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The role of multi-level regulation in the transition towards cleaner production and a circular economy in China: the case of Bao'an District, Shenzhen under the 11th Five Year Plan

Adrian Ely[a], Li Ping[b], Fruzsina Kemenes[c] and Wang Pusheng[b]

a = SPRU -- Science and Technology Policy Research, The Freeman Centre, University of Sussex, Falmer, Brighton, BN1 9QE, a.v.ely@sussex.ac.uk
b = China Institute for Development Planning, Graduate School of Tsinghua University, Shenzhen
c = University of York, UK

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SPRU -- Science and Technology Policy Research
The Freeman Centre
University of Sussex
Falmer, Brighton, BN1 9QE
Correspondence:
library@spru.sussex.ac.uk

University of Sussex
SPRU – Science & Technology Policy Research

Abstract

The "circular economy" first emerged as a movement in China in 2003, when Chinese leaders began embarking upon a series of legislative initiatives that sought to address the country's worsening environmental problems. Led by the National Development and Reform Commission, in cooperation with the State Environmental Protection Agency (now Ministry) and other related ministries, the move towards a circular economy in China is being promoted at provincial and sub-provincial levels through policies focussing on firms, eco-parks and industrial areas.

This particular paper looks at Bao'an District in Shenzhen, a rapidly developing industrial city in the Southern province of Guangdong, that is one of ten cities that were selected for pilot "circular economy" projects nationwide within the country's 11th Five Year Plan (2006-2010). Based on interview data and documentary analysis from 2007 and 2008, the paper provides case studies of ways in which industry actors are contributing to the transition towards cleaner production and a circular economy in Bao'an District. It also investigates the role of municipal regulations in facilitating and incentivising these changes, and contrasts these with other motivations for investment in cleaner technologies.

The paper identifies cost-saving as the primary motivation for investments in cleaner production technologies, and discusses technological upgrading as one of the strategies that has led not only to environmental benefits and cost-saving, but also enhanced long-term competitiveness. Avoiding formal censure through government-enforced fines was less commonly cited as a motivation, raising questions as to the role of such formal regulations in cleaner technology governance in Shenzhen. The paper also highlights less important motivations that are nevertheless of interest - attraction of government subsidies for cleaner technology projects, cultivation of good relationships with government and brand recognition/ public image. The resulting insights provide a better understanding of the decision-making context of Shenzhen's firms (including the role of regulation within this), and point to implications for further government efforts towards encouraging cleaner production and the development of a circular economy.

JEL Classification suggestions
O25 (Industrial policy), O29 (Development planning and policy; other)
Q55 (Covers studies about issues related to technological innovation that is used to control environmental degradation)
P28 (Natural resources, energy, environment in transitional economies)

Keywords: Shenzhen, circular economy, cleaner production, environment, innovation

1. Introduction

This paper represents an exploratory and initial attempt to try to understand some of the motivations for the adoption and development of more sustainable innovations in Bao'an district, Shenzhen, South China (see Figure 1). It contains a brief review of the current regulatory framework for promoting cleaner production and the "circular economy" at the national and local (provincial and municipal) levels. It also looks beyond regulations to identify other incentives that lead to changes in firm behaviour, especially in terms of their investment in energy and resource-efficient and less-polluting technologies. In order to do this, it adopts a case study approach, focussing on 6 firms, derived from a larger sample selected by the Chinese research team for their success in implementing cleaner production technologies and for their prominent reputation within the city. These in-depth case studies are taken from a wider survey of firms in Shenzhen, the results of which are used as complimentary data to understand the reasons behind differing investment decisions across a range of industries. The paper identifies a number of factors promoting and constraining firm behaviour in the transition towards a circular economy and puts forward a number of possible areas for future research.

The paper draws on a number of insights from the innovation and environmental policy literature, although does not adopt a strict analytical framework associated with either one. As the following sections outline, there are clear parallels between the idea of the "circular economy" and earlier Western ideas around ecological modernisation[1], industrial ecology[2] and cleaner production[3]. In many of these cases, problems of co-ordination between different actors within industrial systems have been highlighted as an ongoing challenge.[4] The European literature has more recently highlighted the importance of wider system transitions towards sustainability, with attention to both social and technological dynamics[5], however these theoretical ideas have rarely[6] been applied in the Chinese context. Rather than focussing on the dynamics of system transitions, this paper focuses at the individual firm level, drawing on earlier research on motivations[7] to the adoption environmentally-efficient technologies.

