Title: ICT CLUSTERS PROMOTING INNOVATION AND SOCIAL CHANGE: THE CASE OF DONGGUAN, CHINA[i]

Brief Running Title: **ICT CLUSTERS FOR INNOVATION AND SOCIAL CHANGE**

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Abstract: We investigate under what conditions specializing in ICT pays to a territory in terms of technological innovation and social change. Our analysis focuses on the case of Dongguan, China, which is a core area in the development of the national ICT industry. We perform an empirical analysis based upon a unique township-level dataset covering several years (2001-2015). We integrate the quantitative data with qualitative information on the past and future prospects of Dongguan clusters, gathered through a number of fieldworks and interviews with top managers, policy-makers and relevant stakeholders in both provincial and local institutions. Our findings suggest that (1) specialising in ICT can pay in terms of innovative performances, provided that it is supported by an institutional setting aimed at collectively promoting innovation, a sufficient degree of extra-cluster relations and a sufficiently high level of education of the population. (2) ICT can also pay in terms of social change, if coupled with a significant level of public involvement and of technological innovation. Adding to the literature on the relationship between economic performance of clusters and their social impact, our findings indicate that technological innovation acquires a pivotal role in discriminating those clusters that are able to enhance social wellbeing.

Highlights:

- We focus on ICT clusters performance in technological innovation and social change
- We analyse ICT clusters within the specialized town program in Dongguan
- Educated local population and foreign linkages improve ICT clusters' innovation
- Government expenditure and innovation improve ICT clusters' social change

Keywords: Innovation, Social Change, China, Specialized Towns, Clusters, ICT

JEL: O3; O35; O38; O25; L63

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[i] Abbreviations used in the text: ST(s) – Specialized Town(s)

1. Introduction

Information and communication technologies have gathered much attention since they have arguably changed every aspect of our contemporary life. They have enabled faster connections between people and between economic agents with gains in productivity and efficiency for entire economic and social systems (Siegel, 1983; Disney et al., 2004; Ollo-López and Aramendía-Muneta, 2012, only to cite some). They have improved people's access to goods and – both private and public – services, giving new answers to old needs and potentially enhancing human capabilities (Osei-Frimpong et al., 2016; Gigler, 2011; Lyons, 2009; Balauskat et al., 2012). They have become one of the most powerful tools for social change and social innovation, allowing for new forms of social, political and economic organisation (Linders, 2012; Lechman & Marszk, 2015). They even show to be positively correlated with environmental sustainability (Gouvea et al., 2017). In other words, the benefits of ICT products in the perspective of end-users, being them people or companies or governments, have been extensively documented (Asongu & Le Roux, 2017; Kozma, 2005; Molony, 2009).

However ICT is also a *product:* it is manufactured in specific places around the world, it represents a distinct manufacturing sector, and its production can come at some costs, both for the end users and for those directly engaged in the production processes (NLC, 2009; Hughes et al., 2017). In this perspective: what is happening to the places that produce ICT to the benefit of the rest of the world? Are these places experiencing innovation and social change *thanks to* their specialization in this particular sector? Under what conditions specializing in ICT will pay to a territory in terms of innovation performance and in terms of social change? These are the driving questions of this paper.

Part of the literature, especially the one referring to high-tech clusters and sector specialization, has placed emphasis on high-tech productions *per se* suggesting that some sectors are inherently characterized by higher degrees of knowledge and innovativeness (Coad and Rao, 2008; Chesbrough, 2003). However, different voices and streams of literature, among which is the global value chain approach, point out that what really matters is the specific phase of the production process that firms and clusters cover, rather than the sector itself (Shih et al., 2012; Chen, 2004; Wang et al., 2010). In this respect, some scholars suggest for instance that *upgrading* clusters are more likely to experience higher degrees of productive and social innovation (Giuliani et al., 2005; Rocha, 2004). However, there is no definite consensus on the specific mechanisms that link high-tech clusters, innovation and social change (Fosfuri and Rønde, 2004; Alecke et al., 2006; de Oliveira, 2008). In addition, there is a need for more empirical evidence on developing countries (Morrison et al., 2008; Yang et al., 2009). Despite the attention that ICT clusters have received in the literature also in developing countries, to the best of our knowledge, none of the available studies has jointly investigated the relation between ICT clusters, innovation and social change.

With these premises, we analyse the experience of Dongguan, in the Guangdong Province of China. This relatively small prefecture[1] in Southern China – with a permanent population similar to that of Switzerland on an area no larger than Luxembourg[2] - has witnessed in few years an impressive growth in ICT production, becoming a world hub in this field (Wang and Lin, 2008; Zhou, 2013; Zhou et al., 2011). In 2016, one sixth of all the smartphone sold in the world were manufactured in this city[3]. The organization of ICT production, and in general of the whole manufacturing, in Dongguan is structured around industrial clusters. Such social organizations of production have been officially recognized since the early 2000s in the framework of the Guangdong "Specialized Towns Program" (Di Tommaso et al., 2013; Bellandi & Di Tommaso, 2005) with notable efforts in the institutional setting promoting innovation inside the clusters.

A few studies in the international scientific debate have analysed the experience of Dongguan specialized clusters in ICT (Zhou, 2013; Zhou et al., 2011; Sun and Zhou, 2011, only to cite some).

Most of these contributions use either firm-based or single cluster case studies or macroeconomic descriptive approaches. On the other side, while few studies have analysed Dongguan's dynamics of social change due to demography, migration and various agents' interplay (see for example Liu and Ye, 2016; Ip-Chong, 2014 and Lin, 2006), they do not relate such aspects to the ICT production in Dongguan. In other words, to the best of our knowledge there is not any up-to-date comprehensive evaluation of the degree of innovation and social change that ICT clusters have achieved with respect to other types of productions in Dongguan. With this paper we aim at linking ICT specialization, technological innovation and social change.

Specifically we test the distinctive social, economic and institutional features that enable ICT specialised clusters to promote both technological innovation and social change. Our study has relevant policy implications for the future development of ICT production in southern China and adds to the previous literature on the promotion of high-tech clusters in developing countries (Archibugi

[1] Prefecture represent the second administrative level (below the Provinces) of China (Di Tommaso et al., 2013).

[2] In 2015 (last available data) Dongguan's permanent population summed up to 8,254 million, while its land covers 2.460 square kilometres. Source: Guangdong Bureau of Statistics (2016).

[3] https://news.cgtn.com/news/3d557a4d32454464776c6d636a4e6e62684a4856/share_p.html

and Pietrobelli, 2003). Our analysis is based upon a unique township-level dataset covering several years (2001-2015). We integrate the quantitative data with qualitative information on the past and future prospects of Dongguan clusters, gathered through a number of fieldworks and interviews with top managers, policy-makers and relevant stakeholders in both provincial and local institutions.

The paper is organized as follows: section 2 reviews the relevant literature; section 3 describes the method; section 4 provides a description of the institutional setting emerged around the governments' Specialized Towns Program and frames the experience of Dongguan within this setting. Section 5 presents the empirical analysis and discusses the results on the relation between ICT and innovation, on one side, and ICT and social change, on the other. Section 6 concludes.

2. Literature Review

2.1. Clusters, ICT and innovation

Since Marshall (1961), the linkage between specialized clusters and innovative performance has been widely studied. Some contributions have suggested that territorial specialization and spatial proximity among firms increase innovative capability. This is mainly due to:

- localised learning processes and inter-firm networking that facilitate the diffusion of knowledge (Baptista, 2000 and 2001; Bell, 2005; Breschi and Malerba, 2005);
- externalities among firms, with particular reference to knowledge externalities (Baptista and Swann, 1998; Cappellin, 2009);
- co-location within the cluster of valuable customers that allow an improved knowledge of the market (Porter, 1998).

These advantages not only go to the benefit of the single firms, but they "may simultaneously enhance the knowledge base of multiple local firms" (Delgado et al., 2012, p. 35).

Other papers, however, have highlighted that clustering is not innovative *per se*. According to Wang (2011), proximity only creates a potential for interaction, but the final result in terms of networking and knowledge spill-overs strongly depends on the willingness of firms to participate (Okamuro and Nishimura, 2017).

