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Revisiting the Innovation-export Nexus using Industry-level Data: Evidence from China's Large- and Medium-sized Industrial Enterprises

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ABSTRACT

The paper aims to provide new evidence about the relationship between technological innovation and industrial export in China. In particular, using a unique industry-level data on a panel of China's 27 two-digit manufacturing industries over the 1998-2010 period, the study empirically investigates the impact of various aspects of technological innovation on export performance of large- and medium-sized industrial enterprises (LMEs). The results based on a system-GMM estimation report that: First, domestic innovation efforts and foreign investment have a significant positive impact on China's industrial export performance, whereas the former has a relatively stronger influence on export success than the later; Second, the export growth has benefitted greatly from China's integration into world trade and the effect of trade openness on export boom is greater than both the domestic and foreign innovation efforts. Further, a recent increase in the scientific and technological development staff has initiated the learning process in LMEs and has put a favourable impact on industrial export. Last, market reforms in china have played a crucial role in manufactured export development through improvement in separate ownership and creation of competitive market. These results are robust to several tests, sensitivity checks and alternative variables on diverse channels for technological innovation. Findings of the paper suggest some policy points for designing China's new development strategy in an era of sluggish growth.

Keywords: Technological Innovation, Foreign Investment, Indigenous Innovation, Market-Oriented Reforms, Industrial Export, China
JEL Classifications: F14, F23, O14, O31, O32

1. INTRODUCTION

After more than three decades of astounding economic growth rate which have witnessed country's rapid rise to the leading trading nation and the world's second-largest economy by nominal GDP, China's economy is slowing down. In fact, the outbreak of worldwide financial crisis in 2008 has challenged the global development process, and China was also involved in this recessions and bid farewell to double-digit growth rate. The situation not only concerns researchers and policy makers at home and abroad about some undesired consequences of this slowdown but also prompt them to formulate policies to adapt to the "new normal": an era of slower but sustained growth[1]. In this

1 The term "new normal" refers to the current state of Chinese economy in which quality, efficiency and sustainability of the growth pattern are regarded as the leading principals for the development. This term was first mentioned by President Xi Jinping in his visit to Henan province in May 2014.

regard, rebalancing and restructuring of the economy by orienting it towards supply side structural reforms, enhancing domestic innovation capability and export upgrading are being considered at the core of new development strategy. Objective of this paper is to revisit and empirically investigate the role of innovation-trade relationship as an outline for further reforms in the context of challenges and diverse circumstances of a slower growth regime.

The study is a part of growing literature on the role of domestic efforts for knowledge creation, learning and technical capability improvement from foreign technology, trade openness and institutional view, in assessing export capacity of industrial enterprises. A dominant strand of relevant literatures is evident that technological innovation fosters productivity growth and accelerates industrial upgrade, as well as it contributes to establish a competitive pattern of a country's export capacity (Fagerberg, 1988; Greenhalgh, 1990; Tang and Zhang, 2016). In this regard, domestic and foreign innovation efforts, trade integration, human capital and institutional strength are regarded as main channels which determine the impact of technological innovation on export (DiPietro and Anoruo, 2006; Greenhalgh, 1990; Harris and Li, 2009; Montobbio and Rampa, 2005; Rodil et al., 2015; Tang and Zhang, 2016; Verspagen and Wakelin, 1997; Wakelin, 1998).

However, the existing researches mainly focus on measuring the effect of technological innovation on export performance at the aggregate level. Further, most of the previous studies intend to examine innovation-export nexus by committing to only a single dimension of technological innovation. Thus, there is lack of research investigating the impact of the various aspects of innovation on export performance at the firm level. To this end, the paper combines different variables concerning domestic innovation efforts, foreign investment, human capital, trade integration and market reforms in a comprehensive framework to evaluate their association with export. These diverse channels help capture different aspects of the innovation process. Concisely, our study extends the understanding of the relationship between technology upgrading and the international competitiveness of the Chinese economy, as China's experience has significant policy lessons for other emerging countries as well as many developing countries.