[1] Mol, A. P. J. & Sonenfeld, D. A. (Eds)(2000) Ecological Modernisation Around the World: Perspectives and Critical Debates, London, Frank Cass Publishers
[2] Graedel, T. & Allenby, B. (1995) Industrial Ecology. Englewood Cliffs, NJ: Prentice Hall
[3] Clayton, A., Spinardi, G. and R. Williams (eds) (1999) Policies for Cleaner Technology, Earthscan, London, pp.1-18
[4] Boons, F. & Baas, L. (1997) Types of industrial ecology: the problem of co-ordination, Journal of Cleaner Production 5: 1-2, 79-86
[5] Elzen, B. Geels, F.W., and Green, K., (eds)(2004) System Innovation and the Transition to Sustainability: Theory, Evidence and Policy, Cheltenham: Edward Elgar
[6] The authors are unaware of any research applying the socio-technical transitions literature to empirical case studies in China.
[7] Howes R., Skea J. and Whelan B.: Clean and competitive? Motivating environmental performance in industry, Earthscan Publications Ltd, London, 1997.

The next section of the paper outlines the methodology employed with respect to other work investigating the role of technology regulation in China. Following that, sections 3 and 4 go into more detail on the ideas of cleaner production and the circular economy, and on the industrial, political-economic and environmental history of Shenzhen. Section 5 provides an overview of the regulations at multiple levels relating to cleaner production and the circular economy under the 11th Five Year Plan. Section 6 turns to the six case studies analysed in the paper, pointing to investments and strategies that have delivered cleaner production impacts and the motivations behind these behaviours. The following section discusses these in more detail, with reference to other relevant literatures, and the final section puts forward some priority areas for future research.

2. Methodology

This paper adopts the broad definition of regulation used previously by Van Zwanenberg, Ely and Smith (2011) of "state attempts that shape the use and broader governance of technology". As such, it does not only focus on legal regulations, but also on the institutions and norms that influence behaviour change among private actors in their development and deployment of technology. Regulation (broadly speaking) is thus seen not simply as instructions from above to be implemented by local street-level bureaucrats, but more broadly as a way of 'signposting' preferred pathways of socio-technical-ecological change. Translated onto the Chinese governance system, this metaphor provides a way of understanding the relationship between the slogans created in the political 'centre' ("'serve the people' in Mao's time; 'reform and opening up' and 'the four modernisations' during the Deng Xiaoping period; 'the three represents' of Jiang Zemin; and under Hu Jintao phrases like 'the peaceful rise' and 'the harmonious society'")[8] and the diverse ways in which they are interpreted and implemented on the periphery.[9]

The 'signposting' metaphor also provides a way of understanding how directions set in the centre combine with China's incremental-experimental approach, which often sees pilot policies in particular regions paving the way for the roll-out of wider, national level initiatives. Whilst mandates from Beijing may seem clear and unambiguous, the country's highly diverse localities still needs to 'cross the river by feeling stones with their feet'[10] when it comes to formulating and implementing practical policy instruments and understanding their interactions with a dynamic society. This study itself relies on data provided by firms as part of an experimental programme supported by Bao'an district government between 2006-2010. Firms were invited to apply to become experimental units within the programme[11], and

[8] Wilsdon, J. & Keeley, J. (2007) China: The next science superpower? London, DEMOS
[9] This is discussed with reference to environmental policy-making in China by Economy, E. (2004) 'The River Runs Black: The Environmental Challenge to China's Future', Ithaca NY, Cornell University Press
[10] This is a saying commonly attributed to Deng Xiaoping
[11] The programme itself was linked to two of the regulations described in table X below: The Implementation Scheme of Experimental Work of Circular Economy in Guangdong Province and the Short-term Implementation Scheme of Shenzhen on Completely Promoting the Development of Circular Economy.

selected for inclusion on the basis of multiple technical and political considerations. In order to encourage and fund enterprises to adopt cleaner technology, every experimental unit was given subsidy of RMB 100,000 yuan. If they passed the initial examination, selected cleaner production projects were further funded with RMB 50,000 yuan. After evaluation by the team organized by the government (consisting of researchers and officials), 5 of the 100 projects were awarded RMB 50,000 yuan as "excellent projects".

100 firms were briefly interviewed in the meeting room of the Trade and Industry Bureau of Bao'an District Government in the summer 2007. 89 were selected as experimental units by officials of Bao'an district government, engineers and researchers from Shenzhen graduate school (according to their willingness to adopt cleaner production practices and technologies). The case studies below are drawn from this sample, and based on documents submitted by the firms to the district government. In addition, a number of in-depth interviews were carried out at industry sites by one of the authors (Li Ping) later the same year.