Furthermore, the mere interaction may again be not sufficient to increase the innovative capacity of the cluster. In fact, some sort of coordination in the competitive dynamics among firms is needed in order to transform the interaction into an innovative effort. In this sense, the presence of institutions such as technological innovation centres may facilitate the ignition of processes of innovative networking.

The relation between innovation and firm agglomerations is particularly strong in high tech clusters, which have received a great deal of attention in the literature (see, among others, Bresnahan and Gambardella, 2004; He and Fallah, 2011; Keeble and Wilkinson, 1999). In particular, high tech clusters have been considered to be the engines of the spectacular growth experienced by some regions in advanced countries, such as the Silicon Valley in the U.S. (Kenney, 2000; Saxenian, 1990; Engel, 2015, to cite some), Sophie-Antipolis in France (Ter Wal, 2013; Longhi, 1999) or the Cambridge area in the UK (Athreye, 2004; Cooke, 2001 and 2002; Keeble et al., 1999).

Among high tech clusters, several authors have concentrated their research efforts on ICT (see, among others, Rasiah et al., 2006; Wang et al., 2010; Lee et al., 2011), also on the wave of the success of the American Silicon Valley, which has induced many to consider it as a “model” to be somehow replicated in other countries (Wonglimpiyarat, 2016; Arora et al., 2001). Behind this attention towards the development of high-tech agglomerations, and specifically of ICT clusters, lies the idea that they are particularly effective in favouring the economic enhancement of regions and countries, igniting innovation processes which in turns have the potential to lead to the overall growth of firm performance.

In the case of ICT clusters, analogously to other high-tech sectors, the presence of linkages and knowledge spill-overs among co-located firms is important for strengthening their innovative potential (Keeble and Wilkinson, 1999; Nosova, 2015). However, especially in developing countries these mechanisms of efficiency diffusion among firms may encounter some frictions. For the case of China, for example, Wang et al. (2010) show that there is no significant relation between clustering and economic performance in the ICT industry.

Some authors have underlined that in many of these cases, in order to foster its innovative capacity, the cluster needs to rely on a network of extra-cluster linkages, allowing firms to acquire the qualified knowledge they lack and they are not able to produce internally (Chandrashekar and Subrahmanya, 2017; Eraydin and Armatli-Köroğlu, 2005; Wang et al., 2010).

Another important element boosting the innovative capacity of the cluster is the presence of high levels of education, facilitating the endogenous production of innovation. The lack of sufficiently qualified workforce is among the obstacles hindering the upgrading of Chinese agglomerations (Wei et al., 2007), and it has induced several ICT clusters in China to “import” specialised talents from outside, when possible (Lai et al., 2005). This is coherent with the analysis carried out at national level by Florida et al. (2012), who show that much has still to be done to lead China to shift to a new stage of economic development based on human capital and creativity.

Other contributors studying the determinants that favour an increase in the innovative capacity of IT clusters have also highlighted the importance of having the local support of host-site institutions, as meso-organizations that generate knowledge and support its transfer, favouring therefore an increase in the innovation capability of firms (Rasiah et al., 2016; Keeble et al., 1999; Ganne and Lecler, 2009).

Building upon the existing literature, we can expect an impact of ICT clusters on technological innovation, provided that the clusters display some specific features. Such features related to the presence of extra cluster linkages and of a high level of local education.

H1: Compared to other clusters, ICT clusters perform better in terms of innovation if they display a sufficiently high level of extra-cluster linkages.

H2: Compared to other clusters, ICT clusters perform better in terms of innovation if they display a sufficiently high level of educated population.

2.2. Clusters, ICT and social change

Social change has been defined as a new way of meeting (new) human needs (Swyngedouw, 2005; Barroso, 2011) and has been often associated to the concept of human development (Greenfield, 2009; Mc Michael, 2011).

Several authors have described social change as a phenomenon mainly taking place within local communities and for which the territorial dimension is relevant (Moulaert and Nussbaumer, 2005; Moulaert et al., 2005; Jessop et al., 2013). In the light of these contributions, it is reasonable to think that also clustered economic activities may have a role in enhancing social upgrading. This aspect has been emphasized in the analyses of Italian industrial districts, whose popularity is also related to their impact on society as a whole (Dei Ottati, 2003; Becattini et al., 2009; Bellandi, 2002). Being themselves "social" organisations (Pyke and Sengenberger, 1992), they might induce a form of development that is more compatible with collective welfare. Becattini and Dei Ottati (2006), in their analysis of Italian industrial districts, prove that the areas hosting such productive agglomerations show higher results not only in terms of economic performance, but also of quality of life and social welfare.

Authors that have investigated such role for clusters in less advanced countries highlight, however, that often their functioning is different from that of industrial districts.

First of all, while in industrial districts the interrelations among actors are mainly spontaneous, in the case of clusters elsewhere in the world joint action among actors does not always arise spontaneously (Nadvi and Barrientos, 2004). In these cases, hence, policies can play a role in building platforms for favouring the relations among firms and with institutions, therefore facilitating the diffusion of knowledge and the widespread of social benefits to the local community.

Secondly, not all types of clusters in less advanced countries have the same potential of favouring the social enhancement of the local community and this is because local productive agglomerations may strongly differ one from the other (Rocha, 2004).

Nadvi and Barrientos (2004) sum up the different typologies of clusters in developing countries identified by the literature and assert that not all of them have the same impact in terms of poverty reduction and social change. In particular the authors stress that upgrading clusters, i.e. those that are more capable of evolving and improving their technological capacities, *may* result in positive impacts on the general wellbeing, due to the increase in knowledge and education requirements that such upgrading calls for (Nadvi and Barrientos, 2004).

On a similar line of reasoning, De Oliveira (2008) warns that the economic upgrading of a cluster, i.e. the innovation process improving processes, products, functions and markets, does not necessarily and automatically lead to a social upgrading, i.e. an improvement in environmental standards, labour conditions, health status, and so on.

In essence, the question on the relationship between ICT clusters and social change is fundamentally an empirical one. Building upon the existing literature we can expect an impact of ICT clusters on social change, provided that the clusters display some specific features. Such features related to community and government commitment and to the technological upgrading of the cluster.

H3: Compared to other clusters, ICT clusters perform better in terms of social change if they display a significant level of public involvement.

H4: Compared to other clusters, ICT clusters perform better in terms of social change if they display a significant level of technological upgrading.

3. Methodology

Given the plurality of actors involved and the complexity of the social and institutional framework that we wish to analyse, we adopt a multimethod approach (Goertz, 2017; Hesse-Biber & Johnson, 2015), by complementing a quantitative empirical analysis, with qualitative data gathered during our last on-side investigation in Guangdong (July-September 2017).

To perform the empirical analysis, we built an original panel dataset on Dongguan townships from various sources. First, we collected the information about the product and the year of specialization of each specialized town from the Association of Specialized Towns of Guangdong (Potic) and the Department of Science and Technology of Guangdong. Successively, we classified the specialization product according to standard international classifications (ISIC Rev.4) to identify ICT clusters.

We matched this information with a rich set of data by towns collected from the Dongguan statistical yearbooks (2000-2016). The result of such data gathering consists of an original balanced panel dataset containing information on all Dongguan townships (32) for the period 2001-2015. Additional information about the data are presented in section 5.

As a complementary approach to the quantitative analysis, we integrated the information with interviews and focus groups implemented during the fieldwork. Grounding on our previous knowledge of Specialized Towns (STs) and clustering programs in Guangdong (Di Tommaso et al., 2013; Barbieri et al., 2012; Bellandi and Di Tommaso, 2005), we identified a group of institutional actors that are involved in economic and social planning, innovation and clustering in the province (Table 1). A full list can be found in the appendix. We developed a questionnaire with open-ended questions to perform semi-structured interviews that we administered in person to institutional qualified witnesses of the STs Program. We also interviewed Chinese academic experts directly involved in the STs initiative. Questions concerned the linkage between cluster planning and innovation activity, the relation between ICT production and local social transformations, the prospects and obstacles to further economic and social development of these areas.