Using a range of indicators concerning technological innovation is appropriate as innovation is multidimensional and complex. An extensively used proxy "R and D," for instance, may not efficiently interpret innovation for several reasons: First, innovation may carry the effect of past R and D rather than current one as R and D often produces delayed effect and/or sometime innovation may take effect from external innovative environment and increase innovative capacity even the enterprise has not raised the level of R and D spending (Harris and Moffat, 2011); Second, the relationship between R and D and patent, as input and output of an innovative process, is complex and all R and D may not result in enhancing innovation capability (Mairesse and Mohnen, 2002) because some industries may be R and D intensive but keep a low level of innovation output for reasons such as to maintain secrecy, to avoid additional costs etc., and vice versa. Third, production process is utilized in some industries, such as engineering and instrumentation, to produce innovation rather than R and D, and thus measuring the level of innovativeness using R and D may generate size bias (Wakelin, 1998). To summarize, using R and D intensity as a main explanatory variable is inadequate and restricts the capacity to analyse different aspects of innovation process. Furthermore, recent insights about innovation process and other knowledge creating channels reveal that innovation is a multidimensional process and involves a variety of the types of innovative activities which therefore be captured by distinct indicators of innovation (Rodil et al., 2015).

Drawing on these points, central question of the paper asks: how do various aspects of technological innovation (e.g., domestic innovation, foreign investment, human capital, trade openness, size and market-oriented reforms) influence the export performance of large- and medium-sized industrial enterprises (LMEs) in China's? To answer this question, we rely on unique Chinese dataset on a panel of 27 two-digit manufacturing industries over the 1998-2010 period, specifically relying on LMEs. Further, we introduce a range of alternative measures on technological innovation simultaneously into our empirical model. For each sub-sector level product group, export function is estimated on various determinants related to innovation using instrumental variable (IV) technique to avoid possible endogeneity bias. To do this, we first applied IV-2sls method and consistency of this method is then checked by applying system-GMM method.

The paper contributes to the literature in a number of ways: First, we construct a range of variables to explore the causal link between technological innovation and export growth using firm-level data. A substantial body of research literatures focuses on only a single measure in this concern. Second, since the relationship has not been wholly investigated in the developing countries (Wang and Kafouros, 2009), especially in a sub-sector level analysis similar to ours, the present study not only provides useful insights about innovation-export nexus in emerging countries but also provides significant policy lessons to developing counties on how they can be succeeded to upgrade the technical structure of industrial export. Third, accelerating technical upgrade of manufactured export is crucial for China and the findings of our study provide useful insights about the viability of China's ongoing technological upgrading efforts in enhancing domestic innovation capacity and acquiring more advanced technologies through FDI spillovers. Further, it also provides policy makers with effective policy tools to speed up the process of the formation of an outward pattern of economic development with strong international competitiveness.

The remainder of this paper is organised as follows. The next section describes review of the previous literature. Section 3 then presents model, methodology and data. Section 4 explain the empirical results and discussions. In the last, section 5 conclude the analysis and provide policy implications.

2. LITERATURE REVIEW

Standard classical and neoclassical theories of international trade disregard the role of innovation in international competitiveness of countries, as technology is assumed to be a universal phenomenon which is freely available to all. Instead, these theories rely on factor endowments (e.g., natural resources, and human and physical capital) to ascertain the specialisation pattern of a country. An early viewpoint confirming the importance of innovation and learning is linked to neo-technology models (Grossman and Helpman, 1991; Krugman, 1979; Posner, 1961; Vernon, 1966) which explain the potential role of product and process innovation in driving the production structure. A benchmark model is "Vernon's product cycle theory" which allocate life cycles to the manufacturing process of a product by examining that new products require strong innovative capability and R and D, thus production occurs in advanced countries, while in the later stages, the input requirement changes and the product migrate to developing countries. The remarkable success of Asian Newly industrialised economies provides a relevant evidence. Another viewpoint is presented by technology-gap theories which assume that the technology gap between countries shape their respective trade pattern (Posner, 1961). This gap is reduced or expanded by such technology upgrading efforts as promoting indigenous innovation activities and enhancing the rate of foreign technology transfer among countries (Greenhalgh, 1990). Moreover, Recent developments in trade theories and models associated with endogenous growth provide some standard framework that allow technology, knowledge creation and learning to be a critical part of production processes (Grossman and Helpman, 1991; Romer, 1990; Young, 1991).

