Imitation or Innovation? The impacts of patents and R&D expenditures on the high-tech exports of Newly Industrialised Countries

Robert Ackrill and Rahmi Çetin[1]

Abstract

Exports have long been shown as being important in driving economic growth and development. The development and export of high-tech products has been shown to play a particularly significant role in this. But how do lesser-developed countries develop such products and thus progress to higher levels of income and economic development – by imitation or innovation? This is a dynamic process that warrants being revisited regularly, given also the mixed empirical results in the extant literature. In this study we focus on the high-tech exports of a panel of eight newly industrialised countries (NICs) over 1996–2016. We make two important contributions to the literature: we focus on the country-level, complementing the considerable literature analysing firm-level effects; and we analyse jointly the relationships between patents, research and development (R&D) expenditure and the export of high-tech goods. Employing panel cointegration and panel Granger causality testing procedures, we reject the imitation hypothesis: NICs are engaging in product innovation with R&D activities leading to patents that provide long-run export benefits. Our results also support the self-selection hypothesis over learning-by-exporting in the dynamics of trade-led economic development. NICs' research and innovation activity suggests a growing dynamic benefit in terms of export-led-growth via a focus on high-tech exports.

JEL Classifications: O31; O57.
Keywords: High-Tech Exports; Imitation v Innovation; NICs; Patents; R&D Expenditures.

1. Introduction

The benefit of exports to economies has become an article of faith in recent decades. This has been seen in practical terms as erstwhile developing countries have exported their way to the status of Newly Industrialised Countries (NICs).[2] The process by which countries have made such a progression has become clearer over time, with many initially pursuing 'first stage' import substitution policies (Balassa 1990). Subsequently, those that had developed domestic production capacity tended to switch to an export-oriented trade policy, whilst others moved onto 'second stage' import substitution. The former group, Balassa noted, went on to achieve stronger and more sustained growth that the latter countries (see also Chow 1987).

How, though, did the NICs develop a competitive advantage sufficient to compete on export markets with developed countries? Our principal interest is in understanding whether they have pursued imitation or innovation as their key strategy. Behind this, however, what roles have Research and Development (R&D) expenditures and patents played in this process? Moreover, with this being a dynamic process, how are countries continuing to evolve, for example by moving from imitation to innovation? With earlier studies noting the failure of the literature to account for the dynamics of innovation and exports (Mani 2000; Srholec 2007; Morris 2018), this remains a vital empirical question.

In the present study, we are interested in particular in the development, manufacture and export of high-tech goods. These are based on the OECD definition, using SITC-Rev 4 aggregated data for technical products, the manufacturing of which involves a high intensity of R&D: aerospace, computers and office machinery, electronics-telecommunications, pharmacy, scientific instruments, electrical machinery, chemistry, non-electrical machinery, and armament.[3]

These goods, with higher income elasticities of demand, have been found to offer greater export and growth opportunities (e.g. Tebaldi 2011; Demir 2018; Ersin *et al* 2022). Additionally, it has long been acknowledged (see as far back as, *inter alia*, Lee 1987) that a high level of technological embeddedness offers greater scope for the product differentiation that underpins intra-industry trade. Alongside comparative advantage based on price-competition, this brings non-price competition into play as well, opening up more export opportunities.

Building on Balassa's ideas above and the need to develop manufacturing capacity, so too must countries develop innovation capacity, if firms are to be able to produce competing goods rather than just cheaper copies, and sustain growth in the longer term. Investment in innovation can influence efficiency, productivity, and costs at the firm level, thus promoting both price and non-price competitiveness (for a detailed review of firm-level issues, see Bell and Figueiredo 2012). Although the links between these variables are 'complex and heterogeneous' (Morris 2018 p 1927), successful innovation will enhance countries' export performance at the aggregate level, *ceteris paribus*. Moreover, as countries' economic development evolves over time, as imitation might be replaced with innovation, there is a clear empirical need to revisit this issue periodically.

We also note that, alongside an extensive firm-level literature, relatively very few studies seek to analyse how innovation drives exports at the national level (see Nelson and Pack 1999; Braunerhjelm and Thulin 2008; Tebaldi 2011; Sandu and Ciocanel 2014; and Çetin 2016). The purpose of the present paper is thus to update this sparse literature and to explore how innovation activities drive NICs' high-tech exports. This is especially important as doubts continue to be expressed as to the capacity of the NICs to undertake effective innovation (*inter alia*, Oura *et al* 2016).

In seeking to explore these issues further, the rest of the paper is organised as follows. The next section presents a brief review of some of the literature that gives context to our study. We then describe the data and econometric methods employed. Next, we present the empirical findings, before discussing and offering our concluding thoughts on the results and their implications, for our focus countries and beyond. In so doing we focus specifically on the links between high-tech exports, R&D expenditures and patents and, in turn, what this tells us about imitation and innovation in the NICs. An analysis of the links between these variables and economic growth is beyond the scope of this research (for this see, *inter alia*, Minviel and Bouheni 2022).

2. Literature Review

Economic development and growth are fundamental processes to understand, perhaps most famously and extensively explored through the export-led growth paradigm.[4] Complementing this focus on growth, our focus is on how countries seek to promote development via exports. Our interest in high-tech exports focuses on those goods with higher income elasticities of demand. The following offers a brief review of those studies most relevant to our own contribution. Moreover, these relationships need to be seen in their historical context, in terms of the evolution from imitator to innovator, to explore how countries continue to evolve as exporters. We include a brief reflection on studies that link exports and growth, as this allows us to locate the focus on innovation and, by implication, high-tech exports in this broader framing.

Traditionally, theories of international trade focused on prices as the key driver, influenced internally by costs and externally by exchange rates. Over time, with many countries able to export at lower prices yet still failing to develop and catch up economically, more emphasis has been placed on non-price drivers of exports, such as innovation and product differentiation. This evolution in the theoretical framing of export drivers has also reflected the evolution of economic theories of growth.

Price-focused studies drew on growth theories where technological change was exogenous (e.g. Solow 1956), with empirical studies distinguishing between external price factors, notably the impact of exchange rate movements on R&D spending (e.g. Landesmann and Pfaffermayr 1997; Branstetter and Kwon 2018); and internal price factors coming via innovation that enhances productivity (e.g. Magnier and Toujas-Bernate 1994; Madden *et al* 1999; Tebaldi 2011; Falk and Figueira de Lemos 2019). Theories of endogenous growth (originating with Romer 1986; Lucas 1988) underpin research focusing more on non-price factors, with their emphasis on the positive impacts of technological change driven proactively by economic actors undertaking innovation activities (e.g.