Table 1. Affiliation of respondents

Institutions	Number of interviews
Policy-making institutions	5
Local (township level) governments' representatives	5
Academic experts (think-tanks included)	11

We used such qualitative data to acquire a deeper understanding of the history and development of the STs phenomenon in order to complement the quantitative analysis, as other disciplines do (Gill et al., 2008; Pope & Mays, 1995).

4. Innovative institutional setting: the experience of Specialized towns in Guangdong

Building on the results of our on-site investigation in Guangdong and on the existing literature, we introduce some preliminary findings on the recent experience of Guangdong clusters.

Clusters in Guangdong seem to display a number of distinctive features compared to the experience of other industrial agglomerations in China (Di Tommaso et al., 2013; Barbieri et al., 2012; Wang and Yue, 2010; Lai et al., 2005; Bellandi and Di Tommaso, 2005; Christenson & Lever-Tracy, 1998 among the others).

The first important aspect is the peculiar institutional setting that the government of Guangdong, through the Department of Science and Technology (hereinafter DSTGG), has developed to coordinate and promote innovation within these clusters. Many STs found their seeds in the Spark

Plan launched by the Chinese government at the end of the '80s, but in the early 2000s the STs Program became a separate and unique policy program aimed at coordinating the fast industrialization process, while at the same time promoting innovation (DSTGG, 2003; Bolognini, 2000; Barbieri et al., 2009a, 2009b; Liu and Zhou, 2013; Di Tommaso and Rubini, 2006).

The institutional setting envisaged by the program involves a system of certifications[4] awarded to the towns, and it includes specific policy actions implemented by different layers of government. Technological innovation is at the centre of the STs Program. Once the certification is obtained, the certified STs are entitled to receive a subsidy from the DSTGG, provided that an additional part be financed by the local government in the proportion of 1 (province): 10 (city): 50 (town) (Wang, 2009; Wang and Yue, 2010). The subsidy is due to finance the establishment of an innovation centre or an innovation platform. In the view of Guangdong policymakers, innovation platforms have multiple functions, acting mainly as incubators of various forms of innovation. Firstly, they are designed to help firms with services for the development of new technologies and the upgrading of the production. Secondly, they aim at encouraging the cooperation among the different economic and institutional actors of the town, building a link between private firms and public research institutions to foster innovative projects (GDASS, 2017; GGDST, 2017; Barbieri et al., 2010). In doing so, the activity of the innovation centres should help improve the reputation of the whole productive system of the town, possibly supporting the development of common brands (Arvanitis and Qiu, 2004; Wang J., 2004; DSTGG, 2003, 2006a). From the interviews to policy actors, it has emerged that in recent years the DTSGG has tried to create a competitive market for innovation centres, where several services centres are created and encouraged to compete for the supply of services to the companies in the town. Innovation centres operate in their every-day activities and strategic choices, mostly following a market logic, but at the same time they maintain linkages with the political and funding actors mainly through the board of directors.

Notwithstanding this common institutional setting, very different types of towns have emerged since the early 2000, depending upon the prevailing products, specific location and production environment. Based on their history of economic development, the literature identifies two main categories (Wang, 2009; Wang and Yue, 2010; Bellandi and Di Tommaso, 2005):

[4] In order to be certified as "specialized", towns must meet some specific criteria. First, from the administrative point of view the cluster must be identifiable with a township (even though occasionally there are cases of different administrative units, such as urban districts or counties, recognized as "specialized towns"). Second, at least 30% of its industrial production should come from the specialized industry (defined in specific sectoral terms, analogously to international three-digit classification systems). Finally, the township as a whole should generate an industrial output of at least 2 bln Yuan (Di Tommaso et al., 2013).

1. Exogenous clusters, whose growth and economic development has mainly been triggered by the attraction of foreign direct investment (FDI) and where the policy has been mainly aimed at favouring the relationships between foreign firms and existing enterprises.

2. Endogenous clusters, whose birth is mainly due to local factors. Some of them are the result, for instance, of the evolution of ancient productive systems. Others have been pushed by the privatization of town and village enterprises (TVEs).

STs are not a marginal phenomenon in Guangdong. Since the launch of the program (2000), the number of STs has constantly grown and it has reached the number of 416 in 2016. In 2015, they accounted for 37% of the provincial industrial output and 32% of the total export of the province, but in some prefectures (e.g. Foshan, Dongguan) their contribution was close to 100% of the output: taken altogether, they produce nearly 384Billion US$ a year (GDASS, 2017). Also, these towns notably contribute to innovation in Guangdong: about 39% of total patent applications and 31% of applications for inventions in the province come from these clusters. Most remarkably, 65% of all large enterprises that have R&D internal institutions are based in these towns. In this setting, innovation centres play a leading part: in 2015, for instance, they completed 620 projects and produced more than 3 million yuan output across the whole province[5].

In this framework, the experience of Dongguan is particularly important. This prefecture has been a pioneering place for the growth of industrial clusters: the first ST in Dongguan was recognized in 2000 - just at the launch of the DST Program. Nowadays, all but two of the thirty-two towns of Dongguan have been officially recognized as specialized clusters. This means that the whole prefecture's production is basically organized around STs (Yang and Liao, 2010).

Dongguan STs seem to show distinctive feature compared to others. First, such towns are among the largest ones in terms of total and specialization output (GGDST, 2016). They are also characterized for their exogenous nature (Wang, 2009; Yeung, 2001), as most of the industrial growth of this area has benefited from a huge contribution of Taiwan and Hong Kong capitals (Yang, 2007; Yeung and Liao, 2010). Additionally, STs in Dongguan seem to be particularly innovative with respect to towns in other areas of the Province. According to 2015 data, Dongguan STs show on average higher figures compared to other cities' towns in various indicators of innovation inputs and outputs (see Table 2).

Table 2. Innovation in STs: comparing Dongguan with the remaining Guangdong province, year 2015

[5] All data are elaborated by the authors based on information retrieved from the Guangdong Statistical Office (2016), the GDASS (2017) and from the DSTGG (2016).

Source: authors' elaboration on GDDST data

	Average per total STs	Average per STs in Dongguan	Dongguan's STs percent weight on total
Investment in Science and Technology (1000 yuan)	991.24	3818.84	30.85
Of which public investments (1000 yuan)	111.41	428.65	32.78
Patent applications	351.26	1097.88	26.63
Of which inventions	80.89	288.82	30.42
Patent licenses	236.58	802.29	28.89
Of which inventions	17.65	70.71	34.14
Number of enterprises with R&D offices	8.137	42.118	44.10
Number of innovation services providers	7.27	15.32	17.96
Number of scientific and technology institutes established by public institutions	1.93	4.94	21.84

Finally, 29 out of the 30 STs of Dongguan appear in the Top 100 according to the 2016 Innovation Index, which used by the DSTGG to evaluate the innovation performances of STs (GDASS, 2017).

4.1 The case of Dongguan and its ICT production: some descriptive statistics

Dongguan results as a core area in the development of ICT industry in the whole Guangdong. Born as Shenzhen's back factory (Zhou, 2013), its ICT industrial production has grown under the influx of Taiwan and Hong Kong (Yang and Liao, 2010) and as a global export oriented cluster in 2000s it became the world centre of labour-intensive component manufacturing (Zhou et al., 2011). Together with Shenzhen, it is the place where the majority of Chinese ICT productions are realized and exported all over the world (Lai et al., 2005; Zhou, 2013.). If we exclude Shenzhen, which is a special economic zone, Dongguan is responsible for the 24% of remaining total provincial value added produced in high-tech. More than 88% of Dongguan high-tech value added is contributed by the ICT production. By contrast, ICT in Dongguan is still characterized by assembly functions or low value added activities (Sun and Grimes, 2016): in fact, the ratio of ICT value added on total output in the city is only 14.76%, against a provincial average of 21.20%. While ICT gross output of the city corresponds to 33% of the total in the province, the value added generated is only 27.5%[6].

Although the competitive pressures after the international crisis have pushed this territory's private and public actors to improve their R&D capacity (Zhou, 2013; Marinov and Marinova, 2012), it still has to be verified whether such efforts have produced results in climbing the technological ladder. According to the 2016 DSTGG Innovation Index, the 13 ICT STs in Dongguan appear to perform better than non-ICT ones. First, they seem to distribute differently across the Top-100 ranking (Figure 1). Although a good number of both non-ICT and ICT is concentrated in the first decile, corresponding to higher positions, the ICT-specialized towns are predominantly concentrated in the first half of the distribution, while non-ICT STs are more evenly distributed along the whole ranking.