The earlier research was supplemented by a series of semi-structured interviews with both firms and local officials, conducted by a Chinese researcher (Li Ping) and SPRU post-graduate student (Fruzsina Kemenes) in 2008. Documentary analysis and writing up continued to 2011. In order to provide the background to the case studies and subsequent studies, it is first necessary to outline the context of debates around cleaner production and the circular economy in Shenzhen.

3. Cleaner Production and the Circular Economy

Cleaner production (清洁生产) is defined by the United Nations as:

> "*the continuous application of an integrated preventive environmental strategy to processes, products, and services to increase overall efficiency, and reduce risks to humans and the environment. Cleaner Production can be applied to the processes used in any industry, to products themselves and to various services provided in society.*"[12]

Importantly, cleaner production focuses on the minimisation, rather than abatement, of pollution, entailing a shift from "end-of-pipe" pollution management technologies to the prevention of toxic emissions[13]. It is often associated with "win-win" solutions that provide environmental sustainability without denying economic growth, or a "double-dividend" associated with both environmental sustainability and economic competitiveness[14].

[12] UNEP website http://www.uneptie.org/pc/cp/understanding_cp/home.htm#definition, accessed 23/2/2008
[13] Clayton, A., Ryan, B. and R. Williams (1999) Chapter 1: 'Cleaner technology and the greening of industry' in Clayton, A., Spinardi, G. and R. Williams (eds) *Policies for Cleaner Technology*, Earthscan, London, pp.1-18
[14] Porter, M. E. & C. van der Linde (1995) 'Green and competitive: ending the stalemate', *Harvard Business Review*, Sept/Oct 1995, Vol. 73 No 5, pp. 120-134

Whilst cleaner production focuses on advocating an environmentally-friendly production model, the circular economy extends this notion to the entirety of economic activities by focussing on closing resource flows, and carries and implicit recognition of high growth and progression to a moderately well-off '*xiao kang*' Society' (小康社会)– which describes a society in which people are all modestly well off and economic growth has been balanced with environmental and social goals (Yong, 2007).. The "circular economy" (循环经济) emerged as a movement in China following its use by former President Jiang Zemin at the Members' Assembly of the Second Global Environment Facility (Beijing, October 2002). Since then it has appeared frequently in leaders' speeches from the administration of Hu Jintao[15] and featured as an aspect in the 11th Five Year Plan[16]. The circular economy is a new pattern of economic development that is related to the ideals of promoting sustainable development (可持续发展) and building a harmonious society (和谐社会), with its fundamental features of high-efficiency and recycling of resources.

The working definition for the CE provided by the NDRC website clarifies that:
"The theme of the CE concept is the exchange of materials where one facility's waste, including energy, water, materials - as well as information – is another facility's input. By working together, the community of businesses seeks a collective benefit that is larger than the sum of the individual benefits each enterprise, industry and community would realize if it intended to optimize its performance on an individual basis".[17]

While traditional economic systems are conceptualised as 'linear' (with material flows from resources to goods/services and wastes), the circular economy focuses on cyclical flows of resources such as water – vital in a country where water availability is a serious national concern. For example, under the eleventh five year plan, the government targets included reduced water consumption per unit of industrial added value and an increase in the "coefficient of effective use of water for irrigation", as well as an increase in the use of solid industrial waste. At the centre of the circular economy are the "3R" principles of "Reduce, Reuse, Recycle"[18], and the alternative names "recycling economy" and "recycling society" are sometimes used. Here we will use the term "circular economy" throughout.

In practice the circular economy has been initiated at three distinct levels:

[15] Yong, Ren (2007) The circular economy in China, *Journal of Material Cycles and Waste Management* **9**: 121-129
[16] DfID (2006) China: Country Assistance Plan 2006–2011, Department for International Development, London
[17] NDRC (2006), quoted in Pinter, L. (2006), 'International Experience in Establishing Indicators for the Circular Economy and Considerations for China', Environmental and Social Development Unit, Asia Pacific Region, The World Bank,, page 2. Accessed from http://www.iisd.org/pdf/2006/measure_circular_economy_china.pdf , 02/8/2008
[18] Qian Yi (2006) 'Cleaner Production and Circular Economy: Conception, Methodology, and Cases', Beijing, Tsinghua University Press

