Technological Forecasting & Social Change xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Varieties of capitalism, innovation performance and the transformation of science into exported products: A panel analysis

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ARTICLE INFO

Article history:
Received 19 December 2015
Received in revised form 18 February 2017
Accepted 24 February 2017
Available online xxxx

Keywords:
Varieties of capitalism
Mixed market economies (MMEs) and innovation
Innovation performance and exports
Transformation of national science
Military spending and technology spillover
Institutional incoherence and comparative advantage

ABSTRACT

This study addresses the outstanding question in comparative capitalism literature of whether Mixed Market Economies (MMEs) are always at a comparative disadvantage regarding innovation performance because of their assumed institutional incoherence (lack of institutional complementarities). Based on panel data for 26 OECD countries over 21 years, we compare MMEs with Liberal Market Economies (LMEs) and Coordinated Market Economies (CMEs) in relation to four types of innovation outcomes (publications, patents, exports and transformation of science). The comparative analysis is conducted at both an integrated and a dyadic level. The integrated level of analysis compares different groups of countries. This study shows that MMEs are at a disadvantage regarding publications, patents and exports. However, MMEs perform better than LMEs and CMEs in the transformation of national science into exported products from high R&D intensity sectors. At the dyadic level of analysis, individual MMEs are compared with a typical LME (USA) and a typical CME (Germany). This comparison shows that some MMEs perform better than the USA and Germany. The evidence reduces support for the assumption that MMEs are always at a comparative disadvantage due to institutional incoherence. The findings indicate that institutional incoherence does not in itself inhibit innovation performance in high R&D intensity sectors.

1. Introduction

In their VoC (varieties of capitalism) argument, Hall and Soskice (2001) suggest that an MME (mixed market economy) has a comparative disadvantage in relation to both radical innovation and incremental innovation. Subsequently, evidence from multiple studies either support or oppose this argument. Most of these studies focus on the notion of national 'institutional coherence', or complementarities, in liberal market economies (LMEs) such as the USA and in coordinated market economies (CMEs) such as Germany. Hall and Soskice (2001) posit that there is national institutional coherence in LMEs and CMEs, which offers them comparative advantages in radical and incremental innovation, respectively. On the other hand, MMEs lack national institutional coherence and thus perform poorly in both radical and incremental innovation. Institutional incoherence is the primary source of MMEs' comparative disadvantage. Subsequently, intellectual tension formed between those who see national institutional incoherence as a comparative disadvantage of the MME (Allen, 2013; Hall and Gingerich, 2009; Hall and Soskice, 2001; Schneider and Paunescu, 2012) and those who refute institutional coherence as a necessary or sufficient condition for comparative advantage of MMEs (Allen and Whitely, 2012; Campbell and Pedersen, 2007; Kenworthy, 2006; Lane and Wood, 2009; Nölke and Vliegenthart, 2009; Taylor, 2004; Walker et al., 2014; Witt and Jackson, 2016). The core issue in this divide is that of institutional incoherence in the MME.

One side finds institutional coherence crucial for economic performance. The institutional coherence of the LME is seen as favourable for radical innovation, whereas the CME has the institutional coherence required to support incremental innovation. This is supported by empirical studies of national performance regarding patents (Akkermans et al., 2009; Hall and Gingerich, 2009), export performance (Allen et al., 2006; Schneider et al., 2010) and at other macro levels of analysis and outcome measures. At least partially, the original set of countries in the MME category such as France, Italy, Spain, Greece, Portugal and Turkey (Allen et al., 2006; Hall and Soskice, 2001), as well as a newly added set of MME countries such as Japan, Korea, Norway, Italy, Portugal, Czech Republic and Hungary (Schneider and Paunescu, 2012) fail to have better innovation performance because of their incoherent institutions.

The opposing argument suggests that institutional coherence is neither necessary nor sufficient. External changes and internal sector-level diversity can reduce the institutional coherence of an LME or CME, let alone an MME. Studies show that national economies achieve comparable innovation performance without conforming to either the LME or CME models (Campbell and Pedersen, 2007; Hancke et al., 2008; Nölke and Vliegenthart, 2009; Walker et al., 2014; Witt and Jackson,

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http://dx.doi.org/10.1016/j.techfore.2017.02.032
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2016). Further evidence shows that some firms in LMEs are producing incremental innovation and some in CMEs are conducting radical innovation (Allen et al., 2006; p10; Mudambi, 2008). This evidence reduces support for the critical role of coherence. Sectoral differences deliver another blow to the disadvantages of institutional incoherence in relation to comparative advantage which may originates from sectoral positions of strength rather than institutional coherence (Allen and Whitely, 2012; Crouch et al., 2009; Witt and Jackson, 2016). Externally, internationalization exerts pressure on national economies to partially change and partially retain institutions. Efficient adaptations to external pressure create combinations of institutions that hardly exhibit coherence according to ideal type LMEs and CMEs.

These views argue against the role played by the institutional coherence of LMEs or CMEs to the exclusion of other factors (Lane and Wood, 2009). In short, institutional coherence or incoherence is neither a necessary nor a sufficient condition for comparative advantage (Kenworthy, 2006). The MME model with institutional incoherence can gain a comparative advantage through radical innovation in some sectors and national settings and through incremental innovation in other sectors and national settings (Campbell and Pedersen, 2007; Crouch et al., 2009; Hancke et al., 2008; Howell, 2003; Krammer, 2015; Li, 2015; Nölke and Vliegenthart, 2009; Taylor, 2004; Walker et al., 2014).

This debate has left several questions unanswered in the MME analysis. Firstly, the current literature defines coherence as external alignment to either the LME or the CME. This means that national institutional configurations are considered coherent if they reproduce the institutional complementarities that characterize either one or the other (ideal typical) model. However, institutions may be internal coherent without external alignment with LME or CME which may explain whether, and in which areas, the MME has a comparative advantage or disadvantage to the LME or CME in innovation performance.

Secondly, the literature on innovation performance of VoCs typically focus on patents or exports as proxies for national innovation performance while ignoring other aspects of performance such as scientific publications which are especially relevant in high R&D intensity sectors. In particular, there is no attempt in the literature to include the transformation of science (published and patented) into exported products as measure of innovation performance.

Thirdly, the choice of categories for VoC comparisons is controversial. Most prior empirical studies focus on three fixed categories of capitalism (LME, CME and MME) based on based on data from 19 (Hall and Soskice, 2001) or 22 OECD economies (Akkermans et al., 2009; Allen et al., 2006). A later study based on data from 26 OECD economies identifies five VoC categories encompassing newly included countries as well as dynamic changes of the originally covered models (Schneider and Paunescu, 2012).