Navaretti and Tarr 2000; Licandro and Navas-Ruiz 2007; Benhabib *et al* 2014; Dosi *et al* 2015).

Whilst recent theoretical contributions explore imitation and innovation as a strategic choice (*inter alia*, Sohn 2008; Wanasika and Conner 2011; Benhabib *et al* 2014; Khan and Peeters 2017), much of the empirical literature analyses how firms (or in just a few studies, countries), move from imitator to innovator (*inter alia*, Hobday 1995; Navaretti and Tarr 2000; Keller 2010; Lim 2017; Branstetter and Kwon 2018).[5]

Focusing specifically on innovation, this is enabled through R&D expenditures and subsequently reflected in patent applications, although it has been argued that the links are filtered through commercialisation (Rahman *et al* 2019). These authors identify high-tech exports specifically as being a proxy for commercialisation, which supports our chosen approach. Further, the literature also makes it clear that there is no simple linear relationship between R&D and patents. R&D is seen as the main means of knowledge production (Braunerhjelm and Thulin 2008), but not all innovations arise from R&D spending (Gorodnichenko *et al* 2010). In turn, patents offer 'consistency and objectiveness' (Boone *et al* 2019 p 287). These authors identify shortcomings, but they are directed at firm level factors (see also Jin *et al* 2019). Further, whilst patents are not a perfect measure of R&D, they do reflect its technological effectiveness (Cincera 1997). Although the NICs previously engaged more in imitation and adaptation than innovation (Gorodnichenko *et al* 2010), with limited resources for R&D to enhance their innovation capacity (Oura *et al* 2016), this situation continues to evolve, creating a need to return to the topic periodically.

Building on notions of innovation, including for high-tech goods, a distinction can be drawn between product and process innovation (OECD 2018 p 20; see also, *inter alia*, Lo Turco and Maggioni 2015; Szutowski and Szułczyńska 2017; Yang 2018; Enjolras *et al* 2019; Radicic and Djalilov 2019). A further justification for the present study comes from the observation that much of this literature consists of country-specific studies, with no clear cross-country patterns to be found between the type of innovation, productivity and exports (*inter alia*, Landesmann and Pfaffermayr 1997; Cassiman *et al* 2010; Denicolai *et al* 2015; Azari *et al* 2017).

Most of these studies draw on firm-level data, although some also explore how government policy might explain cross-country differences in innovation. One such study is that conducted by Cimoli *et al* (2019). They develop a model to highlight the importance of a government's industrial policy in explaining countries divergent development paths. They compare Argentina and Brazil with Korea (albeit using data only up to 2008). Significantly, these countries also represent the different paths chosen after Balassa's (1990) first stage of import substitution with, broadly speaking, Asian countries moving away from import-substituting policies earlier than Latin American countries.

Cross-cutting the debate over product and process innovation is the debate over whether firms export that have already enhanced productivity (the 'self-selection' hypothesis), or whether firms export, in order to learn, adopt and/or copy from others, through the dynamics of international trade and competition (the 'learning-by-exporting' hypothesis). Again, most studies are at the firm-level.

Several studies find evidence of both self-selection and learning by exporting (see Kiriyama 2012, for a concise review; and, *inter alia*, Gkypali *et al* 2015; Rodil *et al* 2016; Yang 2018). Studies finding evidence only of learning by exporting include Salomon and Shaver (2005), Liu and Buck (2007) and Damijan *et al* (2010). We do not explore this literature in detail, although we note that many studies have an intrinsic shortcoming in that they do not allow for even the possibility of two-way causality (noted by, *inter alia*, Damijan *et al* 2010; Filipescu *et al* 2013). Referring back to the product/process innovation literature, a link has been found, with evidence that learning by exporting links to process innovation rather than product innovation (*inter alia*, Damijan *et al* 2010).

Turning specifically to the small literature analysing links between R&D and high-tech exports at the country-level, a positive impact has been found for OECD countries (Braunerhjelm and Thulin 2008), EU countries (Sandu and Ciocanel 2014) and individual countries (e.g. Khan *et al* 2024). That said, concerns have been raised about how to measure innovation. R&D expenditure, it has been argued, does not of itself reflect innovation. Hao *et al* (2016) prefer to use new products, whilst Gorodnichenko *et al* (2010 p 199) highlight potential problems with both patents and R&D spending as indicators of innovation.

Gorodnichenko *et al* (*ibid.*) also suggest that firms in (what they refer to as) emerging economies are more likely to engage in imitation and adaptation of existing technologies 'than generating new inventions or expending resources on R&D.' Given that some studies have found a link between R&D expenditures and high-tech exports, the question then becomes one of whether this is real, or a statistical anomaly. In the presence of international supply chains, exports of high-tech products from emerging economies, recorded in their official trade statistics, may not be the result of innovation in those countries. Indeed, it may not even be the result of imitation. Rather, the innovation may have taken place in a developed country, from where firms have outsourced parts of the manufacturing process to emerging or developing economies.

Two key studies in this debate are Mani (2000) and Srholec (2007).[6] Both authors find evidence consistent with the 'statistical anomaly' hypothesis: that emerging and developing countries' high-tech exports result from global production networks, rather than from domestic innovation (or imitation) activity. That said, both authors counsel caution in interpreting these findings. Mani observed that, even at the time of his writing, developing countries were catching up in terms of patents and high-tech exports, whilst Srholec noted that his cross-sectional analysis could not capture innovation dynamics. Herein lies the importance of the analysis presented below in Sections 3 and 4.

We use time series data that cover a much more recent period, enabling a clearer illumination of the issues and shortcomings noted by both Srholec and Mani about their own work[7], whilst also exploring what might have changed about these fundamental relationships in the last quarter-century.

Beyond the statistical anomaly questions, one study that explores innovation across a group of high- and middle-income countries, albeit one that does not consider imitation, is Rahman *et al* (2019). They find that R&D expenditure had no effect on high-tech exports or GDP. High-tech exports affected GDP only in some models. Patents had mixed effects on high-tech exports in different models. Overall, the effects were generally positive in high-income countries, in the short and long run. In middle income countries, the effects were significant only in the long run – and then only with the support of FDI. As we show below, our analysis of NICs (most of our sample being middle-income countries) finds positive impacts from R&D expenditure and patents, in the short and long run, which suggests their domestic capacity for expanding high-tech exports has expanded significantly.