How does TI determine export activity? Technological innovation influences development of new products, improves existing production processes, increase the labour productivity which is a significant determinant of unit cost, thus average cost decreases putting country in a competitive position comparing to its rivals. A substantial body of empirical literature on innovation-trade relationship suggest that export activity is positively associated with the various aspects and certain dimensions of technological innovation. The relationship has been suggested by numerous studies on advanced countries as in Bernard and Jensen 1999; Cassiman et al. (2010); Fagerberg (1988); Greenhalgh (1990); Lachenmaier and Wößmann (2006); Rodil et al. (2015); Roper and Love, (2002); Soete (1987) and Wakelin, (1998, 1998a). The case of Asian economies has received the similar types of results which can be confirmed from the empirical results as presented in Ito and Pucik, (1993); Kumar and Sidharthan, (1994); and Yang and Chen, (2012). In particular, Wakelin (1998), in his version of technology-gap theory, investigates the impact of innovation on trade performance allowing for intra-sectoral and inter-sectoral innovation spillovers in 22 manufacturing sectors of nine OECD countries finding a significant positive impact of innovation on export performance. However, the result is sensitive to different innovation proxies. Montobbio and Rampa (2005) perform structural decomposition analysis to investigate the role of indigenous innovative capability, industrial productivity, initial technological skills etc., on export activity in 25 primary and manufacturing sectors of nine developing countries finding the significant positive impact of these channels on export activity. Dipietro and Anoruo (2006) distinguish between different unique aspects concerning creativity to conclude that innovation significantly improves the level and composition of export and positively influence export promotion. Rodil et al. (2015) explain that diverse aspects concerning technological innovation: innovation decision, innovation variety, the interaction between R and D and innovation, marketing innovation, and sectoral composition of innovation has significant positive effect on export activity. Further, numerous studies find a significant positive relationship between innovation and export activity in case of China as in Guan and Ma (2003); Tang and Zhang (2016); Wignaraja (2012); and Zhao and Li (1997). However, the relationship has not been wholly investigated in the developing countries (Wang and Kafouros, 2009), especially in an industry-level analysis and most of these studies use a single proxy of domestic innovation, i.e. R and D to sales ratio, to investigate the question in concern.

Nonetheless, innovation is multidimensional and complex, and the process of innovation requires several different types of R and D activities before it has been started. Therefore, in an analysis that describes the innovation-export nexus, various aspects of technological innovation must be incorporated. For instance, assessing the effect of innovation activity simply by counting patent applications may lead to overestimation of invention process, as some types of patents may not potentially contribute to enhancing innovation capability. For instance, of all three categories: (a) invention patent; (b) utility model; and (c) external design, only invention patents substantially identify the contribution to new product development, while utility models are related to the shape and structure of the products and external design patents incorporate designs about shape, colour or pattern of a product (Fu, 2008). In addition, domestic enterprises are confronted with strict competition from MNEs in technology-intensive products, as they lack necessary technological capabilities, and thus their patents face much quality differentials and incomparability than that of MNEs. (Sun and Du, 2010). These arguments concisely convey the idea that: innovation variety extends the understanding of innovation process of enterprises and its influence on export activity; and that various dimensions of innovation process should be captured by including a range of variables in empirical model. Furthermore, evidence shows that innovation in latecomers is broadly associated with the imitation, assimilation and learning from foreign knowledge resources (Amsden, 1992; Narula, 2002) as developing countries possess weak internal capabilities. In this sense, scientific and technological development efforts in these countries rely heavily on learning and knowledge spillovers from multinational enterprises (MNEs) (Lall, 2003). Studies show that FDI significantly influences innovation capacity of domestic industries through the exchange of technical know-how, promotion of R and D related activities by MNEs, sharing of managerial skills, movement of trained labour and the demonstration effect (Grossman and Helpman, 1991; Griliches, 1991; Narula and Driffield, 2012).