- **Big Cycles** – Various policies have been set at the provincial or city level in 10 pilot areas "to promote energy saving and an environmentally friendly society"[19]
- **Medium Cycles** – industrial symbiosis has been encouraged via the establishment of 25 eco-industrial parks and eco-industrial networks[20]. Here infrastructural systems ensure common resource supplies of water, gas, electricity etc and common waste treatment sites. Wastes from one enterprise serve as a resource for another firm on-site.
- **Small Cycles** – at the micro-level of the firm, enterprises are required or encouraged to practice Cleaner Production (CP). Firms in the seven industries with the highest energy consumption and pollution emissions are targeted in the pilot project. They are committed to squander less energy, reduce their use of toxic materials and reduce waste[21]

China's environmental woes are not only of immediate concern to the Beijing administration, but a global challenge, viewed with increasing urgency by the international community[22]. China recently became the world's number one greenhouse gas emitter, due primarily to increases in coal consumption and cement production. A reduction in the carbon intensity of the Chinese economy is a national objective for the government (with a long-term goal of 40-45% improvement recommended in the 12th five year plan for 2011-2015)[23], to be tackled both through energy efficiency and promotion of low carbon generation technologies.[24] The moves towards an innovation-based society and the promotion of indigenous or independent innovation (自主创新), especially in areas of cleaner technology[25], combine with government policies in these regions to foster the uptake of such innovations in its technology-based industries. Key areas such as the Pearl River Delta including Shenzhen and the Yangtze River Delta (around Shanghai) are amongst the most

[19] Kuhndt, M., Villar, A., Guomei, Z., Wei, Z., Lizhen, X. (2006), 'Policy Reinforcement for Environmentally Sound and Socially Responsible Economic Development in China (PRODEV) : Policy Framework Study', UNEP, SEPA Online, page 9. Accessed from http://www.unep.fr/scp/nap/clearinghouse/documents/CHN_CircularEconomy2006EN.pdf , 28/ 6/2008.
[2020] Pinter, L. (2006), 'International Experience in Establishing Indicators for the Circular Economy and Considerations for China', Environmental and Social Development Unit, Asia Pacific Region, The World Bank,, page 2. Accessed from http://www.iisd.org/pdf/2006/measure_circular_economy_china.pdf , 02/8/2008
[21] Yong, R. (2007), 'The Circular Economy in China', Journal of Material Cycles and Waste Management, Vol. 9, pp. 121–129
[22] Economy, E. (2004) 'The River Runs Black: The Environmental Challenge to China's Future', Ithaca NY, Cornell University Press
[23] KPMG (2011) China's twelfth five-year plan: Sustainability, accessed from http://www.kpmg.com/CN/en/IssuesAndInsights/ArticlesPublications/Documents/China-12th-Five-Year-Plan-Sustainability-201104-v2.pdf, 23/7/2011.
[24] Ning Zeng, Yihui Ding, Jiahua Pan, Huijun Wang, Jay Gregg (2008) "Climate Change – the Chinese Challenge" Science 319, 730-731. According to Premier Wen Jiabao, China has "established a goal that our GDP [gross domestic product] growth every year must be accompanied by a 4% decrease in energy consumption and a 2% reduction in COD [chemical oxygen demand] and sulfur dioxide emissions every year" (in Science 322, 362-364 (2008)).
[25] Tyfield, D., Jin, J. & Rooker, T. (2010) Game-changing China: lessons from China about disruptive low carbon innovation, London, DEMOS

threatened by potential sea-level rise resulting from global climate change[26] and are among the worst emitters.

4. Shenzhen and Bao'an: historical overview and current situation

4.1 Status of Shenzhen within the Chinese Governance System

In August 1980, Shenzhen was officially designated its status as a Special Economic Zone by the National People's Congress (NPC). From a small fishing town of a few tens of thousands, it has grown to a city with an estimated average population of thirteen million[27]. For the first time in the history of the PRC, a city was promoted to prefecture level and entrusted with the task of running the local economy rather than simply subscribing to the investment decisions dictated by central ministries (Sz.Gov. 2008, Ng 2003). The NPC passed a draft resolution on April 4th 1989, and a decision authorizing Shenzhen's Municipal Government to draw up its own laws for the City on July 1st 1992.[28] Shenzhen City became the first region with local autonomy in decision making within China. With the change in the City's political status came economic, institutional and constitutional reform. The model the city has provided has spread in various forms and to different extents throughout the country. In the 28 years since the special economic zone was established in 1980, Shenzhen has illustrated the potential pace of China's industrial development and modernization.