We can now reflect on the key themes identified in this brief review of the literature that will inform our principal research design. First, almost all studies use firm-level data. Second, strong interlinkages are to be found across themes – so that, for example, several studies exploring whether firms are self-selecting exporters or seeking to learn by exporting, also differentiate between product and process innovation. Similarly, several of these studies also analyse whether the factors underlying the ability to export are derived from price or nonprice innovations or developments. Some studies have specifically questioned whether or not patents and/or R&D spending actually reflect successful innovation activity. Current results are mixed.

From this, we derive our primary research question: how does innovation activity impact on a country's high-tech exports? We then delve in detail to explore the possibly-causal relationships between high-tech exports and two factors that, in different studies, have been shown to influence innovation: research and development (R&D) expenditures and patent applications. Specifically, we apply panel cointegration and Granger causality methods to annual data from 1996 to 2016 for eight NICs, across three continents, to explore the different combinations of potentially-causal relationships between the three key variables of R&D expenditures, patent applications and exports of high-tech goods. These countries, listed below, were selected first on the basis of having been identified as NICs, but also because they were the NICs for which adequate data for our analysis was available.

Our theoretical approach reflects also the existing literature. Thus our choice of key variables are based on the premise that 'R&D is the backbone of innovation activity, and patents can be said to be the output of R&D activities' (Rahman *et al* 2019 p 4). Further, such innovations need to be commercialised, with this proxied by 'the export value of high-tech products' (*ibid*). Such relationships are also underpinned by the idea of 'dynamic comparative advantage' (Braunerhjelm and Thulin 2008 p 97); and the Rybczynski Theorem, which predicts that with development of knowledge as a factor of production, the supply of goods using that factor intensively will increase (*ibid*). From this, we derive seven hypotheses that direct our main analysis.

First, we seek to determine whether there is a long run relationship between innovation and high-tech exports:

> H1: Patents and R&D expenditures affect high-tech exports positively and significantly

We then seek to explore in detail the six possible causal relationships between high-tech exports, patents and R&D expenditures:

> H2: There is causality running from high-tech exports to R&D expenditures
>
> H3: There is causality running from R&D expenditures to high-tech exports
>
> H4: There is causality running from high-tech exports to patents
>
> H5: There is causality running from patents to high-tech exports
>
> H6: There is causality running from patents to R&D expenditures
>
> H7: There is causality running from R&D expenditures to patents.

We include H6 and H7 as a robustness check, to establish whether or not our two explanantia – patents and R&D spending – are themselves causally connected (the empirical literature is inconclusive on this point despite the intuition that, in particular, R&D spending may lead to more patents). It is to this analysis that we now turn.

3. Data and Methodology

The main objective of this study is to investigate empirically both the long-run and causality relationships of patents and R&D expenditures on high-tech exports in eight NICs over 1996–2016: Brazil, Mexico, Malaysia, China, South Africa, India, Thailand and Turkey.[8] Data on high-tech exports, patents and R&D expenditures have been collected from the World Bank.[9] High-tech exports and R&D expenditure are measured as a percentage of GDP, providing the crucial link between the microeconomic level of firm decisions, and their macroeconomic implications. Patents, as is typical in the literature, are measured by the number of patent applications. The data for high-tech exports cover the product sectors as defined earlier.

We use panel cointegration and panel Granger causality testing procedures. Following the literature (see Shan and Sun 1998; Çetin 2016), the long-run multivariate relationships between high-tech exports, patents, and R&D expenditure are set as follows:

$$lhx_{it} = \mu_0 + \phi_1 lrd_{it} + \phi_2 lpt_{it} + \varepsilon_{it} \quad (1)$$

where lhx, lrd, and lpt represent the logarithms of high-tech exports, R&D expenditures and the number of patent applications respectively; t represents time; i represents the eight NICs; and ε's are the error terms. In equation (1), the coefficients of R&D expenditures (ϕ_1) and patents (ϕ_2) are expected to have positive signs, following the literature discussed in Section 2. All three variables used in our model are in log form, so the coefficients of the independent variables are interpreted as elasticities. In order to obtain the long-run coefficients of the independent variables in equation (1), we use vector based panel dynamic ordinary least squares (DOLS) to estimate the following model:

$$lhx_{it} = \mu_0 + \phi_1 lrd_{it} + \phi_2 lpt_{it} + \sum_{k=-K_i}^{K_i} \alpha_k \Delta lrd_{it} + \sum_{k=-K_i}^{K_i} \beta_k \Delta lpt_{it} + \varepsilon_{it} \quad (2)$$

K_i and $-K_i$ represent, respectively, the number of lags and leads included in the DOLS regression to ensure its stochastic error term is independent of all past innovations in stochastic regressors. The strong assumption of homogenous parameter β in the LLC unit root test is difficult to satisfy, given that cross-sectional units may have different speeds of adjustment towards long-run equilibrium. By relaxing this assumption, Im *et al* (2003) proposed a panel unit root test which allows parameter β to vary across all i. Therefore, in the IPS testing procedure, equation (2) is re-written as follows:

$$\Delta y_{it} = \alpha_{it} + \beta_i y_{it-1} + \sum_{j=1}^{k} \delta_j y_{it-j} + \varepsilon_{it} \quad (3)$$

Testing for a unit root in the panel is undertaken using the Augmented Dickey Fuller (ADF) statistic, averaged across groups. The null hypothesis of $\beta_i = 0$ for all i is tested against the alternative hypothesis of $\beta_i < 0$ for at least one i. The null hypothesis accordingly implies that all series have a unit root, while the alternative hypothesis suggests that some of the series in the panel are assumed to be stationary.

Finally, we aim to detect short-run dynamic causality in panel data, using a test developed by Dumitrescu and Hurlin (2012). This test is a simple version of the Granger (1969) non-causality test for heterogeneous panel data models with fixed coefficients. For each individual unit of i, we consider the following linear model:

$$y_{it} = \alpha_i + \sum_{k=1}^{K} \delta_i^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} x_{i,t-k} + \varepsilon_{it} \quad (4)$$

Where x and y are two stationary variables observed for N individuals in T periods. For simplicity, the individual effects α_i are assumed to be fixed in the time dimension. We also assume that lag orders of K are identical for all cross-section units of the panel, and that the panel is balanced. However, we also allow the autoregressive parameters $\delta_i^{(k)}$ and the regression coefficients $\beta_i^{(k)}$ to differ across groups.