Theories suggest that sound market institutions maintain their interaction with other state entities to shape the dynamics of international trade through strict intellectual's property rights (IPRs), credible contract enforcement, lower corruption intensity, efficient bureaucracy, a stabilized financial sector, effective modes of economic policy making etc., (Araujo et al., 2016; Dollar, 2003; Faruq, 2011; Söderlund and Tingvall, 2014). Japan and South Korea's evidence provide substantial examples whereby state ownership interacted with private businesses to formulate a robust development strategy, as well as state intervention protected large business groups, provided preferential access to capital and acquired foreign technology through licensing agreements and technical cooperation agreements so that it can be leveraged in the domestic market for building industrial capability, enhancing TFP and stimulating international competitiveness (Amsden and Chu, 2003; Johnson, 1982; Kohli, 2004; Pack and Westphal, 1986). However, market-oriented reforms in China identifies a system of separate ownership working in tandem with public sector. In other words, these reforms in China explain interaction between public and private ownership for a competitive market, whereby performing state-owned enterprises have a respected place (Hong, 2016). In addition, market-oriented reforms aiming at adjusting standards for the evaluation of tariff rates and the acquisition of new technology determine export activity of enterprises through its effect on the innovative activities. Trade policy specifies tariff rate on import of intermediate inputs from advanced countries that affect the technology transfer rate and the export structure. Tariff rates further change the price of a product in domestic and world market and thus the level of resource allocation (Schott, 2008). State's export promotion policy by providing tax subsidies to the developers of new products emphasize technology intensive exports and improve the technical composition of export basket.

3. METHODOLOGY, VARIABLES AND DATA

China's economic landscape is vast and expanded, so scattered are the technological opportunities in different sectors and regions. For example, coastal areas are considered to be a hub of technology-intensive production processes and therefore the most attracted destination for foreign investment. In fact, technology-intensive sectors (e.g. machinery and equipment industries) facilitate larger proportion of FDI spillovers and diffusion of advanced technologies, which is a diverse channel for technological innovation in latecomers. Nonetheless, other manufacturing sectors are also important as they provide basis for the production of technical products. Therefore, we assume working on a broader aspect of the manufacturing sub-sectors to be more effective. Further, we assume that domestic innovation efforts, foreign investment, human capital, trade openness and market institutions determine export activity at the industry-level.

The analysis is based on various characteristics of China's manufacturing industries[2]. Drawing on two-digit level of Chinese standard industrial classification, a panel of 27 manufacturing industries is constructed. Data on these industries in 13 years (1998-2010) is mainly collected from Ministry of Science and Technology of China and various issues of China Statistical Yearbook.

3.1. Dependent Variable

The dependent variable of the export performance of enterprises is measured by the share of an industry in total manufactured exports (EXP). A difficulty arises concerning the measurement of the dependent variable EXP, as we cannot draw industrial export statistics directly from the designated data arrangements. Fortunately, Sheng (2002) prepares a concordance table to convert SITC three-digit level commodity groups into the two-digit Chinese industries. We, thereby, use Sheng concordance table to draw data for the dependent variable. Data on *EXP* is collected from United Nations COMTRADE database. The database statistics was reported in US dollars, which were converted into Chinese RMB in terms of nominal exchange rate from World Development Indicators database and then were converted into real 2005 values in terms of PPI as reported by the CNBS.

3.2. Independent variables

We have included separate variables on various aspects of technological innovation. Domestic innovation effort is measured by intra-mural R&D intensity (*R and D Int.*), which represents the ratio of intra-mural Rand D spending to gross output of an industry. Foreign Investment (*FDI*) variable is proxied by the share of foreign-owned enterprises in total. The human capital variable (S and T per) is proxied by share of scientists and engineers in overall employees of an industry. It is a more appropriate proxy of human capital comparing other relevant variables which are often used in the existing literature such as secondary school enrolment rate or years of schooling, as expansion of innovation process latches on skill and expertise of technicians to conduct R&D activities. We have also captured the effect of China's integration into world trade by including the variable on trade openness (*Open*). The *Open* variable is proxied by the trade to output ratio in an industry. Further, we capture the effect of market reforms on export by including the (*MARKET*) variable which is proxied by the number of private enterprises in an industry. Our other variables are Physical capital stock to employment ratio in each industry (*K/L*) which is proxied by the value of investment in fixed assets to overall employees in that industry and size of an industry (*Size*) which is proxied by the share of each enterprise in sales. All variables are measured in real 2005 RMBs. Definitions of the variables are summarised in Table 1 while the summary statistics of all the variables is provided in Table 2.