[6] All data are taken from Guangdong Statistical Office (2016).

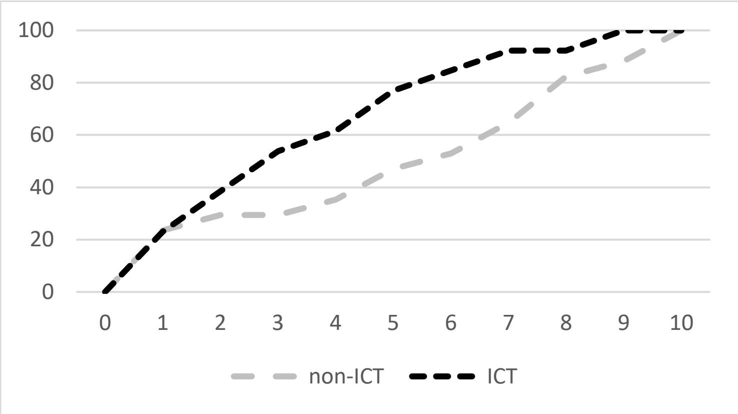


Figure 1. distribution across the 100 towns innovation index ranking, comparison between ICT and non-ICT STs in Dongguan

Source: authors' elaboration on POTIC data.

Given the fact that the innovation index includes variables related to innovation but also to economic size and general competitiveness of the cluster, this higher ranking of ICT-specialized towns may depend on better quality of innovation processes but also on their mere economic size (GDASS, 2017). The empirical analysis that follows will help in better qualifying the positioning of this group of towns.

5. Empirical analysis

In the empirical part we wish to test the relation between ICT certified specialization and innovative performances on one side and social change on the others.

5.1 ICT and innovation: variables and model

5.1.1 Independent variables and modelling

We proxy the innovative capacity of each town for each year with the number of patent applications. Although many criticisms have emerged on the use of patenting as a proxy for innovation (see for a review Acs et al., 2002; Griliches 1990), the number of patent applications it is still largely used in the literature contributions about innovative performances at the national and local levels (see e.g. Lee et al., 2016; Ma et al., 2009; Hu and Mathews, 2008).

We collected data on two types of patents: those issued domestically by the State Intellectual Property of the Popular Republic of China (SIPO) and those recognized by the European Patent Office (EPO)[7]. In particular, we use the national patents as a proxy of township innovation performance related to national markets, while we interpret EPO patents as a proxy of the ability to innovate at the international level.

The figures for patent applications recorded on SIPO and EPO across the whole period are quite different in absolute terms. As it is clear in Table 3, Dongguan towns show on average a better

[7] The data on SIPO are available at http://www.pss-system.gov.cn/ (in Chinese), last accessed 28 October 2017. EPO applications are retrieved by the European Patent Register - https://register.epo.org/regviewer, last accessed on 20 October 2017.

domestic patenting performance than that on the European market, suggesting that the innovation activity of such area is more oriented towards the domestic than towards the international market.

Table 3. Descriptive statistics of outcomes of interest

	Mean	Standard deviation	Min	Max
SIPO	437.384	666.7187	3	7257
EPO	2.771	6.997	0	117

Source: authors elaborations on SIPO and EPO databases.

On the other hand, both variables seem to show that the average innovation activity of the towns have been impressively growing in the last decade, as it is shown in Figure 2[8]. Both SIPO and EPO applications seem to be almost stagnant up to the 2000s, then from 2005 they follow an exponential trend. After the Global Crisis the trajectory is more unstable, although still positive.

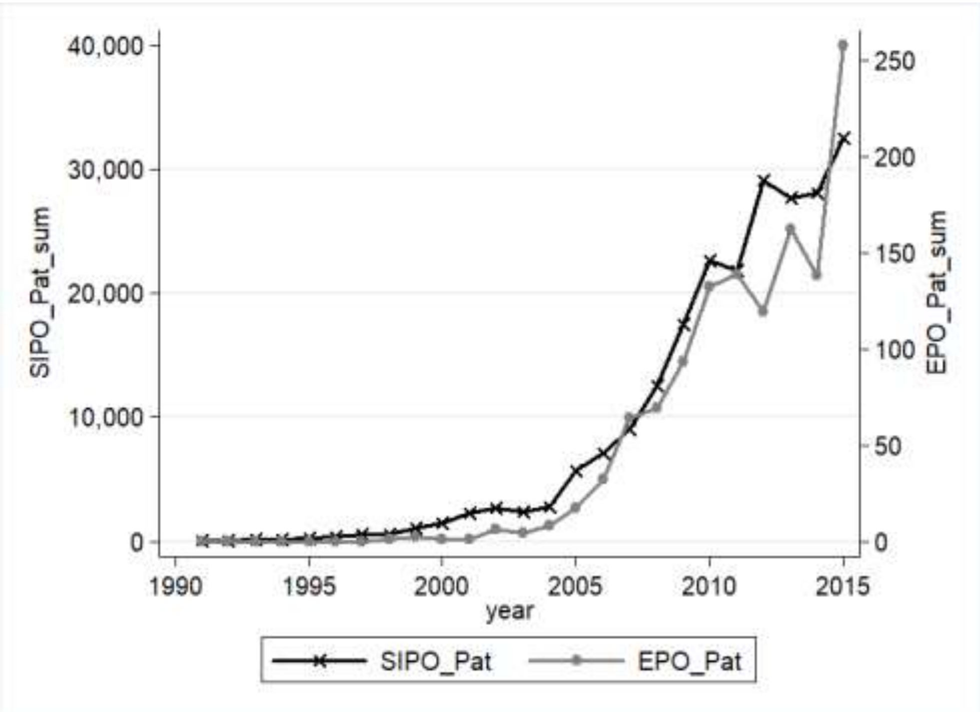


Figure 2. SIPO and EPO applications dynamics in Dongguan

Both SIPO and EPO are count variables with a largely asymmetric distribution and substantial overdispersion (Table 3). This suggests that they should be modelled as a negative binomial function (Cameron and Trivedi 1998; Hilbe 2011; Long and Freese 2014). We will use the panel version of the regression with fixed effects (Hausman et al., 1984) to exploit the longitudinal properties of our data.

[8]In order to show a complete picture of the innovation dynamics, we report data also outside our time-span, before 2001.

5.1.2 Independent variables

Our main variable of interest is the dummy ICT_{it}, taking value 1 when the town *i* in the year *t* has the certified status of specialization in a production related to ICT, while it is 0 either whether the town specialized in another sector or it is not specialized.

To isolate the effect of being officially certified (in any kind of production), we introduce the dummy $No\ OCS_{it}$, that takes the value 1 when the town *i* at time *t* has no officially certified specialization, and 1 otherwise.

To test our first hypothesis (H1), we use as proxy of extra-cluster linkages the number of foreign funded firms in the cluster (*Foreign firms*). To test our second hypothesis (H2) we proxy the higher endowment of human capital (Dakhli and De Clercq, 2004; Lee et al., 2016) with the ratio of the number of graduates in secondary schools on total population of the town in the year preceding that under observation ($Secondary\ graduates_{t-1}$).

To better isolate the potential effect of ICT certified specialization on innovation, we control for other variables. First, an economic environment may be more innovative because the production is particularly capital intensive, as suggested by the classical theory of factor endowments (Acs and Audretsch, 1987). We use the ratio between fixed capital and employees in large firms to evaluate such effect (*capital intensity*). Secondly, there might be a *learning by exporting* process affecting innovation, since exporters may have larger access to various forms of knowledge and innovative inputs than non-exporters (Salomon and Shaver, 2005). For this reason we control for exports in the year preceding that under observation ($Exports_{t-1}$). Finally, we use the number of firms in the town *i* at year *t* (*Total firms*) to observe the link between ICT and innovation to control for the general economic size of the town.

We summarize the variables in Table 4 and we present the summary statistics and the correlation table in the appendix (Tables A1 and A2)[9].