As in Granger (1969), the procedure to determine the existence of a causal relationship between x and y is to test significant effects of past values of x on the present value of y. The null hypothesis is therefore defined as:

$$H_1 = \beta_i = 0 \qquad \forall_i = 1, \ldots, N \tag{5}$$

which corresponds to the absence of causality for all cross-section units in the panel. The Dumitrescu-Hurlin test assumes there can be causality for some cross-section units but not necessarily for all. The alternative hypothesis is thus:

$$\begin{aligned} H_0 &= \beta_i = 0 \quad \forall_i = 1, \ldots, N_1 \\ H_1 &= \beta_i \neq 0 \quad \forall_i = N_1 + 1, \ldots, N \end{aligned} \tag{6}$$

where N_1 is unknown but satisfies the condition $0 \leq \frac{N_1}{N} \leq 1$. If $N_1 > N$ there is no causality for all cross-section units in the panel. The Dumitrescu-Hurlin test involves three average statistics, including $W_{N,T}^{HNC}$ that can be expressed as follows:

$$W_{N,T}^{HNC} = \frac{1}{N} \sum_{i=1}^{N} W_{i,T} \tag{7}$$

where $W_{i,T}$ represents the individual Wald statistics for the i'th cross-section unit corresponding to the individual test $H_0 = \beta_i = 0$.

4. Empirical Results

In our panel cointegration and causality analysis, first, the unit root test determines whether the relevant variables, high-tech exports, patents, and R&D expenditures, are stationary. If not, the estimation of the model yields spurious results (Baltagi 2005). There are two types of unit root test; a common unit root test and individual unit root tests for each panel member. In this study, we use and report only the individual unit root test proposed by Im *et al* (2003). The lag length for the unit root tests was selected based on the Schwarz information criteria, with estimation of an initial three lags on the first-differenced dependent variable.

The results of the panel unit root tests are reported in Table 1. The results do not provide a uniform conclusion that the null hypothesis of a unit root can be rejected at appropriate levels. However, the test statistics for the first-differences strongly reject the null hypotheses, implying that the variables are stationary in first-difference form. From the unit root analysis, we therefore conclude that the variables are integrated of order one, indicating the existence of a possible long-run cointegrating relation among high-tech exports, patents, and R&D expenditures.

Table 1: Results for the panel unit root tests

	Levels		First Differences	
	Constant	*Constant + trend*	*Constant*	*Constant + trend*
lhx	–2.675*** [2] (0.003)	–2.309*** [1] (0.01)	–7.526*** [1] (0.000)	–6.713*** [0] (0.000)
lrd	1.405 [1] (0.92)	0.004 [1] (0.501)	–6.171*** [0] (0.000)	–3.898*** [0] (0.000)
lpt	–1.291* [2] (0.098)	–1.002 [2] (0.158)	–12.21*** [0] (0.000)	–10.58*** [3] (0.000)

Notes: Superscripts *** and * show 1% and 10% significance level, respectively. Values in square brackets and parentheses are the number of lags and probabilities, respectively.

The next step is to test whether there is a long-run relationship between the variables. There are different tests for cointegration, such as Kao (1999), Pedroni (1999, 2004) and a Fisher-type test using an underlying Johansen methodology (Maddala and Wu 1999). In this study Pedroni's (2004) residual based cointegration test is employed, specifically to check whether there is a cointegrating relationship between the variables. The results are provided in Table 2. This test uses seven test statistics; four for 'within dimension' and three for 'between dimension'. From the estimation of equation (1) with an intercept and a trend, five out of eleven test statistics are found to be statistically significant at the 1 per cent and 5 per cent significance levels. This means that we can reject the null hypothesis of no cointegration and assert that there is a long-run relationship between high-tech exports, patents, and R&D expenditures.

Table 2: Pedroni (2004) residual cointegration test results

Alternative hypothesis: common AR coefficients. (within-dimension)				
	t -Stat.	*Prob.*	*Weighted Stat.*	*Prob.*
Panel v-Stat.	–0.456	0.676	–1.203	0.885
Panel rho-Stat.	0.537	0.704	1.072	0.858
Panel PP-Stat.	–2.290**	0.011	–1.865**	0.031
Panel ADF-Stat.	–2.749***	0.003	–2.193**	0.014
Alternative hypothesis: individual AR coefficients. (between-dimension)				
	t -Stat.	*Prob.*		
Group rho-Stat.	1.979	0.976		
Group PP-Stat.	–1.254	0.104		
Group ADF-Stat.	–2.037**	0.020		

Note: Superscripts *** and ** show 1% and 5% significance level respectively. The tests are carried out with one lag. Estimations are carried out using Eviews.

Once the cointegration relationship is established, the next step is to estimate the long-run coefficients of the relevant variables. The long-run coefficients are estimated by means of the dynamic ordinary least squares (DOLS) method developed by Pedroni (1999, 2004). In order to determine the appropriate lag length for the DOLS model, we use four information criteria, namely Final Prediction Error, Akaike Information Criteria, Schwarz Information Criteria, and Hannan and Quinn Information Criteria. For this purpose, we first estimate an unrestricted VAR model with a constant term for our three variables. Most of these lag selection criteria identify a lag length of 1. Results from the panel DOLS estimations are reported in Table 3. As can be seen from the table, both the patent and R&D expenditure variables have positive coefficients, but only the patents variable has a significant impact on the performance of high-tech exports from the NICs. Results indicate that a 1 per cent increase in the number of patent applications is associated with a 0.22 per cent increase in the level of high-tech exports. This finding is also in line with the self-selection hypothesis.

Table 3: Results from Panel Dynamic Least Squares (DOLS) Estimation

Variable	*Coefficient*	*t -Stat.*	*Prob.*
lrd	0.05	0.320	0.749
lpt	0.226	3.204	0.002***
R-squared	0.988	Mean dependent var	0,685
Adjusted R-squared	0.975	S.D. dependent var	1.572
S.E. of regression	0.247	Sum squared resid	3.933
Lon-run variance	0.072		

Notes: Lead and lags were set to one for the panel DOLS estimator. Superscript *** shows 1% significance level.

Having determined the presence of long-run cointegration, we now search for causality and directionality between each pair of variables. The results of the pairwise Granger causality test are presented in Table 4, where the computed W-Statistics and Z-bar-Statistics, with their probabilities, are reported. The results of this analysis showed that high-tech exports have a bi-directional causal relationship with both patents and R&D expenditures for the NICs. That said, whilst both R&D and patents both cause high-tech exports at the one per cent level, the significance of the reverse causality is less strong, at five per cent for R&D and ten per cent for patents. Thus patents and R&D expenditures play a crucial role in enhancing high-tech exports from the NICs in the short-run; with some evidence also of reverse causality. This finding is partially consistent with the outcomes of the panel DOLS estimation above, that patents contribute to enhancing high-tech exports from the NICs in the long-run. The result also shows that there are no causal relationships between patents and R&D expenditures.