Following the previous discussion, export performance of enterprises in manufacturing industry is considered a function of traditional factor endowments (i.e. physical capital stock and labour), domestic R and D efforts, human capital, foreign investment, trade openness and market-oriented reforms. Our estimable equation takes the following form.

$$EXP_{it} = \beta_0 + \beta_1 K/L_{it} + \beta_2 R\&D\,Int_{it} + \beta_3 S\&T\,per_{it} + \beta_4 FDI_{it} + \beta_5 Open_{it} + \beta_6 Size_{it} + \beta_7 Market_{it} + \upsilon_i + \nu_t + \varepsilon_{it} \quad (1)$$

Where subscript i, t denotes industry and time respectively, v_i represents industry specific effect, v_t denotes time-specific effect

2 The paper specifically focusses on Large- and medium-sized enterprises of manufacturing industries, as these industries possess specific level of skill intensity and the innovation capability. Moreover, these industries maintain broader financial constraint to bear the large fixed costs associated with research and development and innovation activities.

Table 1: Definitions and the expected signs of variables

Variables	Measurements	Expected Sign
Dependent var.		
EXP	Share of each industry in total manufactured export	
Independent var.		
K/L	Value of investment in fixed assets to employment ratio in an industry	+
S and T per	Number of scientists and engineers in an industry	+
R and D Int.	Ratio of gross expenditure on R&D to gross output value of an industry	+
Open	The trade to output ratio in an industry	+
FDI	Share of foreign-owned enterprise in total enterprises of an industry	+
MARKET	Share of private fixed assets to total assets in an industry	+
Size	Share of each industry in total sales	+

Source: Authors' own calculations

Table 2: Summary statistics of variables

Variable	Obs	Mean	Std. Dev.	Min.	Max.
EXP	351	−3.863	1.176	−6.991	−1.758
KL	351	1.069	1.419	−2.576	3.608
R and D int	351	−5.051	0.701	−7.209	−3.732
S & T per	351	9.608	1.467	5.677	12.889
FDI	351	−1.691	0.511	−3.134	-0.648
Open	351	−1.116	1.019	−4.071	1.164
Size	351	10.378	0.909	8.484	13.048
Market	351	−2.981	0.907	−5.668	−1.121

Source: Authors' own calculations

and ε_{it} is random error term which is uncorrelated with any of the industry-specific or time specific effects and the independent variables. *EXP* is the dependent variable of export activity of enterprises in an industry. *K/L* and *S and T per* read physical capital stock to labour ratio and human capital respectively. *R and D int* is the variable on domestic innovation efforts. *FDI* reflects foreign investment, *Open* represents trade openness.

Market denotes market-oriented reforms and *Size* shows size of an industry. All variables appear in natural log form in regression models. The correlation matrix of independent variables is provided in Table 3.

Specific tests and sensitivity checks should be conducted to select robust estimation methods. Ample studies find evidence that there may exist reverse causality in the relationship between innovation and export (Harding and Javorcik, 2012; Zhu and Fu, 2013) which may lead to potential endogeneity bias. It renders traditional fixed effect and random effect estimation methods inconsistent. Therefore, the IV regression method is applied to estimate equation (1) and lagged values of endogenous variables are used as instruments because of its appropriateness and high correlation with endogenous variable (Lileeva and Trefler, 2010; Tang and Zhang, 2016). We first estimate equation (1) by applying IV-2sls method. However, various studies show that IV-2sls method possess certain limitations concerning validity of instruments. For robustness, we apply system-GMM panel estimator as proposed by Arellano and Bover (1995) and Blundell and Bond (1998). System-GMM is robust to several measurement biases. Further, we perform Arellano–Bond tests to detect second-order (AR [2]) serial correlation and Hansen test to assess the validity of the instruments.

4. RESULTS AND DISCUSSIONS

The results of empirical analysis based on panel IV-2sls method and system-GMM method are reported in Table 4 and Table 5 respectively, while the models 1 to 4 in these tables reflect alternative approaches to robust estimates by undertaking several sensitivity checks. We first briefly describe the results of IV-2sls method and then explain system-GMM estimation results in detail because the later are more consistent and reliable than the former.

The results presented in Table 4 consider trade openness (*Open*), *FDI* and market reforms (*Market*) to be significant determinant of export performance of LMEs in China while *R and D int*, resource endowment (*K/L*), human capital (*S and T per*) and Size variables fails to reveal a significant effect on exports. Of course, the weak capacity of IV-2sls method to cope with the problem of endogeneity bias may affect our results. Therefore, we next refine the measurement of equation (1) by using system-GMM method. As discussed earlier, we explain these results in detail. In general, the empirical results provided in Table 5 are fair and plausible as well as all the estimated coefficients hold expected signs.