Further, most studies have ignored the role of military spending on technological spillover. Because the military influences national institutions and technological performance (Rustow, 2011), it makes sense to include military spending. For instance, the US military developed drones for internal purposes. However, the technology has spilled over into the commercial arena. Now, for instance, the media uses drones to capture political rallies, social gatherings, horse races and Olympic Games. In the recent industrial activity, some enterprises in the US and China are testing home deliveries from online vendors (e.g., Amazon in the USA and Alibaba in China) through drones. In the past, the development of computer technology and internet has roots in the US military's R&D projects. Thus, the spillover from military technology impacts on innovation performance. High innovation performance, in particular in relation to radical innovation, may partly originate from high military spending rather than institutional coherence or incoherence.

This study addresses the outstanding topical issues in various ways. We seek evidence of comparative advantage in MMEs as an effect of internal coherence rather than alignment with the institutional coherence of either the LME or CME ideal types. The study not only compares MMEs with LMEs and CMEs but also include other VoC categories as identified in more recent studies. Further, it includes military spending as an additional variable explaining innovation performance.

Methodically, this study represents a more comprehensive approach than previous studies exploring whether the MME has a comparative disadvantage in national innovation performance across four measures: (i) publications, (ii) patents, (iii) exports, and (iv) transformation of national science into exports. The comparative analysis is conducted at both an integrated and a dyadic level. Most previous studies have been at the integrated level of analysis comparing different groups of countries. This study also includes a dyadic level of analysis with a comparison of individual MMEs the ideal typical LME (the USA) and CME Germany).

Whereas most VoC studies focus on either LMEs or CMEs or the comparison of these VoCs, this study puts the spotlight on MMEs. The rationale for this focus is threefold. First, whereas some MMEs have adapted institutional features characteristic for LMEs or CMEs, some LMEs and CMEs have lost some ideal typical features and have in effect become MMEs. These dynamics of non-alignment with LMEs or CMEs suggest external incoherence through regional, sectoral and internationalised businesses. Second, evidence showing that the MME category contains multiple countries with institutions partially aligned with LMEs or CMEs and partially aligned with other members of the MME pool provides strong support for the emergence of new mixed categories. Third, differentiating between different MMEs provides opportunities for a better understanding of the actual institutional configurations that enhance innovation performance through internal coherence rather than external alignment with the two ideal types. These theoretical and practical issues rest on the concern for the large number of MME countries that are developing in their unique ways.

The literature on 'varieties of capitalism' rests on the USA as the benchmark of the LME and Germany as the benchmark of the CME. However, none of the existing studies specifically draws comparisons at the dyadic level within and between types of capitalism to assess comparative advantages of nations on various measures innovation performance. The current analysis provides a comparison within the MME, LME and CME as well as between the MME, LME, and CME. In doing so, it fills the void of intra-comparison and inter-comparison at the individual national levels.

2. Literature review and theoretical background

Hall and Soskice (2001) unambiguously argue that MMEs are at a disadvantage compared to LMEs or CMEs because they lack the institutional coherence of either LME or CME institutions. They suggest that LMEs have a comparative advantage in radical innovation performance (e.g., the USA) and that CMEs have a comparative advantage in incremental innovation (e.g., Germany) because of their national institutional coherence. In other words, the MME lacks the international institutional coherence found either in the USA or Germany. Therefore, the MME underperforms in both radical and incremental innovation performance (Hall and Soskice, 2001). In other words, the MME has aspects of the LME and CME but is not fully either type. Its hybrid nature makes it an inconsistent and inefficient form of capitalism and thus unable to attain a comparative advantage. Yet, is it always the case that the MME underperforms in any type of innovation performance, even when using multiple measures of innovation performance and levels of analysis? Before testing this view, we introduce central concepts at the outset.

2.1. Institutions and Innovation

Within the context of innovation, national institutions constitute and constrain strategic behaviour (Whitely and Morgan, 2012). This implies that national institutional mechanisms govern business activities

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by enabling or constraining innovation. Two distinct types of national institutions are formal rules and laws and informal values and norms (North, 1991). Specifically, the VoC literature rests on four main institutional categories and their complementarities (coherence): (a) corporate governance, (b) corporate financing, (c) industrial relations (labour market) and (d) inter-firm relationships (Hall and Soskice, 2001). A subsequent section elaborates on these main elements for a better understanding of the link between institutions and performance (Allen, 2013; Kenworthy, 2006; Schneider et al., 2010). Thus, national institutional coherence is seen to precede national innovation performance.

The notion of innovation in the current context refers to a distinction between product and process innovation. A product innovation represents a new or improved good or service, whereas a process innovation represents a new technological or organizational method of producing goods and services (Edquist, 2005: p182). Other scholars adopt a similar definition of innovation (Allen et al., 2006). For our purpose, there is no need to make a distinction because products and processes or methods of innovation exist together in the outcome of performance measures in high R&D industry sectors (aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery). For instance, in biotechnology and other types of science-driven innovation, publications and patents contain both methodological and product innovations (Kodama and Branscomb, 1999).

2.2. Innovation performance

The current literature builds on three measures of innovation at the national level: (a) patents (Akkermans et al., 2009; Hall and Soskice, 2001), (b) nominal GDP per capita (Hall and Gingerich, 2009) or growth of real GDP per employed person (Kenworthy, 2006) and (c) high technology export performance (Allen et al., 2006; Krammer, 2015; Schneider et al., 2010). For the innovation chain, GDP per capita is too broad to capture the essence of innovation activity. High technology exports are one reasonable measure that links high R&D intensity sectors to exports. Similarly, on the other side of the innovation chain, patents are a good measure of innovation but are incomplete. Patents may exclude innovations that appear in publications and, conversely, publications may exclude patents. Therefore, we introduce publications as the third measure of innovation. Some prior studies have not considered scientific discovery in publications as an instance of radical innovation in related sectors. Allen and Whitely (2012: p116) have mentioned it in passing, and Nelson (2006) has deliberated on it. Thus, we have three measures of innovation performance.

One remaining issue pertaining to the institutional role in innovation is the link between the former (publications/patents) and the latter (high technology product exports). Thus, we use a concept capturing the transformation of national science into exports as the fourth type of measure. In analytical terms, this would be the moderation (interaction) between the type of national institution and the transformation of science into exports. It makes sense to link national science to exported products in the radical innovation sectors (Dalum et al., 1988). Bringing science into the argument in favour or against MMEs and their institutional incoherence can complement the current research.

2.3. Institutional coherence

The notion of institutional coherence (Kenworthy, 2006) refers to complementarities, order and consistencies between the earlier noted four components of national institutions. Institutional complementarities refer to functioning wherein "'the presence (or efficiency) of one institution increases the returns from (or efficiency of) the other" (Hall and Soskice, 2001: p17). In other words, the main proposition of the VoC is that "When firms coordinate effectively, their performance will be better and the result will be better overall economic performance" (Hall and Soskice, 2001: p45). Above all, the institutional coherence (order, complementarities and coordination) between those elements provides a comparative advantage to the economy. Unfortunately, MMEs lack this coherence, while LMEs and CMEs possess it in their national institutions.