Table 4: Results from Pairwise Dumitrescu-Hurlin Panel Granger Causality Tests

Sample: 1996–2016
Lags: 1

Null hypothesis:	*W-Stat.*	*Z-bar-Stat.*	*Prob.*
lhx does not homogenously cause lrd	2.505**	1.975**	0.048
lrd does not homogenously cause lhx	4.027***	4.231***	0.000
lhx does not homogenously cause lpt	2.285*	1.832*	0.066
lpt does not homogenously cause lhx	2.964***	2.913***	0.003
lrd does not homogenously cause lpt	2.182	1.496	0.134
lpt does not homogenously cause lrd	1.618	0.660	0.508

Note: Superscript ***, ** and * show statistical significance at 1%, 5% and 10% levels respectively. The optimal lag length is determined using the Schwarz Information Criteria. Estimations are conducted using Eviews.

5. Discussion and Conclusions

In this paper, we have sought to analyse and update the prevailing literature on the imitation-innovation debate, focusing on the links between R&D expenditures, patents and high-tech exports, for a panel of eight NICs over the period 1996–2016. Our focus on the country level complements the extensive literature analysing firm level data. Our analysis helps to provide an important update on the empirical question of how the NICs, over time, may or may not be evolving from imitators to innovators, vis-à-vis earlier studies.

To give focus to our research we identified seven hypotheses. Following the analysis above, our findings can be summarised as follows. Our first finding is that patents exert a significant and positive effect on these countries' exports of high-tech goods in the long-run. R&D does not, however, meaning that we can only partially accept H1. The impacts of R&D and patents on high-tech exports are significant at the one per cent level, giving strong support for H3 and H5. We also find supporting evidence that high-tech exports impact R&D expenditures, supporting H2 at the five per cent level; and that high-tech exports impact patents, supporting H4 at the 10 per cent level. We find no evidence that patents impact on R&D, or that R&D impacts patents. This allows us to reject H6 and H7, which offers reassurance that our findings could not have been affected by multicollinearity between these two variables.

To reflect further on these findings, we first reiterate the point that the major difference between most earlier studies and our own is that we reflect on those relationships as they play out at the national level. We thus have very few other studies to compare with *directly*. The work of Braunerhjelm and Thulin (2008) has some similarity to ours, albeit for OECD countries. Moreover, they focus on R&D spending – we are unaware of any other such study focusing on both R&D and patents jointly.

Considering first our partial support for H1, we note that countries evolve from imitators to innovators over time, given that 'imitation is a key stepping-stone to innovation' (Lim 2017 p 2). The detailed findings for H1 offer support that, in the long run, our countries have passed from imitators to innovators, with patents but not R&D expenditures having a significant impact on high-tech exports. In the short-run, the acceptance of H2–H5 needs to be interpreted in the context of the literature discussed in Section 2.

Notably, whilst R&D expenditure is seen as the main means of knowledge production (Braunerhjelm and Thulin 2008), not all innovations arise from R&D expenditures (Gorodnichenko *et al* 2010). Moreover, and crucially, patents are not a perfect measure of R&D, but they do reflect its technological effectiveness (Cincera 1997). Given our interest in H3 and H5 we note that H2 and H4, reflecting 'reverse causality', suggest that high tech exports, still provide positive feedback effects, even though, statistically, these effects are less than the impact of R&D and patents on high-tech exports. This might indicate that some, but only some, of the high-tech export revenues generated are being fed back into R&D, with some of this activity in turn generating fewer, but still some, new patent applications.

Although some have argued, even relatively recently, that the NICs were engaging more in imitation and adaptation than innovation (Gorodnichenko *et al* 2010), with limited resources for R&D to enhance their innovation capacity (Oura *et al* 2016), a comparison with Cheng (2019) shows how much these countries' innovation and patenting activities have evolved in recent years – a finding that our study updates and advances. The presence of links between high-tech exports and R&D expenditures in the short-run, but not the long-run, suggests that R&D expenditure generates advances (consistent with Braunerhjelm and Thulin 2008); and whatever impacts are felt initially, they feed through to patents that deliver a long-run boost to high-tech exports, consistent with the arguments of Cincera (1997). By accounting for the dynamics of innovation and exports, we therefore find that the NICs have seen their competitive advantages enhanced by R&D activity that has generated patents having a long-term impact on high-tech exports. Our results thus offer strong support for NICs now innovating rather than imitating.

Related to this debate, as argued in Section 2, is the notion that innovation is linked more to the self-selection hypothesis of exporters than learning by exporting. To the extent that the move through to NIC status, with progressively greater exposure to and engagement in international trade, is underpinned by trade liberalisation, we could expect innovation to run ahead of exports (Costantini and Melitz 2007). From this, we infer support also for the self-selection hypothesis. Further support for the self-selection hypothesis over the learning by exporting hypothesis is found by noting that patent activity is associated with product innovation rather than process innovation (Dosi *et al* 2015; Paula and da Silva 2019); and that product innovation is, in turn, found to be linked more to self-selection (Damijan *et al* 2010; van Beveren and Vandenbussche 2010).

Our results, but especially the partial acceptance of H1 in favour of patents but not R&D expenditures, offer a powerful rejection of the 'imitation' hypothesis in the long run. Imitation might induce expenditures, such as for reverse engineering, but imitation would not in such cases lead to new patents. The finding that high-tech exports are driven significantly by patents in the long run, but not by R&D expenditures, emphasises once again the importance of undertaking analyses that enable the exploration of the inherently dynamic processes linking R&D, innovation, patents and exports. These findings also provide more recent and more positive results for the (middle-income) NICs in our sample, vis-à-vis the results of, for example, Rahman et al (2019) reported earlier. Most notably, the results in our study find a direct and positive impact of innovation on high-tech exports.

We also, therefore, reject, for the countries in our study and the time-period studied, the idea that any link found between innovation and high-tech exports is a statistical anomaly. It is interesting to note that our findings support the innovation hypothesis, notwithstanding the argument that in the presence of global value chains (GVCs), intellectual property diffusion through technology transfer is harder to control (Kuźnar and Folfas 2018). Yet the possible presence of such a flying geese effect (as implied by Hobday 1995 p 1187, and stated explicitly by Lim 2017 p 3), enabled by GVCs, has not discouraged the NICs in our sample from undertaking innovation that has moved them firmly away from any imitative behaviour, towards high-tech innovation.