Table 4. Explanatory variables

Variable	Measured dimension	Measured as
ICT	ICT certified specialization of the township	Dummy variable = 1 if the township is specialized in ICT and 0 otherwise
No officially certified specialization	The township is not/is a specialized town	Dummy variable= 1 if the township has no certified specialization and 0 otherwise

[9] Along the 2001-2015 period, and specifically in 2005, 2008 and 2011, some changes have occurred in the collection and organization of data in Dongguan statistical yearbooks. We account for these changes by adding to the model some dummies that turn on in correspondence with those changes and from those changes on. These variables do not have an economic interpretation but ensure us that we clean the data from the technical changes.

Capital intensity	Source of innovation from capital-intensive production	Ratio between fixed assets (10,000 yuan) and number of employees in large enterprises
Foreign firms	Source of innovation from spillover by foreign firms	Number of foreign funded firms
$Export_{t-1}$	Sources of innovation from *learning by exporting*	Value (10,000 US $) of the exports in the year before the observed one
Secondary $graduates_{t-1}$	Sources of innovation from human capital endowment	Number of graduated from secondary school on the population in the year before the observed one.

Since one of our main intuitions is that ICT specialization may be associated with higher innovation levels according to its characterization, we first present the baseline specification for both SIPO and EPO (tab. 5) and then we test our hypotheses 1 and 2 as moderation effects on ICT of foreign firms and education respectively (tab. 6) [10].

5.2 ICT and innovation: results and discussion

Both for SIPO and EPO we can claim that having an official recognized specialization in the ICT production *per se* does not help townships increase their innovation performances (Table 5). In our model of reference, indeed, such townships have even worse performance than others do. This can be due to the fact that, the capacity of ICT clusters to boost innovation is heavily affected by the positioning of the cluster within the global value chains. Our results confirm that Dongguan ICT clusters still deal with the simplest tasks of the production process and are mainly related to the labour-intensive production of electronic appliances and other ICT goods as downstream suppliers for multinational firms and to meet the national demand (Zhou et al., 2011; Zhou, 2013; Cheng and Peyiu, 2001). These results also support the view that the competitive advantage of Chinese ICT clusters is more related to the capacity to apply quickly the Western technology at lower costs and less to knowledge and technology production elsewhere (Wang et al., 2010). Despite the attempts of favouring the upgrading of the clusters, most of them are still placed in the lower value added part of the GVC and dependant on advanced countries for more sophisticated technologies (Lai et al., 2005; Zeng, 2010; Sun and Grimes, 2016). According to Wang et al. (2010), it is this specific positioning and functioning of the Chinese ICT in the national and global economy that explains the poor innovative performance of national firms.

The results show that the negative effect of the ICT specialization is not due to a negative effect of the ST policy *per se.* In fact, the negative effect of not being part of the STs program on the number of SIPO applications suggests that the institutional setting promoting innovation described in section 4 actually helps in terms of growth of the innovative capacity of the township.

Table 5. The effect of certified ICT specialization on SIPO – raw coefficients

	SIPO Patent applications	EPO Patent applications
ICT	-0.215***	-0.608***
	(-2.89)	(-2.64)
No OCS	-0.264***	-0.482**
	(-4.44)	(-2.57)
Capital intensity	0.001	0.002

[10] To be thorough, in the appendix (Tables A6 and A7) we report the results for the same specification fitted with negative binomial GLM and Unconditional Fixed Effect models, together with all the Poisson counterparts. However, the diagnostics all coherently point to the Conditional Fixed Effect models as the most appropriate.

	(0.60)	(0.34)
$Export_{t-1}$	0.0000004*	-5.28E-08
	(1.76)	(-0.09)
Foreign firms	0.0003***	-7.6E-05
	(3.01)	(-0.24)
$Secondary\ graduates_{t-1}$	8.721***	17.41**
	(3.42)	(2.42)
Total firms	0.000002	0.000007*
	(1.26)	(1.66)
Constant	1.414***	-0.316
	(12.20)	(-1.02)
Effect of change in statistics	Yes	Yes
N	448	434§
Ll	-2426.8	-596.7
Bic	4920.7	1260.3
Aic	4875.6	1215.4
chi2_c	1436.4	180.9

Significance: *10%, **5%, ***1%. Standard error in parenthesis – robust standard error for Poisson regressions. §One group (14 obs) dropped because of all zero outcomes.

Both domestic and international markets innovation outputs seem to profit from a better-educated social environment, likely reflected in a larger availability of human capital at the local level. With respect to the other sources of innovation, SIPO patent applications seem interestingly to profit from the resources coming from abroad, both in terms of learning by exporting and foreign capital, while EPO patents are insensitive to both of them. This may suggest that, while some gain in innovation can occur as a consequence of the exogenous characterization of the clusters, these are only observable with regards to inner market purposes. Finally, while it is not significant for SIPO patenting, the total number of firms positively affect the number of EPO patent applications.

5.2.1 Effects of ICT sophistication: future prospects for Dongguan

Coming to our specific hypotheses, the main results related to H1 and H2 are reported in table 6 with reference to SIPO patents[11]. A first note to make is that, while in the baseline model the moderation variables related to human capital and foreign firms were significant (and positive), in this specification they are only significant when they are interacted with the ICT dummy. This strongly suggests that the main effect of such variables individually taken reflects indeed how they can improve patenting activity *in the ICT context*. Rather than the specialization in ICT *per se*, it can make a huge difference whether ICT production is coupled with a higher level of human capital (Lee et al., 2016) or foreign presence.

Table 6. Moderation effects on SIPO - negative binomial conditional fixed effect regressions

	(1)	(3)

[11] There is no change with relation to EPO patents when we introduce interactions to the model (Table A8 in the appendix).

ICT	-0.417***	-0.564***
	(-3.55)	(-3.94)
No OCS	-0.250***	-0.235***
	(-4.19)	(-3.90)
Capital intensity	0.000689	0.000911
	(0.46)	(0.62)
Total firms	1.27E-06	1.99E-06
	(0.76)	(1.24)
$Export_{t-1}$	3.32E-07	3.07E-07
	(1.60)	(1.49)
Foreign firms	0.000148	0.000291***
	(1.16)	(2.74)
Secondary $graduates_{t-1}$	8.296***	6.518**
	(3.28)	(2.48)
ICT*(Foreign firms)	0.000477***	
	(2.59)	
ICT*(Secondary $graduates_{t-1}$)		10.49***
		(3.17)
Constant	0.632***	1.502***
	(5.23)	(12.86)
Effect of change in statistics	Yes	Yes
Town fixed effects	Yes	Yes
N	448	448
Ll	-2423.4	-2422.2
Bic	4920.1	4917.6
Aic	4870.8	4868.3
chi2_c	1476.4	1496.3

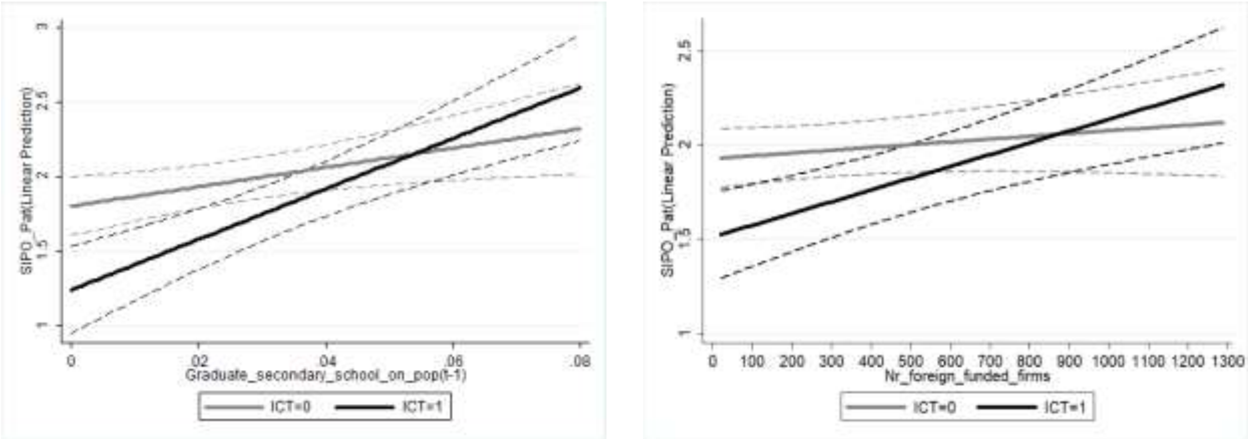
Significance: *10%, **5%, ***1%. Standard error in parenthesis.

