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

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Defence investment and the transformation national science and technology: A perspective on the exploitation of high technology

Tariq H. Malik

International Centre for Organization & Innovation Studies (ICOIS), Liaoning University Business School, 58 Daoyi South Street, Shenbei New District, Shenyang, Liaoning Province 110136, PR China

ARTICLE INFO

Keywords:
Military-civilian technology transformation
Defence dollar and high technology exports
Comparative advantages of NSI in military technology

ABSTRACT

Whether and how defence investment in the industrialised economies contributes to high technology transfer by moderating national science and technology into high economic products is the exploratory question posed in this paper as part of a comparative analysis of OECD economies. Based on defence dollar investments, we perform two analyses. For the first analysis, we assess moderating effects of defence dollars dedicated to national science (articles) and technology (patents) on high technology exports. For the second analysis, we assess the moderating role of defence dollars on individual economies regarding their comparative advantages/disadvantages relative to the US as the leading economy of the OECD. A panel analysis covering 23 years (1993 to 2015) presents three sets of findings. First, defence dollars positively correlate with national science productivity in articles but are not correlated with national patents. Second, defence dollars positively moderate patent technologies but negatively moderate the application of scientific articles for the development of economic products. Third, in the moderation analysis of defence dollars, the US appears to be at a comparative disadvantage relative to the most developed OECD economies. This finding may imply that (a) there is a plurality of institutions in national innovation systems and that (b) not all economies are equally emulating American institutional development. We propose several avenues for future research and policy-making.

1. Introduction

The role of the military in the national economy was a novelty and a form of institutional innovation since the emergence of technologies and agricultural society (Drucker, 2011, p108), and this role was and remains a contentious issue. One contentious issue concerning the military centres on the fact that its legitimacy always emerges in peaceful times, in times of war and in times of technological advancement which, in turn, keeps military troops active around the world in the justification and legitimation of their existence (Boulding, 1989). At times, questions of legitimacy are social in nature, while at other times, such contentions are economic. The latter have emerged more than the former because social contentions arise during conflicts while economic contentions between proponents and opponents permeate throughout the year. The economic contention of legitimacy reflects issues of military-civilian technology transfer through the lens of defence spending.

Proponents demonstrate the positive role of the military in the development of civilian technology transfer and economic development. This stream assumes that the military contributes to innovation and economic growth through science, technologies, products and different stages of the product life cycle (Cowan and Foray, 1995). Management strategies serve as another venue of civil organisation for learning from military organisation (Augier et al., 2014; Cowan and Foray, 1995). In the recent past, roughly 70% of the US Defence Department's hardware acquisitions have been high technology systems (missile, aircraft, space, electronic and communication equipment) in the 1980s (DeGrasse, 1983: p101). The US military's laser and space technologies, which have created a market of unmatchable size, serve as a good example (Vernon, 1982: p159). According to very recent reports, US air force technologies for emergency management systems serve as one example (USFedNews, 2016), and integrated military-commercial escorts serve as another case of international business (USFedNews, 2011). The Chinese government has announced new policies for military-civilian technology transfer (Dominguez and Grevatt, 2016; Zhao, 2017a). These developments are positive signs.

The opposite side of the argument on military-civilian technology transfer and economic development is rooted in three points. First, unlike in the past, military procurement of semiconductors in the US fell to 10% 1981 (Flamm, 1984: p36). This decrease does not justify the

E-mail addresses: t.h.malik@lnu.edu.cn, T.H.Malik@outlook.com.
URL: http://www.coba.lnu.edu.cn.

http://dx.doi.org/10.1016/j.techfore.2017.09.020
Received 20 June 2017; Received in revised form 16 September 2017; Accepted 21 September 2017

diversion of resources from commercial R & D to military spending (Nelson, 1984: p72). Instead, this phenomenon suggests that civilian R & D would have functioned better than military R & D (Mansfield, 1980: p598). Even the procurement needs of the military, which induced private firm spending on R & D in the past, did not materialise in significant ways in the US (Rosenberg, 1986). Similar doubts emerged in Germany (Krupp and Kuntze, 1986: p27). The second point of opposition concerns the notion that a small proportion is dedicated to basic R & D, while the rest is dedicated to applied research, and the latter form supports commercially unviable technology. Such military-specific applications of technology are inefficiently applied outside of military institutions. The point of contention is that the inherently closed structure of military organisation hampers the inflow and outflow of knowledge between military and commercial institutions.

To support this opposing argument, once empirical study explored the patent assigned to military-linked civilian organisations and observed no significant differences between the two parallels (Schmid, 2017). Another study suggests that high technologies in the domain of the military are declining while the private market is expanding (FitzGerald and Parziale, 2017). A third study reviews the existing literature and concludes that "military R & D is not an important factor for economic growth" (Dunne and Braddon, 2008). This follows from earlier documented doubts on military-civilian technology transfer stating that military investment has "stymied U.S. productivity growth and contributed to the decline of U.S. performance in world commercial markets" (Reppy, 1985). Most recently, Mowery (2012) has provided a detailed account of doubts regarding the military-civilian technology relationship (Mowery, 2009, 2012; Mowery et al., 2010).

