
Croatia	Philippines	Italy
Côte d’Ivoire	Rep. of Moldova	Japan
Dem. Rep. of the Congo	Romania	Kuwait
Dominican Rep.	Russian Federation	Latvia

Ecuador	Rwanda	Lithuania
Egypt	Senegal	Malta
El Salvador	Serbia	Netherlands
Ethiopia	Sierra Leone	New Zealand
Fiji	South Africa	Norway
Gabon	Sri Lanka	Oman
Gambia	Suriname	Poland
Georgia	TFYR of Macedonia	Portugal
Ghana	Tajikistan	Qatar
Guatemala	Thailand	Rep. of Korea
Guinea-Bissau	Timor-Leste	Saudi Arabia
Guyana	Togo	Singapore
Haiti	Tunisia	Slovakia
Honduras	Turkey	Slovenia
India	Uganda	Spain
Indonesia	Ukraine	Sweden
Iran	United Rep. of Tanzania	Switzerland
Jamaica	Venezuela	Trinidad and Tobago
Jordan	Viet Nam	USA
Kazakhstan	Yemen	United Arab Emirates
Kenya	Zambia	United Kingdom
Kyrgyzstan	Zimbabwe	Uruguay
Lebanon		

Appendix 3 One-sided Kolmogorov-Smirnov Test for First Order Stochastic Dominance

Comparing new entries' relatedness distributions with randomly generated counterfactual distributions (all countries; five-year time intervals from 1995 to 2015)

New entry identification strategy: RCAt0<0.5 and RCAt1>=1.						
Time interval	**Maximum proximity**		**Weighted average proximity**		**Average proximity**	
	Dn	**p-value**	**Dn**	**p-value**	**Dn**	**p-value**
1995 - 2000	0.106	0.000	0.177	0.000	0.172	0.000
1996 - 2001	0.106	0.000	0.176	0.000	0.161	0.000
1997 - 2002	0.110	0.000	0.175	0.000	0.163	0.000
1998 - 2003	0.108	0.000	0.192	0.000	0.175	0.000
1999 - 2004	0.122	0.000	0.189	0.000	0.175	0.000
2000 - 2005	0.116	0.000	0.181	0.000	0.167	0.000
2001 - 2006	0.118	0.000	0.163	0.000	0.159	0.000
2002 - 2007	0.105	0.000	0.167	0.000	0.159	0.000
2003 - 2008	0.118	0.000	0.163	0.000	0.169	0.000
2004 - 2009	0.120	0.000	0.142	0.000	0.151	0.000
2005 - 2010	0.118	0.000	0.164	0.000	0.166	0.000
2006 - 2011	0.123	0.000	0.168	0.000	0.170	0.000
2007 - 2012	0.129	0.000	0.167	0.000	0.162	0.000
2008 - 2013	0.111	0.000	0.158	0.000	0.152	0.000
2009 - 2014	0.109	0.000	0.166	0.000	0.147	0.000
2010 - 2015	0.109	0.000	0.168	0.000	0.152	0.000

Note: For all three definitions of relatedness, we cannot reject the null hypothesis and thus conclude that the cumulative distribution of randomly generated data stochastically dominates that of actual data (i.e. higher and statistically significant concentration of the latter at higher proximities).

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