The LME has a comparative advantage due to institutional coherence in four institutional components (Hall and Soskice, 2001). First, corporate governance (relations between firms and investors) and institutions govern through an arm's-length exchange (Williamson, 1985). Second, inter-firm interactions rest on a hierarchical supplier-buyer relational structure for the transaction of resources in which the price determines the level of competition. The legal contractual relations that govern these inter-firm transactions reduce the influence of networks and relationships. Third, LME institutions support general skills and formal education for the development of labour. The generic human capital from formal education and general skills provides incentives and wage conditions, promoting inter-firm labour migration. Fourth, financing of the LME economy depends on equity and private investment. The development of venture capital is an example of private equity. Financial institutions and regulatory bodies demonstrate minimal interference in LME business practices (Hall and Soskice, 2001). Fifth, deregulated flexible labour markets make it relatively easy to hire and fire workers. The private ownership structure, weak industrial relations, inter-firm independence, generic/flexible knowledge skills and flexible labour markets support LME's comparative advantage in radical innovation performance. LME firms have access to new knowledge from highly qualified and diverse internal and external human capital, including new discoveries through university-industry interaction (Blumenthal et al., 1986; Kenney, 1986) and the financial system and the labour markets makes it possible to quickly mobilize and reallocate the resources needed for investment in radical innovation.

The CME has a comparative advantage in another type of innovation because it offers institutional coherence across a different set of the four types of institutional components (Hall and Gingerich, 2009; Hall and Soskice, 2001). First, regarding corporate governance, the CME firm relies on bank financing rather than equity financing. Second, inter-firm relationships (buyer-supplier) rest on the cooperation between members in a network system. These non-market network mechanisms govern both corporate governance and inter-firm relations. Furthermore, these networks foster the flow of private information among members in the network (Hall and Soskice, 2001: p8). Third, regarding knowledge and skills, CMEs foster vocational training and specialized education that is organization-specific and industry-specific. Because of the specialized nature of the skills, the labour in CMEs cannot easily migrate between firms. Fourth, industrial relations with employees (information-sharing, work effort incentives) and bargaining conditions in CMEs tend to rely on long-term job security and social contracts (Hall and Soskice, 2001). These institutional characteristics and their coherence in the CMEs is the source of the CMEs' comparative advantage in incremental innovation over MMEs (Hall and Soskice, 2001). They provide companies with the required skills, stability and a long-term strategic orientation needed for incremental innovation.

The MME is at an absolute and obvious comparative disadvantage in radical innovation as well as in incremental innovation. It lacks inter-institutional coherence across those four components in the institutional setting (Hall and Gingerich, 2009). The MME partially adopts institutions from both the LME and the CME. This hybridization is the source of its disadvantage compared to either of the two main types of capitalism and their respective types of innovation performances (Hall and Soskice, 2001). In other words, the MME does not fully conform to either the LME or the CME: it has a combination of the four institutional elements but no coherence between them. To gain a comparative advantage in one or the other type of innovation, the MME needs to adopt either LME institutions or CME institutions. Once it achieves full conformity, it will cease to be an MME and will become either an LME or CME. As long as the MME remains a hybrid institution, it will continue

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to underperform. This conclusion gives rise to the contention of the VoC hypothesis.

The assumption of the VoC is that the development of those four institutional types is a necessary but not a sufficient condition. For a sufficient condition, the institutions need to have complementarities and order (Hall and Gingerich, 2009; Hall and Soskice, 2001). MMEs may have the necessary conditions by having four types of national institutional components but this is not sufficient because they lack complementarities and order between the four components.

2.4. The MME's innovation performance

The literature on the integrated VoC has two groups in chronological order. The first stream uses 22 OECD members to evaluate the MMEs' comparative performance on the innovation scale. This literature uses the original three categories: the MME versus the LME or the CME (Kenworthy, 2006). The second stream of literature uses 26 OECD members to evaluate the MME's relative innovation performance with five categories, including LLMEs (liberal-like market economies) and SDEs (state-dominated economies) (Schneider and Paunescu, 2012). Eastern European countries in transition reflect another type of capitalism that results from internal and internationalization pressures and opportunities (Nölke and Vliegenthart, 2009). For the current test, it is sufficient to compare the MME with the LME and CME in the five categories of capitalism.

Nonetheless, there are internal diversities and external pressures in the globalization of businesses. Furthermore, although there is evidence that LMEs can produce incremental innovation and that CMEs can produce radical innovation (Allen and Whitely, 2012; Krammer, 2015; Mudambi, 2008), there is a fair level of agreement favouring LMEs and radical innovation. Scientific discoveries such as those in publications and their transformation into high technology exported products should lead to a similar conclusion that MMEs underperform in the model of published and patented science. Because MMEs have incoherent institutions and appear to be at a disadvantage in prior studies of national innovation performance, we assume that the link between MMEs and national innovation performance is measured in terms of publications, patents and exports.

Hypothesis 1. MMEs will have a comparative disadvantage over LMEs and CMEs regarding the national innovation performance (publications, patents and exported products).

2.5. MMEs and national science transformation

An MME is likely to underperform in terms of science transformation because of the incoherence of those institutions relevant to the transformation of radical innovation measures. An MME needs to develop and complement the four types of LME institutions for this purpose to achieve better transformation capability. Three types of studies allude to the weaknesses of MMEs in the transformation of science into products. One suggests that MMEs are at a disadvantage in the transformation of discoveries into patents (Akkermans et al., 2009). This branch confirms the VoC hypothesis (Hall and Soskice, 2001). Another view suggests that MMEs experience a disadvantage in the transformation of patents into exported products (Allen et al., 2006; Schneider et al., 2010). A third hypothesis goes further, suggesting that institutional incoherence between countries may impair technological transfer (Costantini and Liberati, 2014; Krammer, 2015). Therefore, we propose that MMEs will have a comparative disadvantage in the transformation of science into exports compared to LMEs or CMEs.

Hypothesis 2. MMEs will have a comparative disadvantage over the LME or CME regarding the transformation of national science (publications and patents) into exported products.

2.6. MMEs and national innovation performance

Two arguments have emerged against the integration of national economies into a handful of VoC. The first view opposing this integration concerns sub-national institutions (Li, 2015). This view argues that local institutions and location of diverse industries foster innovation. The sector-level position also supports sub-national institutional diversity for innovation performance (Casper and Whitley, 2004). Marine energy in the UK is weaker than in Denmark for such reasons, and weak inter-organizational relationships exist when taking the long-term perspective (Allen and Whitely, 2012). Similarly, differences between the UK and Germany with regard to the internationalisation of institutions of higher education reflect national differences (Graf, 2009). In high technology sectors, biotechnology development is stronger in the UK than it is in Germany (Casper and Whitley, 2004).

In contrast to this internal focus, the second view takes an external focus and links institutional diversity to international business activity. This view suggests that international pressure, foreign direct investment and broader global market opportunities merit an analytical focus on internationalization. This global perspective examines the role of institutional variety in the transfer of technology between developed and transitional economies (Krammer, 2015). Other related literature assesses how the quality of institutions moderates technology transfer through exports from developed to developing economies (Costantini and Liberati, 2014). Both the narrow stream addressing sub-national institutions and the broader stream involving supra-national institutions are important and relevant for understanding the source and role of institutional coherence in MMEs and their comparative advantage. Our purpose orients the focus towards testing the MMEs' comparative disadvantage at the national level.