Overall, our research offers important findings that complement the prevailing literature on innovation and exports. We have provided evidence that supports the argument that the NICs have seen their high-tech exports boosted in the long-run by innovation activity. In the short run, R&D boosts high-tech exports. Crucially, however, patents then provide a long term boost to high-tech exports. The prevailing literature found evidence indicating primarily that NICs (what some studies referred to as emerging economies) were imitating rather than innovating. Our updated analysis suggests that innovation activities in the NICs have advanced considerably, with considerable positive consequences for the export of high-tech products. The extent of reverse causality, whilst less strongly significant, confirms the suggestion that this is a dynamic process of positive feedback that will further boost high tech exports over time. More recent analyses will be impacted by the impacts of COVID-19 and subsequent disruption to GVCs. For now, a focus on the pre COVID-19 period allows for a less clouded analysis of these effects.

Our findings also suggest that more country-level research is warranted and we hope that this study will stimulate research in this direction. For example, we have confirmed that countries move from imitator to innovator over time. This highlights a case for the evolution of other emerging economies from imitator to innovator to be regularly re-examined. The literature analysing national-level data on the links between patents, R&D expenditures and high-tech exports remains nascent, so work is also required to determine whether other factors, not yet explored, are contributing to the growth in high-tech exports. Further, this will allow for a deeper comparison with the findings of the many firm-level studies.

As research progresses, clearer understanding can be developed regarding the implications for government policy, notably how best governments can create a facilitating environment for innovation activity, that can drive high-tech exports. From this, greater understanding can emerge concerning the dynamics around promoting economic transformation and economic growth, through research and innovation.

Accepted for publication: 16 April 2025

Endnotes

1. Professor Emeritus Robert Ackrill (corresponding author), Department of Economics, Nottingham Business School, Nottingham Trent University, Burton Street, Nottingham, NG1 4BU, UK; Email robert.ackrill@ntu.ac.uk. Professor Rahmi Çetin, Kahramanmaraş Sütçü İmam University, Faculty of Economy and Administrative Sciences, Department of Economics, Kahramanmaraş, Turkey; Email: crahmi@hotmail.com. We gratefully acknowledge valuable comments from reviewers and the Editor on previous versions of the paper. The usual disclaimer applies.

2. In this paper we describe our focus countries as NICs, rather than as 'emerging economies', to reflect our analytical interest in industrialisation in general, and the growth of exports in high-tech products in particular.

3. https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an_5.pdf (last accessed 6 February 2025).

4. A search for "export led growth" on 5 February 2025 yielded 971 hits on the Econlit database, and 'about 65,500' hits on Google Scholar.

5. There is an extensive literature that links these issues with intellectual property rights protection. A consideration of this is beyond the scope of the present paper. Contributions include, *inter alia*, Maskus 2016; Zhang and Yang 2016; Branstetter 2017; Kuźnar and Folfas 2018; Ivus and Park 2019.

6. Our intention here is to explore only the specific point of whether evidence on non-developed countries' high-tech exports may, or may not, be the result of a statistical anomaly resulting from globalised production networks. A detailed consideration of the empirical literature analysing foreign direct investment and the emergence of NICs within these networks is beyond the scope of the present paper. See, amongst many, Hill and Athukorala 1998; Yusuf and Nabeshima 2009.

7. Strictly speaking, 'anomaly' and 'artefact' (artifact as Mani spells it), are not synonyms. That said, it is clear from the text that Mani is referring to what others call an anomaly (see, in particular, Mani, 2000: 33).

8. This is a notably broader set of countries than, for example, Cimoli *et al* 2019, although their particular interest was industrial policies. All bar India are classified by the World Bank for fiscal year 2025 as upper middle income countries, with India classified as a lower middle income country (accessed 5 February 2025): https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

9. Full details of the definition and coverage of each variable can be found in the accompanying metadata on the World Bank Website.

R&D Expenditures: https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS

Patents: the sum of applications by residents (https://data.worldbank.org/indicator/IP.PAT.RESD) and non-residents (https://data.worldbank.org/indicator/IP.PAT.NRES).

High-tech exports: in US dollars (https://data.worldbank.org/indicator/TX.VAL.TECH.CD).

References

Azari M J, Madsen T K and Moen Ø (2017) 'Antecedent [sic] and Outcomes of Innovation-Based Growth Strategies for Exporting SMEs', *Journal of Small Business and Enterprise Development*, 24, 733-752.

Balassa B (1990) 'Policy Choices in the Newly Industrializing Countries', World Bank Policy, Research and External Affairs Working Paper WPS 432. Available at: http://documents.worldbank.org/curated/en/428541468770403738/Policy-choices-in-the-newly-industrializing-countries (last accessed 13 October 2019).

Baltagi B H (2005) *Econometrics Analysis of Panel Data*, 3e. Chichester: John Wiley & Sons.

Bell M and Figueiredo P N (2012) 'Building Innovative Capabilities in Latecomer Emerging Market Firms: Some key issues' in Amann E and Cantwell J (eds) *Innovative Firms in Emerging Market Countries*, Oxford: Oxford U P, 24-109.

Benhabib J, Perla J and Tonetti C (2014) 'Catch-up and fall-back through innovation and imitation', *Journal of Economic Growth*, 19, 1-35.

Bernard A, Jensen J B, Redding S J and Schott P K (2012) 'The Empirics of Firm Heterogeneity and International Trade', *Annual Review of Economics*, 4, 283-313.

Boone C, Lokshin B, Guenter H and Belderbos R (2019) 'Top Management Team Nationality Diversity, Corporate Entrepreneurship, and Innovation in Multinational Firms', *Strategic Management Journal*, 40, 277-302.

Branstetter L (2017) 'Intellectual Property Rights, Innovation and Development: Is Asia different?', *Millennial Asia*, 8, 5-25.

Branstetter L G and Kwon N (2018) 'South Korea's Transition from Imitator to Innovator: The role of external demand shocks', *Journal of the Japanese and International Economies*, 49, 28-42.

Braunerhjelm P and Thulin P (2008) 'Can Countries Create Comparative Advantages? R&D expenditures, high-tech exports and country size in 19 OECD countries, 1981-1999', *International Economic Journal*, 22, 95-111.