As we are in a non-linear framework, their interpretation is not straightforward and should be supported with graphs of the effects (Rubini et al., 2017; Williams, 2012), which we show in figure 3. It is clear that both *the percentage of secondary graduates* and *the number of foreign firms* display some threshold values for which the ICT specialization pays in terms of innovation versus non-ICT clusters. ICT clusters have a chance to perform significantly better than non-ICT clusters if the percentage of secondary graduates is above 0.6 or the number of foreign firms is above 900. Thus both hypotheses H1 and H2 are confirmed.

Figure 3. Moderation effects on ICT

a) Secondary $graduates_{t-1}$

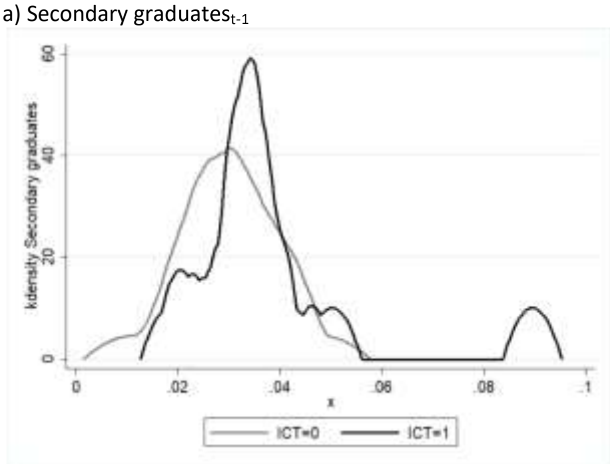
b) Foreign firms



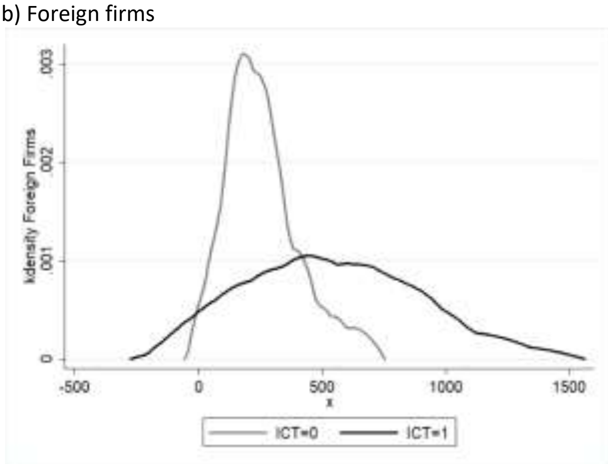
These results are very informative to understand the future prospects in terms of policies for technological innovation of ICT clusters in Dongguan. At present, in fact, these clusters have not yet reached those thresholds, as it is shown by the distributions of the variables and the comparison of ICT group with other specialised towns (Figure 4).

Figure 4. Distribution of ICT vs non-ICT towns over interaction variables, 2015

a) Secondary graduates$_{t-1}$



b) Foreign firms



Wilcoxon test z-value: 0.2542	Wilcoxon test z-value: 0.000

On the one hand, both the presence of foreign firms and – although to a lesser extent – the intensity of human capital are actually higher in ICT clusters compared to non-ICT STs[12]. However, ICT STs still show a far lower value than the threshold identified in fig. 4, especially for what concerns the percentage of secondary graduates. Such evidence suggest that, while there might be some potential gains coming from the specialisation in ICT for Dongguan clusters under certain conditions, more has still to be done to reach them.

[12] In the case of foreign firms the difference is also confirmed by the significance of the Wilcoxon-test, which compares non-parametrically the distributions of the two sample to assess whether there is statistical difference (Wilcoxon, 1945).

5.3 ICT and social change: variables and model

5.3.1 Dependent variable and modelling

The second part of our empirical analysis deals with hypotheses H3 and H4. Since social innovation and social change in its macro perspective has been widely associated with human development (see e.g. Jessop et al., 2013), we use this perspective to study the relation between ICT and social change. We measure the possible impact of ICT specialization on an index that, given the available data, tries to replicate the Human Development Index (HDI). Our data range in this case is 2006-2015. We follow the same standardization and aggregation methodology used to build the HDI (UNDP, 2016). Similarly to the HDI, we summarize some measures of the economic status (*EC*) of each township, of the level of education (*Edu*) and of the health status (*Hea*) in a single index, that we call "Townships Social Change Index" (*TOSCI*). The economic status is measured with the GDP per capita, used in its logarithmic transformation. As for education, we summarize in an additive index the number of graduates in primary school on the population (*Primary graduates*) and the number of graduate in secondary school on the population (*Secondary graduates*). Finally, since we do not have any data on the health status of the population, we try to proxy it with one measure of the supply of health services (number of beds in health institutions on the population - *Beds*). Each of these dimensions is standardized with *minmax* scaling. The three dimensions are presented in Table 7, and we report the summary statistics and the correlations for the original variables in the appendix (Table A3).

Table 7. Dimensions of the TOSCI index

Dimension	**Component**	**Dimension index***
Economic Status (*EC*)	Per capita GDP (*GDPpc*)	$EC = STD(GDPpc)$
Education (*Edu*)	Primary graduates (*GrP*)	$Edu = \frac{[STD(GrP) + STD(GrS)]}{2}$
	Secondary graduates (*GrS*)	
Health (*Hea*)	*Beds*	$Hea = STD(Beds)$

*STD=Standardization via *minmax* scaling.

The final *TOSCI* index results as geometric mean of the three dimension indices:

$$TOSCI = \frac{EC * Edu * Hea}{3}$$

We study social change as a function of some variables of interest in a fixed effects panel model framework, through which we wish to identify the semi-elasticity of the outcome with respect to the main independent variables and some controls (log-linear function):

$$log(TOSCI_{it}) = \alpha_i + \beta_1 ICT_{it} + \beta_2(no\ OCS) + \boldsymbol{\beta X_{it}} + \varepsilon_{it}$$

5.3.2 Independent variables

We have already discussed the meaning of the variables *ICT* and *No OCS* in section 5.1.2. In line with hypothesis H3, we include a measure of public involvement in economic development.

Following Binder et al. (2013) we proxied this with public expenditure per capita (Government Expenditure), and the sum of inputs and exports (total trade) which proxies policies for trade liberalization.

As regards hypothesis H4, we include in the regression variables related to technological innovation and economic dynamism. In particular, we control for the number of Chinese and foreign firms and we proxy innovation with the number of patent application in the domestic market.

In addition, the vector of controls $\boldsymbol{X}_{it}$ includes variables that, based on the literature, are likely to affect the social and human development of a territory (all independent variables are summarized in table 8).

1) *Joint action*. To further control for other forms of joint action that might arise in the cluster (beyond those entailed by the official certification), we use the number of specialized market in the township (*markets*), which are bounded areas where usually small and medium producers involved in the manufacturing of similar products gather. Such social institutions have already been taken as representative of collective action and linkage between economic and social actors in the Chinese production framework (Bellandi and Lombardi, 2012; Wang and Mei, 2009).

2) *Inequality and socioeconomic status*. While studying the relationship between clustering and social change, in the case of China it is necessary to consider the role that migration flows have in the economic development process of coastal areas (Di Tommaso et al., 2013). On one side the massive inflow of workers coming from inner areas of the country has allowed the coastal region to count on a vast amount of low-cost labour that has represented its initial competitive advantage. However, due to the specific household registration system of the country, called *'hukou'*[13] system (Song, 2014), migrant workers have different access to social services and economic rights, and often suffer from social exclusion phenomena (Zhan, 2011). A phenomenon that has been observed also in the case of Dongguan (Luo and Zhu, 2015). Including the number of temporary immigrants (immigrants) is a way to proxy inequalities in the access to social services.[14]. Summary statistics and correlation tables of the explanatory variables are reported in the appendix (Tables A4 and A5).