Regional and sectoral specialization as well as adaptations to globalisation has differential impacts on individual MMEs. In effect, some of them attain hybrid characteristics that result in superior innovation performance than the 'pure' LMEs and CME. This has been captured by examining national economies for their comparative advantage. For instance, Denmark has performed better than either the LMEs or the CMEs in innovation outcome because rather than in spite of its hybrid characteristics (Campbell and Pedersen, 2007). However, the VoC argument suggests that any MME will underperform any LME or CME in national innovation performance. The Following this assumption, an MME should perform worse than the USA, as a typical LME, and Germany, as a typical CME. This is tested with the 26 OECD member countries representing different types of national capitalism.

Hypothesis 3. MMEs will have comparative disadvantage over the LME or CME regarding the national innovation performance (publications, patents and exported products).

2.7. MMEs and national science transformation

The VoC argument suggests that any MME underperforms on any measure of innovation performance in the radical innovation sectors (Hall and Gingerich, 2009; Hall and Soskice, 2001). It implies that, regardless of internal and external diversity and the various types of national capitalism (Allen and Whitely, 2012; Howell, 2003; Kenworthy, 2006), the MMEs (e.g. Poland, Italy, Czech Republic, Hungary, Korea and Japan) will face more challenges in the transformation of science to exports than will the LMEs and CMEs. Hence, they will lag behind with respect to transformation of national science into exports as well.

Hypothesis 4. MMEs will have a comparative disadvantage over the LME or CME regarding the national science (publications and patents) transformation into exported products.

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3. Methods

3.1. Setting

The context of this research is manifold. First, it focuses on exports of the 26 OECD member economies that are within one or more categories in the VoC. This focus relates to international business as captured in the trade of high technology exports. Second, the internal context includes multiple innovation performance measures for inter-cluster and inter-country analysis. Third, at the sector level, this research includes six high-intensity R&D sectors, which the VoC literature refers to as radical innovation sectors. Fourth, this study context also includes the role of military expenditures. The argument is not to capture military capability; rather, it recognizes the effects and the reflection of military technology on national institutions and innovations.

3.2. Data

The panel data comprises 21 years between 1994 and 2015. There are 26 OECD member economies, creating a panel observation size of 546 cells (21×26). The primary source of data on these variables is the World Bank (TheWorldBank, 2016), which provides clear and consistent information on the volume of scientific articles, patents, high technology exports and military expenditures. To assign 26 countries within the five categories of the VoC, we used the literature (Schneider and Paunescu, 2012). Hence, we used publicly accessible data for internal and external validity and reliability.

3.3. Variables

3.3.1. Dependent variable

The dependent variable is innovation performance measured at the national level. We used three measures: scientific publications, patents and high technology exports. Scientific publications represent science codified within articles, measured by a country's annual publications during the preceding 21 years. Patents represent the yearly patent count data of an economy in the related sector. High technology exports measures the respective percentage of total manufactured exports. These three measures represent the six radical innovation sectors. Prior studies have proposed a similar argument favouring the transformation of technology for innovation performance (Allen et al., 2006; Schneider et al., 2010).

3.3.2. Independent variables

There are two groups of primary independent variables. The first group of independent variables represents five VoC categories as binary variables (LME, CME, LLME, MME and SDE). The second group of independent variables represents national economies. Because there are 26 national economies, there are as many binary variables. We developed a third group of independent variables to capture the moderating role of institutions in the transformation of science to exports. This group of variables represents the interaction between science (publications and patents) and types of capitalism at both the integrated level (5 types) and the disintegrated level (26 national economies). The Appendix A demonstrates the construction of the relevant World Bank data.

Regarding the construct of high technology exports, the original VoC literature (Hall and Soskice, 2001) rest on the notion of 'radical' innovation' based on these sectors in the World Bank's database. Richard Nelson has argued in support of this measure and its components in his writing (Nelson, 2005) and it has been used in the empirical literature (Schneider et al., 2010). Regarding the scientific and engineering publications, this construct comprises articles published by the authors affiliated with the respective countries. Publications are the most important and relevant measures of national science productivity. These constructs in the database of the World Bank constitute the ranking of nations with regard to scientific productivity.

Regarding patents, the current analysis uses residents' patent counts as indicator of national innovation productivity. We have used the term 'national patented science' in this article, which is consistent with past studies. Regarding military expenditures, the SIPRI (Stockholm International Peace Research Institute) is the main source of the World Bank data. The military expenditure in OECD economies affects and reflects national institutions and technological innovation directly or indirectly. Lastly, the categorisation of economies into integrated types is derived from the VoC literature, earlier as well as its later development.

We controlled for military spending as a percentage of national economic income. The US case warrants the inclusion of military expenditures, as historically, US military technology has successfully spilled over to industry. In particular, the Central Intelligence Agency (CIA) engages in high technology innovation to raise its intelligence level. Direct defence-related R&D spending is another instance of military expenditures for new technological projects (Li, 2015; Witt and Jackson, 2016). The Defence Advanced Research Projects Agency (DARPA, 2016) in the U.S. has produced several military and industrial innovations since its inception in 1957. As military technologies can serve as a source of industrial scientific knowledge, we included military expenditures as a control variable.

3.4. Analysis & model specification

We used panel analysis because it has advantages over conventional cross-section or time-series data analysis (Hsiao, 2003), both in general and, in particular, for the analysis of institutional effects on innovation activity towards economic development. Because the varieties and countries are fixed variables, we used a fixed effects model after performing the Hausman test. The formal model for fixed effects in this panel is as follows:

$$Y_{it} = c + X_{it}{}' \alpha + \delta_t + \delta_i + \varepsilon_{it}$$

Y_{it}	dependent variable
c	constant
X_{it}	a vector of independent variable
α	interested parameters
δ_t	a vector of time dummies
δ_i	a vector of individual dummies
ε_{it}	error term

The transformation of science into exports through moderation effects offers four scenarios. First is when innovation performance exists but exports do not. Second is when high technology exports exist but innovation performance (publication) does not. The third scenario is when neither innovation nor exports exist. The fourth, our concern for the analysis, is when national innovation performance measures exist and high technology exports occur as a result.

4. Results

Table 1 shows a summary of the sample. The MME represents 27% of the sample, which is equal to the LLME[1] (27%). The LME, CME and SDE represents 19%, 15% and 12% respectively. The combination of the SDE[2] (12%) and MME (27%) becomes (39%) in the sample. The combination of LLME and MME is even higher (54%).

Table 2 shows the inter-variable correlations, some of which are high. For instance, the interaction between the LMEs' patents and publications is very high, as is the interaction of CMEs with patents and publications. We expected these high correlations in the panel data.

[1] The LLME type has institutional configuration of the LME more than the CME.