Results presented in Table 5, report the coefficients of domestic innovation efforts (*R and D int*) and scientific and technological development staff (*S and T per*) to be positive and statistically significant across all models, implying that domestic innovation activities and recent development in the skill and expertise of scientists and engineers in China have played a crucial role in the export success of LMEs. These results validate the favourable effect of China's ongoing efforts to raise scientific and technological development activities. Further, the result proves to be consistent with theoretical prediction in the literature. High domestic R&D intensity provide opportunity to produce new products and improve export performance by raising the quality of existing product, in addition, the improvement of process innovation reduce cost and increase competitiveness (Wakelin, 1998). Similarly, research and development activities generate sustained export growth if they are aimed at the sectors with increasing technological opportunities, as well as help interact with novel technologies when facilitate the production of new technical assets (Guan and Ma, 2003; Montobbio and Rampa, 2005). These results are in line with the findings of recent studies (Rodil et al., 2015; Zhu and Fu, 2013). The positive impact of the *S and T per* variable reveal that the speed of technology upgrading process in China can be increased by improving the

Table 3: Correlation matrix

	KL	R and D int	S and T per	FDI	Open	Size	Market
KL	1						
R and D int	0.097	1					
S and T per	0.198	0.572	1				
FDI	0.126	0.024		1			
Open	−0.289	0.106	−0.163	0.593	1		
Size	0.509	−0.010	0.547	0.318	−0.377	1	
Market	0.619	−0.099	−0.225	0.034	−0.037	−0.044	1

Source: Authors' own calculations

Table 4: Panel IV-2sls estimates (Dependent variable: Export performance)

Variable	Model 1	Model 2	Model 3	Model 4
Constant	−2.887***	−2.424**	−2.983***	−2.338**
	(0.842)	(1.072)	(0.949)	(0.931)
R and D	0.149	0.213	0.106	0.099
	(0.156)	(0.154)	(0.172)	(0.169)
K/L	0.034**	0.045***	0.020	-0.035
	(0.016)	(0.017)	(0.026)	(0.030)
Openness	0.239***	0.345***	0.288***	0.323***
	(0.071)	(0.067)	(0.094)	(0.090)
S and T per		−0.003	0.045	0.052
		(0.046)	(0.064)	(0.063)
FDI			0.541**	0.533**
			(0.221)	(0.214)
Size			0.041	0.019
			(0.096)	(0.096)
				0.149***
Private				(0.053)
No. of Obs.	324	324	324	324
R-Squared	0.538	0.538	0.589	0.581

Standard errors are in parenthesis, *Significance level of 10%, **Significance level of 5%, ***Significance level of 1%

Table 5: Panel IV-GMM estimates (Dependent variable: Export performance)

Variable	Model 1	Model 2	Model 3	Model 4
Constant	0.033	-0.201*	-0.354*	-0.375*
	(0.037)	(0.108)	(0.194)	(0.205)
EXP_{t-1}	0.930***	0.942***	0.885***	0.891***
	(0.011)	(0.008)	(0.017)	(0.022)
K/L	0.012***	0.008***	0.006*	-0.010
	(0.002)	(0.002)	(0.004)	(0.006)
R&D	0.047***	0.025**	0.048***	0.049**
	(0.007)	(0.011)	(0.018)	(0.020)
OPENNESS	0.074***	0.069***	0.109***	0.101***
	(0.012)	(0.007)	(0.009)	(0.014)
S and T per		0.018***	0.027***	0.029**
		(0.006)	(0.009)	(0.014)
FDI			0.031**	0.032**
			(0.015)	(0.015)
SIZE			0.006	0.018
			(0.014)	(0.019)
PRIVATE				0.029**
				(0.013)
Specification and validity tests (P-value)				
Hansen test	0.409	0.370	0.441	0.355
AR (2) test	0.286	0.228	0.941	0.955
No. of Obs.	324	324	324	324

Standard errors are provided in parenthesis; ***, ** and * indicates significance levels of 1%, 5% and 10% respectively

quality of human capital. For instance, high quality human capital not only assimilate and internalize external knowledge, through its interaction with external technological environment, but also give impetus to domestic innovation activities for creation of sound innovation capability (Powell, 1998, Guan and Ma, 2003). These findings are in line with that of recent studies (Tang and Zhang, 2016).