Table 8. Explanatory variables

Variable	**Measured as**
Collective action	
No OCS	Dummy variable=1 if the township has no certified specialization and 0 otherwise
Markets	Number of Specialized Markets by Township

[13] The hukou is the residence permit for Chinese citizens. It is related to the birthplace of each person, and is very difficult to change.

[14] On the other hand, we excluded the rural-urban gap as a source of inequality, since Dongguan city is highly urbanized and homogeneous across townships.

Public involvement	
Government Expenditure	Ratio of government expenditure (10.000 yuan) on population of the town
Total trade	Sum of imports and exports (10.000 USD) of the town
Inequality and socioeconomic status	
Immigrants	Number of temporary immigrants in the town
Innovation and economic dynamism	
SIPO	Number of SIPO patent applications by the town
Local firms	Number of Chinese-owned firms in the town
Foreign firms	Number of foreign funded firms in the town

5.4 *ICT and social change:* results and discussion

The main results related to H3 and H4 are reported in table 9. In the base model, where no interaction is implemented, being specialised positively affects social change, while being specialised in ICT has no influence *per se*. On the other hand, we find a positive - although small in magnitude - correlation with the per capita public expenditure and the number of SIPO patent applications. In both cases, this might highlight that, in this area of Southern China, the major contribution to social change comes from a strong involvement of public actors and from the innovative effort of the economic actors.

Table 9. The relation between ICT specialization and TOSCI

	(1)	(2)	(3)
ICT	0.147	0.480**	0.387**
	(0.87)	'(2.10)	'(2.00)
No OCS	-0.335***	-0.249**	-0.294**
	'(-2.89)	'(-2.04)	'(-2.53)
SIPO	0.0001*	0.0001*	0.0003***
	'(1.77)	'(1.86)	'(2.90)
Local firms	0.00001	0.00001	0.00001
	'(1.63)	'(1.61)	'(1.60)
Foreign Firms	0.00006	0.00002	0.00003
	'(0.23)	'(0.07)	'(0.11)
Total Trade	0.00000	0.00000	0.00000
	'(0.61)	'(0.57)	'(1.30)
Markets	0.004	0.004	0.004
	'(0.97)	'(1.01)	'(0.98)
Government Expenditure	0.0000277**	0.0000827***	0.0000259*
	'(2.00)	'(2.83)	'(1.88)
Immigrants	-0.00005	-0.00005	-0.00005
	'(-1.20)	'(-1.23)	'(-1.23)
ICT*Government Expenditure		-0.0008**	
		'(-2.13)	
ICT*SIPO			-0.0003**
			'(-2.45)
_cons	-4.492***	-4.724***	-4.626***
	'(-26.78)	'(-23.73)	'(-26.42)
N	318	318	318
r2	0.196	0.209	0.213

r2_o	0.272	0.249	0.299
r2_w	0.196	0.209	0.213
r2_b	0.324	0.288	0.347
Rmse	0.536	0.532	0.531
F	7.513	7.304	7.481
F(p-value)	≈0.000	≈0.000	≈0.000
Corr	0.243	0.215	0.237
sigma_u	0.944	0.96	0.922
sigma_e	0.536	0.532	0.531

This is further confirmed by the specifications of the model in (2) and (3), where the interaction between per capita public expenses and ICT specialization, and that between SIPO and ICT specialization, are analysed. In both cases, even if the coefficient related to the interactive term has a negative sign, overall the joint computation of the effect would suggest that ICT specialized clusters show better performances than others in correspondence with growing levels of per capita public expenditure (hypothesis H3 confirmed) and number of patent applications[15] (hypothesis H4 confirmed). In other terms, we may claim that the ICT specialization is associated to better social and life conditions, provided that there is an adequate involvement of the public sector and that the economic environment of the town expresses an adequate level of innovative capability.

Even though we cannot distinguish in this case the typology of public expenses (whether in production or social infrastructures, public procurements, salaries and so on), we can add some further considerations given the other results related to the base regression. First, in other versions of the model that we do not present here, when we substituted variables related to social infrastructures (number of schools, number of hospitals) to government expenses, they would yield similar results and interpretations. This would suggest that a part of the effect of Government Expenditure is related to expenses in social infrastructure and not to efforts toward international liberalization (total trade is not significant). Additionally, the importance of innovation infrastructures is signalled by the significance of the *no OCS* variable, that nonetheless does not affect the significance of the government expenses, suggesting that both types of public involvement are relevant.

Finally, in the context of our analysis it does not seem that private economic actors (i.e. local and foreign firms), and their collective action through specialised markets, have an additional role in determining the levels of social development of such territories, suggesting that most of the currently

[15] In fact, the effect of the interaction should be analysed jointly with the single significant coefficients of the main terms. In our cases, the joint effects are given: in the second regression by the coefficient related to ICT (0.155), that of Govt_exp_pc (0.0009) and the interaction (-0.0008); in the third regression by the sum of the coefficient related to ICT (0.387), SIPO (0.0003) and the interaction (-0.0003). Both yield a positive result.

relevant interactions still seem to take place within the institutional framework of government policies.

6. Final Remarks

Our study represents a first attempt to jointly investigate the relation between ICT clusters, innovation and social change.

By analysing the experience and evolution of Dongguan ICT clusters, we provide some evidence on the specific features that enable ICT clusters to become places that promote technological innovation as well as increased human development. Our findings in particular suggest that specialising in ICT can pay in terms of innovative performances, provided that such specialization is supported by an institutional setting aimed at collectively promoting innovation, a sufficient degree of extra-cluster relations and a sufficiently high level of education of the population. Results emphasise that Dongguan ICT clusters as a whole, in both the dimensions of extra-cluster relations and education, need to make further steps ahead. Hence our results carry some relevant policy implications and can be used as a support for the future planning of innovation policies. In particular, for the future, in order to encourage innovation, the government should aim at promoting higher degrees of education for the whole population. Part of the experience from developing countries suggests that this target, and in general broad growth and development goals, can be reached in particular by investing in training and education at the local level to grow local talents, rather than engaging in a global or national "talent war" (Ng, 2011, Thite, 2011, Leigh, and Blakely, 2016).

In addition, our findings suggest that ICT in emerging economies can also pay in terms of social change, if coupled with a significant level of public involvement and of technological innovation. In our findings, the latter becomes in fact an important input for the improvement of human development indicators in ICT clusters. Adding to the literature that investigates on the relationship between economic performance of clusters and their social impact (Nadvi and Barrientos, 2004; De Oliveira, 2008), our findings indicate that technological innovation acquires a pivotal role in discriminating those clusters that are able to enhance social wellbeing.

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Appendix

List of institutions visited during July-August 2017 fieldwork:

- Department of Commerce of Guangzhou City
- Guangdong Provincial Department of Science and Technology
- Development and Reform Commission of Guangdong

- Guangdong Academy of Social Sciences
- Guangzhou Academy of Social Sciences
- South China University of Technology (School of Business Administration, School of Economics)
- Department of Economics of Shenzhen University (Guangdong)
- Changping Town (Dongguan) Local Government representatives
- Songshan Lake Hi-Tech Industrial Development Zone representatives
- Ronggui Town (Foshan) Local Government Reprentatives

Table A1. Summary statistics for independent variables - innovation

	Variable	Observations	Mean	Std. Dev.	Min	Max
(1)	ICT	448	0.214	0.411	0	1
(2)	No OCS	448	0.542	0.499	0	1
(3)	Capital intensity	448	10.506	20.421	0.296942	304.7941
(4)	Foreign firms	448	298.623	229.607	26	1288
(5)	Export_{t-1}	448	164129.800	175883.200	0.142279	976850
(6)	$\text{Secondary graduates}_{t-1}$	448	0.028	0.011	0	0.082407

Table A2. Correlation table for independent variables - Innovation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	1									
(2)	-0.5686***	1								
(3)	-0.0839*	0.1286***	1							
(4)	0.3220***	-0.2239***	-0.0689	1						
(5)	0.4816***	-0.3823***	-0.1207**	0.6191***	1					
(6)	0.1916***	-0.1987***	-0.1071**	0.3084***	0.3321***	1				

Significance: *10%, **5%, ***1%.