[2] The SDE type has institutional configuration of the state controlled institutions.

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Table 1
Summary statistics.

Variable	N	Mean	Std. Dev.	Min	Max	VoCs
HT exports	541	2.60	0.69	0.19	3.87	
Publications	520	9.60	1.25	6.82	12.94	
Patents	536	8.16	1.96	0.00	12.86	
Military expense	546	0.47	0.43	−0.74	1.54	
Post-2004	546	0.48	0.50	0	1	5 VoC types in 2005
LME	546	0.19	0.39	0	1	(US, UK, CH, DK, CA)
LLME	546	0.27	0.44	0	1	(ES, FI, NL, SW, AU, IE, NZ)
CME	546	0.15	0.36	0	1	(AT, BE, DE, FR)
MME	546	0.27	0.44	0	1	(PO, IT, NO, CZ, HU, KR, JP)
SDE	546	0.12	0.32	0	1	(PT, GR, TR)
LME-pub	520	2.02	4.19	0	12.94	(US, UK, CH, DK, CA)
LLME-pub	520	2.49	4.13	0	10.89	(ES, FI, NL, SW, AU, IE, NZ)
CME-pub	520	1.52	3.61	0	11.53	(AT, BE, DE, FR)
MME-pub	520	2.56	4.27	0	11.56	(PO, IT, NO, CZ, HU, KR, JP)
SDE-pub	520	1.01	2.80	0	10.32	(PT, GR, TR)
LME-pat	536	1.80	3.76	0	12.57	(US, UK, CH, DK, CA)
LLME-pat	536	2.06	3.38	0	8.35	(ES, FI, NL, SW, AU, IE, NZ)
CME-pat	536	1.35	3.20	0	10.85	(AT, BE, DE, FR)
MME-pat	536	2.25	4.00	0	12.86	(PO, IT, NO, CZ, HU, KR, JP)
SDE-pat	536	0.71	1.97	0	8.47	(PT, GR, TR)

Sample: LME 19%; LLME 27%; CME 15%, MME 27%; SDE 12%.

Table 3
The VoC and innovations (publications, patents & high-tech export).

Variables	Publication [a]	Patents [a]	Hi tech export [a]	VoC
Constant	9.99(.13)**	8.40(.19)**	3.08(.07)**	
Military expense	0.99(.12)**	1.43(.19)**	−0.08(.07)	
Liberal	Default	Default	Default	(US, UK, CH, DK, CA)
Liberal–like	−0.96(.14)**	−1.25(.22)**	−0.33(.08)**	(ES, FI, NL, SW, AU, IE, NZ)
Coordinated	−0.26(.16)	−0.15(.25)	−0.38(.09)**	(AT, BE, DE, FR)
Mixed	−0.92(.14)**	−0.35(.22)	−0.44(.07)**	(PO, IT, NO, CZ, HU, KR, JP)
State–dominated	−2.23(.18)**	−3.81(.28)**	−1.47(.10)**	(PT, GR, TR)
F–Statistics	42**	50**	57**	
R–Square	.29	.33	.37	

[a] Log of dependent variables; standard error in parentheses (MANOVA)
N = 505, DOF = 6
**p<.001; *p<.01

Table 3 shows the five categories in the VoC and their innovation performance (publications, patents and exports). It appears that MMEs are at a comparative disadvantage to both LMEs and CMEs. It also appears that MMEs are at a comparative disadvantage to LLMEs and SDEs. The obvious inference from this is that Hypothesis 1 supports the VoC argument: the MME has a comparative disadvantage in publications, patents and exports.

Table 4 shows the VoC categories and the transformation of publications and patents into exported products in two models. In Model 2, the MME performs better than the LME, CME and LLME but similar to the SDE in the transformation of publications into high technology exports. However, regarding patent transformation into exported products in Model 3, the MME shows no difference from the CME, the MME is better than the SDE, and it is worse than the LME or LLME. Therefore, there is a lack of support for Hypothesis 2, which predicted that the MMEs would have a comparative disadvantage in any type of innovation performance.

Table 5 compares the 26 OECD economies at the dyadic (disintegrated) level. The typical LME is the USA, and the typical CME is Germany (Hall and Soskice, 2001). The US is the default category for the analysis of the three types of innovation performance. In Model 1, performance is measured by publications, and the MMEs (PO, IT, NO, CZ, HU, KR & JP) are spread along the scale. It appears that Korea and Hungary are lower than the USA and Germany. All other MMEs are higher than Germany (the CME) but lower than the USA (the LME). In Model 2, the performance is the patents. Three MMEs (Hungary, Korea and the Czech Republic) are lower in performance than Germany, while others are higher than Germany. All MMEs are lower than the USA.

Model 3 shows high technology exports to the national economies of 26 OECD countries. Two MMEs (Norway and Korea) are lower than Germany (the CME), while the other MMEs are higher than Germany. Moreover, two MMEs (Poland and Hungary) show no difference from the USA (LME). Elsewhere, scholars have noted similar patterns in transition economies in the Eastern European region regarding direct exports (Nölke and Vliegenthart, 2009). Therefore, there is a lack of support for the argument that MMEs have an institutionally inherent comparative disadvantage. Now, we turn to the transformation scenario.

Table 6 shows the transformation of published and patented national science into exports in two models. The German economy is a proper CME, and the USA is an LME. In the transformation of publications in Model 1, three MMEs (Hungary, Italy and Japan) perform worse than Germany, while four others (Czech Republic, Poland, Korea and

Table 2
Inter-variable correlations.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
HT export	1																
LME	0.29*	1															
LME	0.29*	1.00*	1														
LLME	0.10*	−0.30*	−0.30*	1													
CME	−0.04	−0.21*	−0.21*	−0.26*	1												
MME	−0.02	−0.30*	−0.30*	−0.37*	−0.26*	1											
SDE	−0.42*	−0.18*	−0.18*	−0.22*	−0.15*	−0.22*	1										
Military	−0.08	0.12*	0.12*	−0.26*	−0.14*	−0.04	0.43*	1									
LME pub	0.26*	0.56*	0.56*	−0.16*	−0.11*	−0.16*	−0.10*	0.51*	1								
LLME pub	−0.07	−0.21*	−0.21*	0.72*	−0.18*	−0.26*	−0.16*	−0.15*	−0.11*	1							
CME pub	0.05	−0.15*	−0.15*	−0.18*	0.72*	−0.18*	−0.11*	−0.01	−0.08	−0.13*	1						
MME pub	−0.34*	−0.13*	−0.13*	−0.16*	−0.11*	−0.16*	0.75*	0.28*	−0.07	−0.11*	−0.08	1					
SDE pub	0.07	−0.18*	−0.18*	−0.22*	−0.15*	0.61*	−0.13*	−0.12*	−0.10*	−0.16*	−0.11*	−0.10*	1				
LME patent	0.24*	0.46*	0.46*	−0.14*	−0.10*	−0.14*	−0.08	0.52*	0.98*	−0.10*	−0.07	−0.06	−0.08	1			
LLME patent	−0.01	−0.27*	−0.27	0.91*	−0.23*	−0.33*	−0.20*	−0.17*	−0.15*	0.82*	−0.17*	−0.14*	−0.20*	−0.12*	1		
CME patent	0.14*	−0.13*	−0.13*	−0.16*	0.62*	−0.16*	−0.09	−0.05	−0.07	−0.11*	0.89*	−0.07	−0.10*	−0.06	−0.14	1	
MME patent	−0.26*	−0.10*	−0.10*	−0.13*	−0.09*	−0.13*	0.59*	0.08*	−0.06	−0.09*	−0.06	0.46*	−0.08	−0.05	−0.12*	−0.06	1
SDE patent	0.21*	−0.13*	−0.13*	−0.16*	−0.11*	0.44*	−0.09*	−0.13*	−0.07	−0.11*	−0.08	−0.07	0.87*	−0.06	−0.14*	−0.07	−0.06

* $p < 0.01$.