Cassiman B, Golovko E and Martínez-Ros E (2010) 'Innovation, Exports and Productivity', *International Journal of Industrial Organization*, 28, 372-376.

Çetin R (2016) Yeni sanayileşen ülkelerde ar-ge harcamaları ve yüksek teknoloji ürünü ihracatı arasındaki ilişkinin panel veri analizi yöntemi ile incelenmesi, *İktisat Fakültesi Mecmuası*, 66(2), 30-43.

Cheng W (2019) 'China Engages with the [sic] Global Intellectual Property Governance: The recent trend', *The Journal of World Intellectual Property*, 22, 146-161.

Cimoli M, Pereima J B and Porcile G (2019) 'A Technology Gap Interpretation of Growth Paths in Asia and Latin America', *Research Policy*, 48, 125-136.

Cincera M (1997) 'Patents, R&D, and Technological Spillovers at the Firm Level: Some evidence from econometric count models for panel data', *Journal of Applied Econometrics*, 12, 265-280.

Chow P C Y (1987) 'Causality Between Export Growth and Industrial Development: Empirical evidence from the NICs', *Journal of Development Economics*, 26, 55-63.

Costantini J A and Melitz M J (2007) 'The Dynamics of Firm-Level Adjustment to Trade Liberalization', Manuscript available at: http://scholar.harvard.edu/files/melitz/files/liberalizationdynamics8.pdf (last accessed 23 February 2020).

Damijan J P, Kostevc Č and Polanec S (2010) 'From Innovation to Exporting or Vice Versa?', *The World Economy*, 33, 374-398.

Demir O (2018) 'Does [sic] High Tech Exports Really Matter for Economic Growth? A Panel Approach for Upper Middle-Income Economies', *Online Academic Journal of Information Technology*, 9, 43-54.

Denicolai S, Hagen B and Pisoni A (2015) 'Be International or be Innovative? Be Both? The role of the entrepreneurial profile', *Journal of International Entrepreneurship*, 13, 390-417.

Dosi G, Grazzi M and Moschella D (2015) 'Technology and Costs in International Competitiveness: From countries and sectors to firms', *Research Policy*, 44, 1795-1814.

Dumitrescu E-I and Hurlin C (2012) 'Testing for Granger Non-Causality in Heterogeneous Panels', *Economic Modelling*, 29, 1450-1460.

Enjolras M, Camargo M and Schmitt C (2019) 'Are High-Tech Companies More Competitive Than Others: An empirical study of innovative and exporting French SMEs', *Technology Innovation Management Review*, 9, 33-48.

Ersin Ö, Ustabaş A and Acar T (2022) 'The nonlinear effects of high technology exports, R&D and patents on economic growth: A panel threshold approach to 35 OECD countries', *Romanian Journal of Economic Forecasting*, 25, 26-44.

Falk M and Figueira de Lemos F (2019) 'Complementarity of R&D and Productivity in SME Export Behavior', *Journal of Business Research*, 96, 157-168.

Filipescu D A, Prashantham S, Rialp A and Rialp J (2013) 'Technological Innovation and Exports: Unpacking Their Reciprocal Causality', *Journal of International Marketing*, 21, 23-38.

Gkypali A, Rafailidis A and Tsekouras K (2015) 'Innovation and Export Performance: Do young and old innovative firms differ?', *Eurasian Business Review*, 5, 397-415.

Gorodnichenko Y, Svejnar J and Terrell K (2010) 'Globalization and Innovation in Emerging Markets', *American Economics Journal: Macroeconomics*, 2, 194-226.

Granger C W J (1969) 'Investigating Causal Relations by Econometric Models and Cross-spectral Methods', *Econometrica*, 37(3), 424-438.

Hao L, Qiu B and Cervantes L (2016) 'Does Firms' Innovation Promote Export Growth Sustainably? Evidence from Chinese manufacturing firms', *Sustainability*, 8 (11), 1173.

Hill H and Athukorala P (1998) 'Foreign Investment in East Asian [sic]: A survey', *Asian Pacific Economic Literature* [sic], 12, 23-50.

Hobday M (1995) 'East Asian Latecomer Firms: Learning the Technology of Electronics', *World Development*, 23, 1171-1193.

Im K S, Pesaran M H and Shin Y (2003) 'Testing for Unit Roots in Heterogeneous Panels', *Journal of Econometrics*, 115, 53-74.

Ivus O and Park W (2019) Patent Reforms and Exporter Behaviour: Firm-level evidence from developing countries', *Journal of the Japanese and International Economies*, 51, 129-147.

Jin B, García F and Salomon R (2019) 'Inward Foreign Direct Investment and Local Firm Innovation: the moderating role of technological capabilities', *Journal of International Business Studies*, 50, 847-855.

Kao C (1999) 'Spurious Regression and Residual-Based Tests for Cointegration in Panel Data', *Journal of Econometrics*, 90, 1-44.

Keller W (2010) 'International Trade, Foreign Direct Investment, and Technology Spillovers' in Hall B H and Rosenberg N (eds) *Handbook of the Economics of Innovation*, Volume 2, Amsterdam: North Holland, 793-829.

Khan A and Peeters R (2017) 'Imitation and Price Competition in a Differentiated Market', *Journal of Economic Dynamics and Control*, 82, 177-194.

Khan T, Wei L, Khan A, Fahlevi M, Aljuaid M and Ali S (2024) 'Economic expansion and innovation: A comprehensive analysis of Pakistan's path to technological excellence', *PLoS ONE*, 19, e0300734.

Kiriyama N (2012) 'Trade and Innovation: Synthesis report', OECD Trade Policy Papers No. 135, Paris: Organisation for Economic Cooperation and Development. Available at: https://www.oecd-ilibrary.org/trade/trade-and-innovation_5k9gwprtbtxn-en (last accessed 7 October 2019).

Kuźnar A and Folfas P (2018) 'How Does the Protection of Intellectual Property Rights Affect Hi-Tech Exports from the Most Advanced Countries?', *Argumenta Oeconomica*, 41, 277-296.

Landesmann M and Pfaffermayr M (1997) 'Technological Competition and Trade Performance', *Applied Economics*, 29, 179-196.

Lee Y S (1987) 'A Study of the Determinants of Intra-Industry Trade among the Pacific Basin Countries', *Weltwirtschaftliches Archiv*, 125, 346-358.

Licandro O and Navas-Ruiz A (2007) 'Trade Liberalization, Competition and Growth', EUI EUI Working Paper ECO 2007/19. Available at: https://cadmus.eui.eu/handle/1814/7106 (last accessed 7 October 2019).