Shenzhen was approved as one of the original 16 sub-provincial cities on February 25, 1994 by the State Commission for Public Sector Reform (中央机构编制委员会). A sub-provincial city (副省级城市; fù shěng jí chéng shì) in the People's Republic of China is an administrative unit that is ruled by a province, but has some political and legislative autonomy. In addition, Shenzhen is one of the five cities that are listed separately in the national five-year and annual plans (on a similar level to provinces and national ministries). These cities (计划单列市; ji(4) hua(4) dan(1) lie(4) shi(4)) which are administered independently with regard to economy. The mayor of a sub-provincial city is equal in status to a vice-governor of a province. Its status is below that of municipalities (such as Beijing, Tianjin, Chongqing and Shanghai), which are independent and equivalent to provinces, but above other provincial capital cities, which are completely ruled by their provinces.

[26] Ning Zeng, Yihui Ding, Jiahua Pan, Huijun Wang, Jay Gregg (2008) "Climate Change – the Chinese Challenge" *Science* **319**, 730-731

[27] The official population of the sub-provincial city is 8.9 million (Shenzhen Municipal Statistic Bureau. 2010-04-26. http://www.sztj.com/main/xxgk/tjsj/tjgb/gmjjhshfzgb/201004265740.shtml), however this is bolstered by migrant labourers

[28] People's Daily (2000) '全国人大授予深圳立法权', www.people.com.cn/zgrdxw/news/200008/03/80307.html, accessed 23/8/2011