Please cite this article as: Malik, T.H., Varieties of capitalism, innovation performance and the transformation of science into exported products: A panel analysis, Technol. Forecast. Soc. Change (2017), http://dx.doi.org/10.1016/j.techfore.2017.02.032

Table 4
VoC, national science and high technology exports (Panel).

Variables	Model 1	Model 2	Model 3	VoCs
	VoC	VoC & publication	VoC & patents	
Constant	2.25(.39)***	2.65(.16)**	0.01(.56)	
Published	0.08(.03)**		0.09(.03)**	
Patented	0.00(.02)	−0.02(.02)		
Military expense	0.01(.10)	−0.20(.10)*	−0.03(.10)	
Liberal	*LME*[a]			(US, UK, CH, DK, CA)
Liberal–like	−0.21(.32)	−0.26(.05)**	0.43(.11)**	(ES, FI, NL, SW, AU, IE, NZ)
Coordinated	−0.36(.36)	0.03(.08)	0.38(.32)	(AT, BE, DE, FR)
Mixed	−0.42(.32)	0.24(.04)**	0.20(.12)	(PO, IT, NO, CZ, HU, KR, JP)
State–dominated	−1.38(.40)**	0.09(.04)*	−0.10(.04)*	(PT, GR, TR)
Wald–Chi X^2	28**	13.8**	5.95**	
R–Square	0.35	0.05	0.06	
N	480	485	480	
Hausman test	Fixed Effect	Fixed Effect	Fixed Effect	

[a] Default category; Dependent variable = Log of High tech export (1 year lag); standard error in parentheses; LLME is negative in publications and positive in patents; on the opposite, SDE is positive in publication and negative in patents
**p<.01
*p<.05
***p<.001

Norway) perform better than Germany on the scale of coefficients. Moreover, two MMEs (Korea and Poland) behave similarly to the US and Germany. Therefore, Hypothesis 3 does not find support based on the coefficient size for the publication transformation.

Model 2 shows the transformation of patents into exported products. Regarding the coefficient size, the USA (the LME) performs better than Germany (the CME), and Germany performs better than MMEs except Italy (an MME). Since only one MME economy performs better

Table 5
National capitalism and innovation performance (Panel).

Institution	Publication [a]	Institution	Patent [a]	Institution	HT export [a]
	Model 2		Model 2		Model 3
Constant	15.7(.20)**		12.99(.31)**		3.46(.12)**
Military % GDP	−2.4(.14)**		0.67(.21)**		−0.12(.08)
Ranking		Ranking		Ranking	
HU	−8.73(.28)**	NZ	−7.34(.24)**	UK	−2.63(.08)**
AT	−7.43(.24)**	HU	−6.63(.42)**	NO	−2.07(.09)**
GR	−6.87(.20)**	BE	−6.43(.31)**	NZ	−1.67(.09)**
KR	−6.53(.19)**	FR	−6.22(.21)**	PT	−1.47(.11)**
TR	−6.53(.24)**	CH	−6.21(.28)**	IE	−1.34(.10)**
DE (Germany)	−6.16(.20)**	GR	−6.19(.30)**	BE	−1.19(.13)**
CH	−6.09(.18)**	UK	−5.67(.21)**	KR	−1.18(.11)**
BE	−6.07(.21)**	NL	−5.56(.26)**	FR	−1.15(.08)**
CZ	−5.97(.19)**	KR	−5.42(.29)**	CH	−1.00(.11)**
NL	−5.83(.17)**	AT	−5.42(.36)**	AT	−0.96(.14)**
NZ	−5.79(.16)**	CZ	−5.40(.28)**	AU	−0.84(.09)**
SW	−5.22(.18)**	DE (Germany)	−5.18(.29)**	CA	−0.77(.12)**
JP	−4.97(.19)**	JP	−5.01(.28)**	ES	−0.67(.11)**
CA	−4.78(.21)**	TR	−4.86(.36)**	SW	−0.65(.11)**
NO	−4.75(.16)**	AU	−4.82(.25)**	NL	−0.60(.10)**
PT	−4.56(.19)**	PT	−4.78(.28)**	DE (Germany)	−0.59(.11)**
FR	−4.48(.14)**	SW	−4.70(.28)**	CZ	−0.55(.11)**
IT	−4.47(.23)**	NO	−4.68(.25)**	GR	−0.50(.11)**
AU	−4.33(.16)**	CA	−4.55(.31)**	TR	−0.36(.14)**
UK	−3.95(.14)**	IE	−3.62(.29)**	IT	−0.35(.13)**
ES	−3.84(.19)**	DK	−2.85(.22)**	DK	−0.28(.08)**
IE	−3.84(.17)**	FI	−2.61(.23)**	JP	−0.16(.11)
PO	−3.60(.15)**	ES	−2.03(.29)**	FI	−0.12(.09)
DK	−2.75(.15)**	PO	−0.95(.22)**	PO	0.01(.08)
FI	−2.52(.15)**	IT	−0.28(.34)	HU	0.02(.16)
The US	*Default*	*The US*	*Default*	*The US*	*Default*
Wald–Chi2	3783***		4171***		3647***
R–Square	0.88		0.90		0.88
N	520		410		515

[a] Log of exports (DV); standard error in parentheses; Random Effects
**p<.001; *p<.01; ***p<.001
DOF = 26

Please cite this article as: Malik, T.H., Varieties of capitalism, innovation performance and the transformation of science into exported products: A panel analysis, Technol. Forecast. Soc. Change (2017), http://dx.doi.org/10.1016/j.techfore.2017.02.032

Table 6
Transformation of national science to exported products.