Besides, we find that estimated coefficient of FDI variable is positive and significant across all the empirical models. The result note that export boom in china has largely benefitted from foreign investment as it provided necessary knowledge spillovers to domestic enterprises. Further, foreign enterprises are committed to export technology-intensive products which otherwise may not be present in the export basket of a developing country. The finding is consistent to several recent studies (Tang and Zhang, 2016). In addition, the coefficient of the *Open* variable is also positive and statistically significant at 1% level across all models. It reveals that China's integration into world trade, which is prominent feature of its 'opening-up' strategy, have provided its enterprise the required motivation to involve in the production of manufactured products rather than primary products. Further, as our dataset ranges over the period 1998-2010, we can assume that China inclusion into WTO has been functioning as a stimulus to the domestic economy and have brought a magnificent success to the domestic industries for the production of exportable.

Similarly, the coefficients on MARKET is positive and significant in all estimated models. The result show that market-oriented reforms aiming at creation of a competitive market by rising the share of separate ownership (Hong, 2016) have shown a favorable impact on industrial export through improving on contract enforcement, minimizing currency fluctuations and smooth working of the financial sector, improving protection of IPRs etc., Our other variables including *K/L* and *Size* are also positive and significant, implying that resource endowment and size of an industry is a significant determinant of export activity in LMEs.

5. CONCLUSION AND POLICY IMPLICATIONS

On the onset of worldwide financial crisis in 2008, China has given farewell to double-digit GDP growth rate. To sustain a moderate to high level growth rate, the researchers and policy makers at home and abroad consider the role of innovation-export interplay at the core of new development strategy. The paper contributes to the policy literature by empirically investigating the impact of the various aspects of innovation on export performance of LMEs.

While there are many studies on innovation-export relationship, existing researches mainly focus on relevant studies conducted in advanced countries, while such studies in developing countries are provide much less attention, Further, studies which intend to examine an industry-level analysis using a range of aspects concerning technological innovation are scarce. To fill this gap in the existing literature, we take the sample of LMEs in China and utilize a panel dataset of China's 27 two-digit manufacturing industries over the period 1998-2010 and combine variables on domestic innovation efforts, foreign investment, human capital, trade openness and market reforms to examine their impact on industrial export. Using a range of indicators is appropriate to capture different aspects of technological innovation, as it is multidimensional and complex, and involves a variety of the types of innovation activities. Further, the empirical methodology we apply is based on IV methods. In this regard, the IV-2sls and system-GMM methods have been applied to obtain robust and consistent estimates.

Subject to robust methods, alternative measures and various tests and sensitivity checks, the basic findings of the paper are described below. First, domestic innovation activities and recent development in the skill and expertise of the S and T development staff in China have played a crucial role in the export success of LMEs. It reveals that the speed of technology upgrading process in China can be increased by improving the quality of human capital which may help maintain a competitive outward pattern of economic development. Second, the export boom in china has benefitted greatly from foreign investment and certain innovation activities of foreign enterprises which have provided necessary knowledge spillovers to domestic enterprises. Our finding reveal that China can still take more advantage of the technology spillovers as provided by MNEs. Third, China's integration into world trade has provided its industries the required motivation as well as the necessary impetus to carry out large scale production activities. In addition, the technology imported has significantly improved the technical structure of exports in China. Last, market-oriented reforms have contributed to put a crucial impact on the competitiveness of China's manufactured export. Further, the market related institutions and their reforms have motivated the enterprise in the market to carry out export promotion activities which may further increase the benefit of a competitive market.

Findings of the paper suggest some policy lessons. An increase in the R and D spending in China is a significant policy to boost the innovation activities and to establish a strong innovation capability. Particularly, investing in high quality human capital, such as increasing the share of scientists and engineers, is an effective way for China to achieve the standards of technology upgrading that may help increase the likelihood of maintaining its international competitiveness. Moreover, improvement in some aspects of innovation capability such as indigenous manufacturing and marketing capabilities is necessary to increase the proportion of sales attributable to indigenous innovation and to internalize maximum benefits from a sound domestic innovation base. Further, further opening-up is a beneficial policy for China in the wake of the current economic situation. Last, China should continue deepening market-oriented reforms for the creation of a competitive market and the favourable interaction of public and private ownership and its contribution to export upgrading.

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