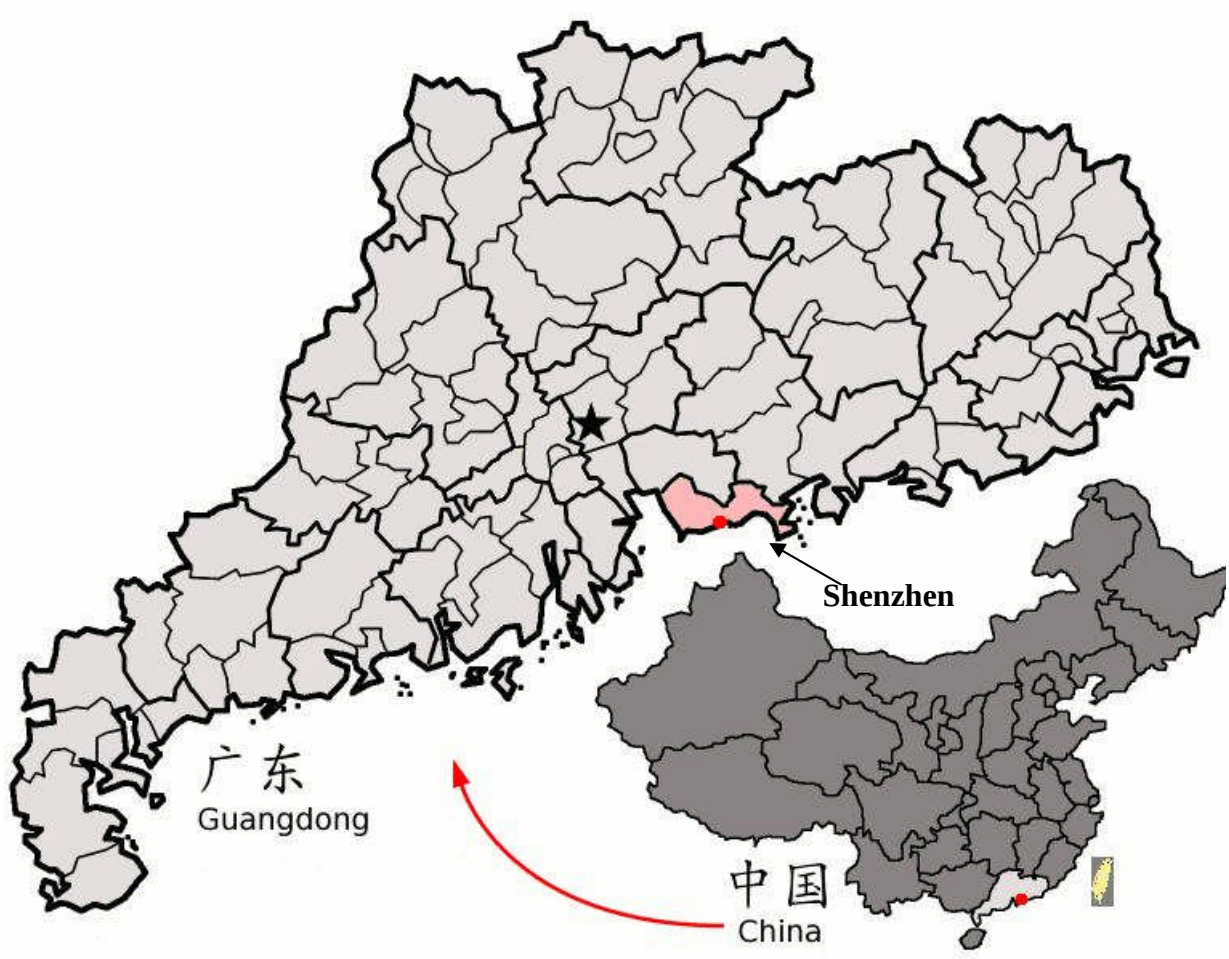

Figure 1. Location of Shenzhen in relation to Guangdong province and the People's Republic of China[29]

4.2 Industrial Development

Over the past 30 years, Shenzhen's overall GDP has grown phenomenally at an average annual rate of over 25.8%.[30] Today ties with international markets are strong. The city is like a magnet for foreign direct investment (FDI); in 2006 FDI totalled US$ 3.269 billion, up 10.1 percent over the previous year (SzGov., 2008). Scarce commodities as well as capital are channelled into this region from all over China because of the promise of higher return on investment (Lu M. & Hsieh, 2004, p 114). Shenzhen has the highest total value of exports of any city in China (Bruton et al 2005)(US$ 136. 1 billion in 2006 - SzGov., 2008). There are 160, 000 firms operating in Shenzhen, around 50% are export orientated (SzGov., 2008), the other half cater for the home-market. Goods are no longer simply 'made in Shenzhen' but 'designed in Shenzhen' too as local companies are moving on from contract manufacturing to knowledge production (Cyranoski, 2007). The value of high-tech merchandise with

[29] Map courtesy of www.wikipedia.com, accessed 3/4/2008
[30] Speech by Guo Yonghang at the second press conference of the fifth CPC representative conferences of Shenzhen, 23rd May 2010. Source: Shenzhen government online., http://www.sz.gov.cn/cn/xxgk/xwfyr/wqhg/ddh5/wbh_20100523/, accessed 2/8/2011

independent intellectual property rights made up 58.9 percent of the city's total industrial output in 2006 (SzGov., 2008).

Ming Xia has described the "Shenzhen revolution" as an example of central-local synergism in the Chinese multi-level governance system[31]. Xia reports that Deng Xiaoping, who he dubs "the midwife of the reform", encouraged the officials in Guangdong (the provincial capital under which Shenzhen is governed) and Shenzhen "to conduct bold experiments, to innovate creatively, and to break through a bloody path (for China)"[32].

Xia also highlights that many crucial components for a market economy were first developed in Shenzhen, such as stock-ownership, stock issuing firms, the stock exchange, enterprise groups, the sale of land use rights, the contract system for cadres and labourers, the social security system, insurance for labourers, and the open bidding process for government procurement, and quotes a Shenzhen official as telling him "if you want to see the China of the past, look at Beijing; the China of the present is Shanghai; but Shenzhen is the China of the Future".[33]

Over the past thirty years Shenzhen has moved through periods of industrialisation based on low labour/land costs/environmental standards, from basic manufacturing towards higher value-added production as capabilities in the IT sector developed.
"Shenzhen speed" (深圳速度) is a commonly-used term in China[34] and the cost efficiencies that initially attracted FDI from Hong Kong and elsewhere make the city host to 161 Fortune 500 companies.[35]

Many of the industries of Shenzhen still display the extensive growth style characterised by low labour and environmental standards and a shortage of innovative products. In the eleventh five-year plan (2006-2010), Shenzhen began its "third industrial transition" which focuses on intensive sustainable development and industry structure optimization. The proportion of tertiary industry will be increased while finance, logistics, culture and the high-tech industry will be promoted as four leading sectors.