These debates have highlighted new intellectual issues. First, there have been numerous cases of successful technology transfer from the military to the commercial sector. South Korea serves as one example (Lee and Yoon, 2015). Other anecdotal evidence is found in the case of Israel (Vekstein and Mehrez, 1997). The Netherlands serves as another successful case (te Kulve and Smit, 2003). France serves as a fourth case (Serfati, 2001). Thus, the debate continues between proponents and opponents. Second, the main case used for analysis is the US, while others emulate national innovation systems (Dosi et al., 2006; Mowery and Sampat, 2005; Pavitt, 2001). However, the other OECD economies do not provide sufficient information for the national comparative analysis of military-civilian technology transfer. OECD members countries differ in levels of defence investment, technology transfer and high technology exports from those of the US (Malik, 2017). Third, the scope of technological transfer varies across the product life cycle and between product and process oriented technologies (Cowan and Foray, 1995). Moreover, upstream and downstream technological developments show a gap between the US and Europe (Dosi et al., 2006). Organizational learning at the operational level from the military also contributes to civilian organisations in subtle ways (Augier et al., 2014). Taken together, defence investments should support global performance as a focus on high technology exports becomes more central (Delum et al., 2010; Nelson, 2005). Anecdotes confirm this trend on defence and commercial interactions of technology transfer (USFedNews, 2011).

Naturally, projected trends of interaction, the transaction of knowledge and the transformation of technology raise new questions. In the past, the focus of national innovation systems was on university-industry integration. At present, there is an emerging sense of military-industry integration (Mowery, 2012; Mowery et al., 2010). The Chinese government has initiated this process (Dominguez and Grevatt, 2016) by declassifying military patents for commercial use (Zhao, 2017b).

These issues raise two important questions. The first question addresses military-civilian technology as measured through national innovation performance (publications, patents and high technology exports). The role of defence dollars is a source of input while the national difference both directly and indirectly reflects high technology exports. The second question addresses the comparative positioning of national economies in military-civilian technology transfer. For this question, the role of defence dollars moderates the economy to secure a comparative advantage. Both questions are of relevance to industrialised economies (OECD) with respect to comparative differences with the US, which is the leader and exemplar in this domain (Dosi et al., 2006).

Questions:

a) Do defence dollars positively predict national innovation performance (publications, patents and exports) directly or indirectly?
b) Does the US lead or lag in the transformation of defence dollars into national innovation performance (publications, patents and high technology exports)?

Answers to these questions can determine whether military expenditures are legitimately necessary for the stability, growth and enabling of the military in international business. In regards to research, this study sets the stage for scholarship on supportive questions to be asked in comparative institutional settings, and it differentiates between successful vertical transformation paths that are publication-driven, patent-driven or both. Further research can draw on this study to examine non-OECD countries, such as Brazil, China or India.

2. Framework

Given its flexibility and comprehensiveness at the national level, the National Innovation System (NIS) is relevant to the analysis of innovation performance, where questions reflect on antecedents or causes of national performance or national differences in performance. The concept of the NIS (Lundvall, 2010; Nelson, 1993) or of Systems of National Innovation (SNI) (Freeman, 1988) refers to the same phenomenon, and the two abbreviations are often used interchangeably at the national level of interaction between national institutions for knowledge transfer, technological innovation and economic growth. Several researchers of the NIS framework refer to this as STI (Science, Technology & Innovation) (Smith, 2005). Others refer to it as Triple-Helix (Etzkowitz and Leydesdorff, 2000; Leydesdorff, 2000). Others refer to it as 'Mode 2', referring to an interaction between inter-disciplinary institutions (Gibson, 1998). Many terms are used to refer to interaction, innovation and economic development in the context of intra-national institutions (Johnson, 2010).

Given the NIS's simplicity and soundness, we use the NIS concept within this framework to examine relationships between military and commercial institutions. The extant literature has applied NIS concepts to university-industry relationships while disregarding the fact that the military as an institution is critical as a producer of research and technology and as an enabler or inhibitor through resource diversion (Mansfield, 1980; Rosenberg, 1986). As an enabler, two potential levels of technology transfer can occur from defence investment to civilian application. One is product related knowledge transfer and the other is operation (process) technology transfer with the latter being an enabler more than the latter (Cowan and Foray, 1995). In particular, there are potential opportunities for organisations to learn from military organizational structures and operational norms (Augier et al., 2014). Therefore, applying the NIS framework to an analysis of defence-commercial interactions, technological flow and innovation performance is an adequate approach (Mowery, 2012).

To benefit from the NIS framework for the purpose of answering the above question, we use the general form of NIS terminology at the risk of losing specificity. To this end, we highlight sources of the fluidity of the NIS concept (Edquist, 2005a). First, three main definitions of the NIS are used in temporal order (OECD, 1997: p10). To Freeman, the NIS is a "network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman, 1987). To Lundvall, the NIS refers to "the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge… and are either located within or rooted