Lim K Y (2017) 'Assessing the Double-Edged Sword of Using Imitation as a Stepping Stone to Innovation: A case of Malaysia's K-Economy Puzzle', *The Singapore Economic Review*, 63, 29 pp.

Liu X and Buck T (2007) 'Innovation Performance and Channels for International Technology Spillovers: Evidence from Chinese high-tech industries', *Research Policy*, 36, 355-366.

Lo Turco A and Maggioni D (2015) 'Dissecting the Impact of Innovation on Exporting in Turkey', *Economics of Innovation and New Technology*, 24, 309-338.

Lucas R E (1988) 'On the Mechanics of Economic Development', *Journal of Monetary Economics*, 22, 3-42.

Maddala G S and Wu S (1999) 'A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test', *Oxford Bulletin of Economics and Statistics*, 61, 631-652.

Madden G, Savage S J and Thong S Y (1999) 'Technology, Investment and Trade: Empirical evidence for five Asia-Pacific countries', *Applied Economics Letters*, 6, 361-363.

Magnier A and Toujas-Bernate J (1994) 'Technology and Trade: Empirical evidences [sic] for the major five industrialized countries', *Weltwirtschaftliches Archiv*, 130, 494-520.

Mani S (2000) 'Export of High Technology Products from Developing Countries: Is it real or a statistical artifact [sic]?', United Nations University Institute for New Technologies Discussion Paper #2001. Available at:

http://archive.unu.edu/hq/library/Collection/PDF_files/INTECH/INTECHdp2001.pdf (last accessed 7 October 2019).

Maskus K (2016) 'Patents and Technology Transfer Through Trade and the Role of Regional Trade Agreements', East-West Center Working Papers, Innovation and Economic Growth Series No. 10. Honolulu: East-West Center. Available at:

https://www.eastwestcenter.org/publications/patents-and-technology-transfer-through-trade-and-the-role-regional-trade-agreements (last accessed 3 November 2019).

Minviel J-J and Bouheni F B (2022) 'The impact of research and development (R&D) on economic growth: new evidence from kernel-based regularized least squares', *The Journal of Risk Finance*, 23, 583-604.

Morris D (2018) 'Innovation and Productivity Among Heterogeneous Firms', *Research Policy*, 47, 1918-1932.

Navaretti G B and Tarr D G (2000) 'International Knowledge Flows and Economic Performance: A review of the evidence', *The World Bank Economic Review*, 14, 1-15.

Nelson R R and Pack H (1999) 'The Asian Miracle and Modern Growth Theory', *The Economic Journal*, 109, 146-436.

OECD (2018) *Oslo Manual 2018: guidelines for collecting, reporting and using data on innovation*, Paris: Organisation for Economic Cooperation and Development.

Oura M M, Novaes Zilber S and Luiz Lopes E (2016) 'Innovation Capacity, International Experience and Export Performance of SMEs in Brazil', *International Business Review*, 25, 921-932.

Paula F de O and da Silva J F (2019) 'The Role of the Appropriability Mechanisms for the Innovative Success of Portuguese Small and Medium Enterprises', *International Journal of Innovation Management*, 23, 1950032.

Pedroni P (1999) 'Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors', *Oxford Bulletin of Economics and Statistics*, 61, 653-670.

Pedroni P (2004) 'Panel Cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis', *Econometric Theory*, 20, 597-625.

Radicic D and Djalilov K (2019) 'The Impact of Technological and Non-Technological Innovations on Export Intensity in SMEs', *Journal of Small Business and Enterprise Development*, 26, 612-638.

Rahman S, Suwitho S, Oh A and Purwati A A (2019) 'Commercialization of High-Tech Innovations and Economic Growth in The Worldwide Most Innovative Countries', MPRA Paper 97766, Munich Personal RePEc Archive. Available at: https://mpra.ub.uni-muenchen.de/97766/ (last accessed 6 February 2025).

Rodil Ó, Vence X and del Carmen Sánchez M (2016) 'The Relationship Between Innovation and Export Behaviour: The case of Galician firms', *Technological Forecasting & Social Change*, 113, 248-265.

Romer P M (1986) 'Increasing Returns and Long-Run Growth', *Journal of Political Economy*, 94, 1002-1037.

Salomon R M and Shaver J M (2005) 'Learning by Exporting: New insights from examining firm innovation', *Journal of Economics & Management Strategy*, 14, 431-460.

Sandu S and Ciocanel B (2014) 'Impact of R&D and Innovation on High-Tech Export [sic]', *Procedia Economics and Finance*, 15, 80-90.

Shan J and Sun F (1998) 'On the export-led growth hypothesis: The econometric evidence from China', *Applied Economics*, 30, 1055–1065.

Sohn S J (2008) 'The Two Contrary Effects of Imitation', *Economic Modelling*, 25, 75-82.

Solow R M (1956) 'A Contribution to the Theory of Economic Growth', *Quarterly Journal of Economics*, 70, 65-94.

Srholec M (2007) 'High-Tech Exports from Developing Countries: A symptom of technology spurts or statistical illusion?', *Weltwirtschaftliches Archiv*, 143, 227-255.

Szutowski D and Szułczyńska J (2017) 'Exploring Companies' Innovation Policies in the Industrial Sector in Central and Eastern Europe', *Journal of Management and Business Administration: Central Europe*, 25, 158-176.

Tebaldi E (2011) 'The Determinants of high-Technology Exports: A panel data analysis', *Atlantic Economic Journal*, 39, 343-353.

Van Beveren I and Vandenbussche H (2010) 'Product and Process Innovation and Firms' Decision to Export', *Journal of Economic Policy Reform*, 13, 3-24.

Wanasika I and Conner S L (2011) 'When is Imitation the Best Strategy?'. *Journal of Strategic Innovation and Sustainability*, 7, 79-93.

Yang C-H (2018) 'Exports and Innovation: The role of heterogeneity in exports', *Empirical Economics*, 55, 1065-1087.

Yusuf S and Nabeshima K (2009) 'Tiger Economies Under Threat: A Comparative Analysis of Malaysia's Industrial Prospects and Policy Options', Washington DC: The World Bank. Available at: http://documents.worldbank.org/curated/en/920331468088743340/Tiger-economies-under-threat-a-comparative-analysis-of-Malaysias-industrial-prospects-and-policy-options (last accessed 31 October 2019).

Zhang H and Yang X (2016) 'Intellectual Property Rights Protection and Export Quality', *International Journal of Development Issues*, 15, 168-180.