4.3 A focus on Bao'an District

Officially established on 1st January, 1993, Bao'an, as one of the six districts of Shenzhen, has a land area of 733 km2, a coastline length of over 30 km and with a total population of over 5 million. In 2005, Bao'an received foreign direct investment

[31] Xia, M. (2000) "The dual development state: development strategy and institutional arrangements for China's transition", Aldershot, Ashgate
[32] Xia, M. (2000) page 183
[33] Xia, M. (2000) page 191
[34] Xia, M. (2000) "The dual development state: development strategy and institutional arrangements for China's transition", Aldershot, Ashgate, page 189
[35] Shenzhen Bureau of Trade and Industry, advertisement in Financial Times China Special, November 24th 2008 page 3

of USD 0.846 billion,[36]. As China's first city for exports for almost the last two decades [37], it generated export revenues of USD 42.902 billion and had a GDP of RMB 116.345 billion[38] (which is claimed by the city's Bureau of Trade and Industry to be the highest per capita of any city in mainland China[39]). Although specific figures for Shenzhen or Bao'an are not available, Wang and Watson (2007) estimated that in 2004 net exports accounted for 23% of China's overall CO2 emissions; For Shenzhen's industrial sector, with its focus on high energy-intensive exports, the percentage can be expected to be higher.

Recently the Bao'an district government has been actively promoting circular economy, especially through encouraging cleaner production in enterprises. On the one hand, they severely punish the enterprises that do not abide by environmental standards and produce serious pollution, such as medium-small electroplate factories, and force them to carry out cleaner production auditing. The case studies below describe some of the firm behaviours that such policies have been trying to promote.

4.4 Environmental pressures

This rapid growth can not be sustainable if the city continues to keep the original style of economic growth characterized by high input, high consumption, low efficiency, and low output. The internal obstacles to hinder the city from keeping sustainable rapid growth are becoming more and more evident, such as limited space, serious shortage of energy and water resources, and the ceaselessly swelling population.

Despite being lower than most other cities in China, energy intensity in Shenzhen is much higher than that is most OECD countries. In 2005 energy intensity in Shenzhen was 0.59 ton standard coal per 10,000 yuan GDP. Shenzhen's improving electricity generation system relies entirely on imported energy resources. In 2005 water consumption per 10,000 yuan GDP in Shenzhen was 33.8 m^3, efficiency of which is 12 times China and is 30% of Japan.[40] Because Dongjiang river, the external water resource, is soon to reach its limit of exploitation, it will be impossible to extend the scale of industrial water use in the future. [41]

According to present consumption levels and the development pattern thus far, a local leader has estimated that if Shenzhen wants to realize 10,000 billion yuan annual GDP, it will use 90% of the city's land, and consume water, electricity and environmental resources equivalent to 3 times that of the present. [42] Along with the high

[36] *ibid*
[37] *ibid*
[38] Bao'an district government Website http://english.baoan.gov.cn/main/en/, accessed 27th November 2008
[39] Shenzhen Bureau of Trade and Industry, advertisement in Financial Times China Special, November 24th 2008 page 3
[40] Shenzhen Government (2006) Eleventh five year plan of Shenzhen for Development of Circular Economy'
[41] Shenzhen Government (2006) Eleventh five year plan of Shenzhen for Development of Circular Economy'
[42] Speech of Liu Yingli, deputy mayor of Shenzhen municipal government, on video conference on the development of a circular economy held by the State Council (21 Dec, 2006)

environmental standards in countries to which Shenzhen exports, the above environmental constraints require Shenzhen to shift quickly to a more 'circular' form of economic development.

5. Shenzhen government regulation and the interplay between national, provincial and municipal levels

As described above, government regulation at the municipal (Shenzhen) level enjoy significant freedom from those set in Beijing for the country as a whole, and to a large extent have pioneered those promoting cleaner production and circular economy ahead of other Chinese regions. Although a national level law promoting cleaner production (2002) sparked the development of legislation in Shenzhen, solutions experimented with in the SEZ have fed back into both national level policy and impacted on more local – district level administrations. The various multi-level regulations are outlined in Table 1 below. The regulations (treated in a broad sense) covered here focus on laws, but also include the adoption of political slogans and party incentive structures as well as practical education programmes and demonstration projects.

5.1 Brief overview of selected laws and regulations related to cleaner production and the circular economy

After the national law of promoting cleaner production was issued in the year 2002, Shenzhen started to take a series of actions to draft and put forward further laws and regulations around cleaner production and the circular economy.