Institution ranking	Publication transformed [a]	Institution ranking	Patent transformed [a]
	Model 1		Model 2
Constant	2.86(.39)***		−0.8*(0.74)
Military % GDP	−0.11(.12)		0.28(.11)**
Publications			0.21(.03)**
Patents	−0.02(0.02)*		
Ranking		Ranking	
SW	−0.47(.22)*	GR	−1.69(.37)**
HU	−0.43(.08)**	JP	−1.43(.65)*
IT	−0.37(.16)**	IE	−1.13(.57)*
FI	−0.32(.16)*	PT	−1.02(.28)**
JP	−0.27(.14)	AU	−0.81(.18)**
DE (Germany)	−0.20(.15)	NL	−0.42(.67)
CZ	−0.18(.14)	PO	−0.39(.15)**
PT	−0.16(.09)	CA	−0.39(.21)
IE	−0.15(.14)	NZ	−0.21(.07)**
CA	−0.14(.13)	UK	−0.18(.05)**
AU	−0.06(.11)	DK	−0.17(.95)
BE	−0.04(.27)	TR	−0.01(.02)
UK	−0.01(.06)	FR	0.12(.13)
AT	0.02(.11)	KR	0.24(.30)
PO	0.07(.05)	BE	0.31(.39)
NL	0.07(.11)	AT	0.36(.50)
ES	0.08(.14)	SW	0.47(.20)**
KR	0.08(.13)	ES	0.47(.72)
DK	0.10(.14)	CZ	0.77(.40)
NZ	0.12(.06)*	HU	0.91(.17)**
FR	0.33(.07)**	NO	0.96(.21)**
TR	0.35(.15)**	CH	1.01(.30)**
NO	0.37(.07)**	FI	1.53(.39)**
CH	0.46(.07)**	DE (Germany)	1.65(.32)**
GR	0.87(.10)**	IT	1.75(.45)**
The US	*Default*	*The US*	*Default*
F–Stat	9.23***		8.82**
R–Square	0.06		0.01

[a] Log of dependent variable (High tech exports); standard error in parentheses; Fixed Effects (Hausman, p<.01); N = 480, DOF = 26; **p<.01; *p<.05; ***p<.001

than the typical CME (Germany), it suggests that there is partial support for Hypothesis 4, which predicted that all MMEs would be at a comparative disadvantage because of their institutional incoherence with respect to LMEs and CMEs.

5. Discussion

We explored one of the outstanding questions in the comparative capitalism debate: do MMEs always underperform comparatively in their innovation performance (publications, patents and high technology exports) and their transformation of national science into exported products. In other words, is institutional incoherence, as the central tenet of the MME, also the source of its disadvantage in the national innovation performance? We used 26 OECD economies and five categories in the VoC in a panel analysis over 21 years. First, we assessed the integrated effects of MMEs compared to LMEs and CMEs at the cluster level. Then, we assessed disintegrated MMEs at the national level of analysis. In both stages, we assessed three types of innovation performance (scientific articles, patents and high technology exports) for MMEs compared to LMEs or CMEs in six high R&D intensity sectors (aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery). We also used the link between science and exports to assess the role of institutions in the transformation of national science into commercial products. Thus, the two types of outcomes match with two levels of analysis: clustered MMEs and non-clustered MMEs.

At the cluster (integrated) level, the MME shows a comparative disadvantage in the three innovation performance measures (publications, patents and exports). LMEs and CMEs significantly outperform MMEs on these measures. This revelation is consistent with prior literature finding that the LME or CME outperforms the MME in patent innovation (Akkermans et al., 2009; Hall and Soskice, 2001) and in high technology exports (Allen et al., 2006; Schneider et al., 2010). We introduced publications as the third type of innovation performance and found that the MME is at a comparative disadvantage in producing publications. Comparing the LME and the CME, the former outperforms the latter in terms of exports. The perceived reason for the LME's comparative advantage over the CME regarding exported products is its dynamic nature, which allows it to access external talent and general knowledge through the internationalization process (Allen et al., 2006; Allen and Whitely, 2012). In conclusion, there is significant support for the VoC hypothesis.

However, that support wanes when the transformation of national science is analysed. The result of the clustered level of analysis shows that the MME has a comparative advantage in the transformation of publications into exports. Moreover, the MME is not significantly different from the LME or CME in terms of the conversion of patents into exported products. This finding alludes to two types of export-related advantages. One group of those economies that performs in exports uses the internationalization process without the development of strong national science (Nölke and Vliegenthart, 2009). The other group of those economies that performs in exports uses the nationally developed science into exports. Apparently, both groups of MMEs are capable of transforming the national and foreign science; neither LMEs nor CMEs have a comparative advantage in patent transformation. Therefore, at best, there is partial support for the VoC hypothesis (Hall and Gingerich, 2009; Hall and Soskice, 2001) at the integrated level of analysis using multiple measures of innovation performance (publications, patents and exports) (Allen et al., 2006).

The clustered (dyadic level) analysis further reduces the support for the VoC argument in terms of direct innovation performance and transformation into exports. Regarding national innovation performance, the results reflect 26 economies. With the US as a typical LME and Germany as a typical CME in the cross-national comparison at the dyadic level, the comparison with the MMEs provides some useful insights. Firstly, some MMEs (e.g. Czech Republic, Japan, Norway, Italy and Poland) perform better than the typical CME (Germany) but worse than the typical LME (the USA) in *publication* output.

The VoC hypothesis (Hall and Soskice, 2001) posits, in absolute terms, that the MME will underperform the LME in radical innovation unless it adapts to the institutional coherence of the LME. The finding of these selected MMEs is that they are better than the CME in radical innovation. In other words, the presumed incoherent institutions of the MMEs are producing radical innovation in published science. At the same time, some MMEs (e.g. Hungary) support the original hypothesis by performing lower than the benchmarked CME (Germany) in publication.

Secondly, regarding the patent innovation outcome, some MMEs (Japan, Norway, Poland and Italy) perform better than Germany (benchmarked CME) but worse than the USA (benchmarked LME) in patent output. Taking the original hypothesis that the LME performs better in radical innovation comparative to other types of capitalism, we find support. However, this support reflects a partial picture. The performance of the MME better than the CME disturbs the assumption of the VoC in two ways. One way is that, although Italy (MME) has a lower comparative performance over the USA, it has a higher comparative performance over the three LMEs (UK, Canada and Switzerland). Moreover, the two LMEs (UK and Switzerland) perform comparatively lower than Germany (benchmarked CME). Thus, the argument for the external alignment to the LME for radical innovation becomes a weak one(Allen et al., 2006; Kenworthy, 2006).

Thirdly, regarding the high technology export outcome, some MMEs (Czech Republic, Italy, Japan, Poland and Hungary) perform better than Germany (benchmarked CME) in *export* output. Furthermore, two MMEs (Poland and Hungary) show no difference from the USA in *export* output. The capability of these two MMEs is similar to that of the USA (benchmarked LME) and better than several other LMEs (e.g. the UK, Ireland, Switzerland, Canada) in the VoC hypothesis. These revelations refute the assumption that MMEs are always at a disadvantage in all types of performance measures in time and space (Allen et al., 2006; Kenworthy, 2006).

The three measures of innovation output in the above discussion and as the innovation input of exports through the transformation highlight the possibilities of unflustered analysis and national institutions for the innovation performance. In other words, the MMEs adapt parts of the LME and part of the CME institutions. Partially, the MMEs are have evolved their unique ways based on technological, regional and cultural determinants.