Table A3. Summary statistics and correlation for TOSCI index components

	Obs	Mean	St. dev	Min	Max	*GDPpc*	*GrP*	*GrS*	*NHw*
GDPpc	383	20.487	14.741	0.226	108.207	1			
GrP	383	0.046	0.022	0.000	0.145	0.723***	1		
GrS	383	0.030	0.011	0	0.090	0.5577***	0.7770***	1	
NHw	383	0.010	0.008	0.00004	0.040	0.6092***	0.6312***	0.4448***	1

Significance: *10%, **5%, ***1%.

Table A4. Summary statistics for independent variables – Social Change

	Variable	Obs	Mean	St. dev	Min	Max
(1)	$\text{Log(N\_markets)}_{t-3}$	344	2.864	0.724	1.099	4.554
(2)	Log(Total firms)	344	9.280	0.911	5.986	11.713
(3)	log(n_primary_schools)	344	2.231	0.548	1.099	3.401
(4)	log(n_secondary_schools)	344	1.526	0.545	0	2.565
(5)	log(n_hospitals)	344	0.507	0.599	0	2.303

(6)	Log(SIPO)$_{t-3}$	344	5.168	1.266	1.099	8.643
(7)	Log(cap_on_emp)$_{t-3}$	344	1.681	1.038	-1.214	5.720
(8)	Log(Foreign firms)$_{t-3}$	344	5.359	0.757	3.258	7.161
(9)	Log(Exports)$_{t-3}$	344	11.371	1.334	-1.950	13.711

Table A5. Correlation table for independent variables – Social Change

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)	1								
(2)	0.6280***	1							
(3)	0.5839***	0.6093***	1						
(4)	0.6242***	0.5723***	0.5304***	1					
(5)	0.6017***	0.5680***	0.4938***	0.3753***	1				
(6)	0.6345***	0.6138***	0.3342***	0.5305***	0.5290***	1			
(7)	-0.1178**	-0.0775	-0.0065	-0.1569**	-0.027	-0.2885***	1		
(8)	0.5058***	0.5960***	0.4892***	0.4888***	0.4284***	0.5860***	-0.0975*	1	
(9)	0.5020***	0.5220***	0.3725***	0.4268***	0.3230***	0.6055***	-0.0955*	0.5417***	1

Significance: *10%, **5%, ***1%.

Table A6. The effect of certified ICT specialization on EPO – raw coefficients

	GLM		Unconditional Fixed Effects		Conditional
		Negative	Poisson	Negative	Fixed Effect
	Poisson	Binomial		Binomial	Poisson
ICT	-0.183**	-0.145*	-0.230	-0.0711	-0.230
	(-2.39)	(-1.68)	(-1.48)	(-0.66)	(-1.48)
No OCS	-0.060	-0.159**	-0.210**	-0.269***	-0.210**
	(-0.71)	(-2.21)	(-2.53)	(-3.47)	(-2.53)
Capital intensity	-0.003	-0.004***	0.002	0.001	0.002
	(-0.55)	(-3.39)	(0.38)	(0.83)	(0.38)
Total firms	0.00001***	0.00003***	0.000004*	0.000004	0.000004*
	(3.17)	(7.80)	(1.87)	(1.60)	(1.87)
Export$_{t-1}$	0.000001***	0.000001***	0.0000005	0.0000003	0.0000005
	(6.03)	(5.04)	(0.90)	(1.10)	(0.90)
Foreign firms	0.001***	0.001***	0.0004***	0.0003*	0.0004***
	(6.73)	(4.93)	(3.73)	(1.80)	(3.73)
Secondary graduates$_{t-1}$	0.770	0.0443	13.97***	5.003*	13.97***
	(0.30)	(0.01)	(2.79)	(1.83)	(2.79)
Constant	4.845***	4.702***	No	5.066***	No
	(29.91)	(42.36)		(35.01)	
Effect of change in statistics	Yes	Yes	Yes	Yes	Yes
Town fixed effects	No	No	Yes	Yes	Yes
N	448	448	448	448	448
Ll	-31576.6	-2857.7	-13990.1	-2679.2	-13990.1
Bic	63220.3	5782.5	28041.3	5614.7	28041.3
Aic	63175.1	5737.3	28000.2	5442.3	28000.2
Dispersion	137.1	1.088	.	1.162	.
chi2_c	1606.2	1294	3741.6	3600.8	3741.6

Significance: *10%, **5%, ***1%.

Table A7. The effect of certified ICT specialization on EPO – raw coefficients

	GLM		Unconditional Fixed Effects	

	Poisson	Negative Binomial	Poisson	Negative Binomial	Conditional Fixed Effect Poisson
ICT	-0.478***	-0.623***	-0.583**	-0.457*	-0.583*
	(-3.01)	(-3.30)	(-2.07)	(-1.66)	(-1.71)
No OCS	0.082	0.049	-0.494**	-0.396*	-0.494*
	(0.44)	(0.31)	(-2.31)	(-1.72)	(-1.81)
Capital intensity	-0.017**	-0.022***	-0.012	-0.001	-0.012
	(-2.06)	(-2.97)	(-1.37)	(-0.11)	(-1.10)
Total firms	0.00002***	0.00004***	0.00002**	0.00002**	0.00002*
	(3.01)	(4.61)	(2.50)	(2.48)	(1.81)
Exportt-1	0.000001**	0.000001**	7.82E-07	3.64E-07	7.82E-07
	(2.27)	(1.99)	(0.73)	(0.49)	(0.56)
Foreign firms	0.0017***	0.0011***	0.0004	-3.4E-05	0.0004
	(5.10)	(2.90)	(0.76)	(-0.10)	(0.70)
Secondary graduates$_{t-1}$	9.494*	9.734	16.34	27.42***	16.34
	(1.80)	(1.58)	(1.62)	(3.36)	(1.10)
Constant	-0.768**	-0.942***	0.211	-0.183	No
	(-2.50)	(-3.89)	(0.58)	(-0.44)	
Effect of change in statistics	Yes	Yes	Yes	Yes	Yes
Town fixed effects	No	No	Yes	Yes	Yes
N	448	448	448	448	434§
Ll	-1055.3	-762.4	-850.3	-679.5	-772.3
Bic	2177.7	1591.9	1957	1615.4	1605.4
Aic	2132.5	1546.8	1784.6	1443	1564.7
Dispersion	3.127	0.947	2.357	0.946	.
chi2_c	235.7	285.2	3195.2	502	299.2

Significance: *10%, **5%, ***1%. Standard error in parenthesis – robust standard error for Poisson regressions. §One group (14 obs) dropped because of all zero outcomes.

Table A8

Moderation effects on EPO – negative binomial conditional fixed effect regressions

	(1)	(2)	(3)
ICT	-0.726*	-0.583**	-0.902**
	(-1.65)	(-2.34)	(-2.52)
No OCS	-0.475**	-0.484***	-0.470**
	(-2.51)	(-2.58)	(-2.51)
Capital intensity	0.00246	0.00426	0.00174
	(0.34)	(0.44)	(0.24)
Total firms	0.00000687*	0.00000695*	6.31E-06
	(1.66)	(1.68)	(1.51)
Export$_{t-1}$	-6.53E-08	-5.85E-08	-6.49E-08
	(-0.11)	(-0.10)	(-0.11)
Foreign firms	-8.6E-05	-7E-05	-0.00026
	(-0.27)	(-0.22)	(-0.72)
Secondary graduates$_{t-1}$	16.86**	17.47**	16.77**
	(2.28)	(2.43)	(2.34)
ICT*Secondary graduates$_{t-1}$	2.813		
	(0.27)		
ICT*Capital intensityoyee_ads		-0.004	
		(0.29)	
ICT*Foreign firms			0.0005
			(0.98)
Constant	-0.295	-0.328	-1.618***
	(-0.93)	(-1.05)	(-4.11)
Effect of change in statistics	Yes	Yes	Yes
Town fixed effects	Yes	Yes	Yes

N	434	434	434
Ll	-596.7	-596.7	-596.1
Bic	1266.2	1266.3	1265.2
Aic	1217.3	1217.4	1216.3
chi2_c	181.3	180.8	183.5

Significance: *10%, **5%, ***1%. Standard error in parenthesis

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