The vertical transformation of published and patented science at the dyadic level of analysis also weakens support for the original VoC hypothesis and the MMEs' comparative disadvantage. In the publication transformation, Norway, South Korea, Poland and Czech Republic (MMEs) perform better than Germany. Similarly, in the patent transformation, Italy, Norway and Hungary (MMEs) show comparative advantages over the USA, and Italy shows a comparative advantage over both Germany (CME) and the USA (LME). If the coefficient correlations provide any clues in the panel data from the 21 years, the results reveal that there is a lack of full support for the VoC argument that institutional coherence is a necessary and sufficient condition for a comparative advantage in innovation performance in high R&D intensity sectors.

Some prior literature reaches similar conclusions from other contexts that institutional coherence is equivocal. It argues that institutional diversity (incoherence) may support or stifle the transformation of published/patented science into industrial technology at the international, national and regional levels in some sectors (Allen et al., 2006; Krammer, 2015; Lane and Wood, 2009; Li, 2015).

One reason is that no economy absolutely fixed to conform either to the LME or CME (Kenworthy, 2006). The evidence shows that the ideal LME (the USA) and CME (Germany) are not consistent across different types of performance in their respective types of radical versus incremental performance (Allen et al., 2006). On the other hand, MMEs borrow some practices from LMEs and some from CMEs. Therefore, they have the potential to perform in some areas more than in other areas. Secondly, the performance measure captures differences between publications, patents and exports. The level of comparative analysis also matters from the integrated or disintegrated perspectives, leading to varied results because institutional coherence or incoherence can positively or negatively affect innovation performance (Lane and Wood, 2009). There are firms in LMEs with advantages in incremental innovation and firms in CMEs that produce radical innovation (Allen et al., 2006; Lane and Wood, 2009; Mudambi, 2008). Therefore, the narrow view of "either incremental or radical innovation overlooks the possibility that both radical and incremental innovators can succeed within the same market (Allen et al., 2006: p14)".

The second reason is that the absolute emulation of the LME or the CME may stymie the transformation of science to technology and exported products in the national context. The successful models of some Eastern European economies conform to neither the LME nor the CME, showing that the MME can be successful in one or other ways and that importing institutions from an LME or CME to an MME has been unsuccessful (Nölke and Vliegenthart, 2009). It is thus not the coherent institutions that underlie the success of this model, but the entry of foreign enterprises, the exports from these economies and the access to foreign markets.

The third reason is that internal diversity can be a source of comparative advantage rather than disadvantage for innovation performance (Allen and Whitely, 2012). Lane and Wood (2009) explain the equivocal influence of institutional diversity (incoherence) in the MMEs. On the positive side, firms in an MME are less vulnerable to external pressures, and they can complement resources in their sectors to deflect that pressure. Local institutions at the sector or regional level can support the practices of individuals or associations in firm operations. Geographic or local institutional diversity such as inter-industry rather than interfirm colocation is an important source of innovation and growth rather than specialization through the mechanism of externalities (Li, 2015). University-industry colocation makes sense here. Moreover, local competition, institutional moderation and other factors affect incremental and radical innovation differently.

The negative side of institutional coherence, according to Lane and Wood (2009), brings new challenges, exerts continuous pressure and erects contradictory logics. Such a disturbance can undermine the value of the order without providing an alternative system. Internal institutional diversity does not always mean the support of innovation through adaptation. Instead, institutional incoherence can be fragmented and static. Fragmentation can reinforce disruption, and stagnation can impair the transformation from innovation to progressive change (Lane and Wood, 2009). For instance, those innovations expressed in publications and patents are innovations. However, institutional diversity may impair their transformation into an export product in high R&D intensity sectors.

We make three types of clear contributions to the literature through this study. First, we show that innovation performance leads to different results when combined with multiple measures along the value chain (publications, patents and exports). Prior studies have used one of the latter two measures and have neglected publications as either outcomes or predictors (Allen et al., 2006). Second, we show that the transformation of national science into exported products shows the real function of an innovative economy better than relying on either patents or exports (Kenworthy, 2006). Third, and most important, we show that exploring the varieties of national capitalism offers a better perspective for systematic evidence and decision making than integrated capitalism. In addition to these contributions, we also included military expenditures, which earlier studies have ignored, as an influential factor in capitalism. In particular, military expenditures show positive effects on publications and patents at the integrated level as well as on the transformation of these technologies at the disintegrated (dyadic) level of analysis.

5.1. Limitations

First, the study did not take into consideration all possible newly introduced categories based on the OECD economies in a variety of literature. We adopted 26 OECD economies, forming five types of capitalism based on 2005 information. Our panel data include 21 years between 1994 and 2014. The national level analysis captures all of these changes. However, the integrated categories would change prior to and after 2005. We did not directly analyse the institutional elements and their coherence. Second, the number of publications and patents are included in the analysis but not their type or quality. Third, we included sectors related to radical innovation that require high R&D intensity for publication/patent performance but did not include some of the low technology sectors.

Fourth, the LLME and SDE categories in the OECD have shown strong and potentially positive effects regarding the transformation of published science. If we extend this research to economies beyond the OECD members, the role of the SDE becomes important in some emerging economies. Similarly, the role of military spending is influential in some countries. Fifth, although a dyadic level of analysis is better than a cultured level of analysis, it overlooks some subtle roles played by multinational enterprises and regional institutions (Allen and Whitely, 2012). In particular, we did not consider national cultural factors in the performance and transformation of national technology.

Appendix A. The construction of the data (World Bank)

Variables	Performance definition[a]	Variable
High technology exports	High-technology exports: - Products with high R&D intensity (aerospace, computers, Pharmaceuticals, scientific instruments, and electrical machinery). Data are in current U.S. dollars.	Continuous
Publications	Scientific and technical journal articles: - The number of scientific and engineering articles published in the following fields (physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences).	Count
Patents (resident)	Patent applications:- Worldwide patent applications filed through the (i) Patent Cooperation Treaty procedure or (ii) with a national patent office for exclusive rights for an invention–a product or process that provides a new way of doing something or offers a new technical solution to a problem.	Count
Military expenditure (% of GDP)	Military expenditure:- from Stockholm International Peace Research Institute OR SIPRI (https://www.sipri.org/databases/milex); NATO's definition: all current and capital expenditures on the armed forces (defense ministries engaged in defense projects; paramilitary forces, and military space activities, operation and maintenance; procurement; military research and development)	Continuous
Economies	Five types of VoC definitions Based on the literature (Schneider and Paunescu, 2012); elaborated in the framework and methodology	Binary

[a] From the World Bank.

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Please cite this article as: Malik, T.H., Varieties of capitalism, innovation performance and the transformation of science into exported products: A panel analysis, Technol. Forecast. Soc. Change (2017), http://dx.doi.org/10.1016/j.techfore.2017.02.032