Level at which policy applies	**Name of law/ policy initiative**	**Enacting Body**	**Date (that policy came into force)**
National Level	Law of the People's Republic of China on Promoting Cleaner Production (中华人民共和国清洁生产促进法)	National People's Congress	June 2002
	The Experimental Work of Green National Accounting for GDP (绿色国民经济核算试点工作)	CEPB, NBSC (National Bureau of Statistics of China)	2005
	Accounting system for energy consumption per unit of GDP (单位 GDP 能耗考核体系任务)	China's State Council General Office	Nov 2007
	Comprehensive Working Scheme of Energy Saving and Discharge Reduction (节能减排综合性工作方案)	China's State Council	May 2007
Provincial Level (Guangdong Province)	The Implementation Scheme of Experimental Work of Circular Economy in Guangdong Province (广东省开展循环经济试点实施方案)	Guangdong leading group office for constructing economical	Mar 2006

		society and developing recycle economy	
Municipal Level (Shenzhen city)	Regulation on Promoting Circular Economy in Shenzhen Special Economic Zone (深圳经济特区循环经济促进条例)	Shenzhen Municipal People's Congress	Mar 2006
	Shenzhen Government Policy on Completely Promoting the Development of Circular Economy (深圳市委、市政府关于全面推进循环经济发展的决定)	CPC Shenzhen Municipal Party Committee, Shenzhen Municipal government	Apr 2006
	Short-term Implementation Scheme of Shenzhen on Completely Promoting the Development of Circular Economy（2006－2008）(深圳市全面推进循环经济发展近期实施方案)	Shenzhen Municipal government	Apr 2006
	The Eleventh Five-year Plan of Shenzhen for Development of Circular Economy (深圳市循环经济发展"十一五"规划)	Shenzhen Municipal government	Dec 2006
	The Comprehensive Evaluation Index System of Circular Economy (深圳市循环经济综合评价指标体系)	Shenzhen Municipal government	Dec 2006
	Regulations of Shenzhen Special Economic Zone on Architectural Energy Saving (深圳经济特区建筑节能条例)	Shenzhen Municipal People's Congress	Jul 2006
	Regulations of Shenzhen Special Economic Zone on environmental protection of construction programs (深圳经济特区建设项目环境保护条例)	Shenzhen Municipal People's Congress	Jul 2006
	Regulations of Shenzhen city on comprehensive use of resources (深圳市资源综合利用条例)	Shenzhen Municipal People's Congress	Feb 2003
	Regulations of Shenzhen city on saving water (深圳市节约用水条例)	Shenzhen Municipal People's Congress	Dec 2004
District Level (Bao'an district)	Bao'an District Government Policy on Promoting the Development of Circular Economy (中共深圳市宝安区委深圳市宝安区人民政府关于全面推进循环经济发展的若干意见)	Bao'an district government	Jul 2006
	The Plan of Bao'an District for Development of Circular Economy (2006-2020) (深圳市宝安区循环经济发展规划 2006-2020)	CPC Bao'an District Party Committee, Bao'an District government	Jan 2007

Table 1. Multi-level regulations associated with the circular economy and cleaner production in Bao'an

Those laws referring directly to cleaner production circular economy in their title are introduced below：

NATIONAL LEVEL

- **Law of the People's Republic of China on Promoting Cleaner Production** (中华人民共和国清洁生产促进法)

This national level law was adopted on the 29th June, 2002 at the 28th meeting of the Standing Committee of the Ninth National People's Congress. It entered into force as of January 1st, 2003. The law mostly references the definition of cleaner production from United Nations Environment Programme (UNEP) "Cleaner Production is the continuous application of an integrated, preventive strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment" (UNEP, 1990)[43]. Consisting of 6 chapters and 42 articles, the law specifically regulates promotion and implementation of cleaner production in industrial production and sets out the principles for the implementation of cleaner production in agriculture and services. The law provides incentives in the form of capital grants, preferential loans, tax relief and other measures to encourage enterprises to implement cleaner production. The law mainly focuses on the establishment of mechanisms to encourage and guide enterprises to promote clean production, rather than compel enterprises to do so. Nonetheless it provides rules on the legal liability for enterprises that fail to meet statutory obligations. The objective of the law is to mobilize all fields of the community to promote and implement cleaner production across the nation. The law indicates a major change in strategy for environmental protection in China as well as cleaner production in China entering into a new historical period of environmentally-friendly development patterns.

PROVINCIAL LEVEL

- **The Implementation Scheme of Experimental Work of Circular Economy in Guangdong Province** (广东省开展循环经济试点实施方案)

The implementation scheme was issued by the Guangdong leading group for building a circular economy on Mar 22th, 2006. The work operated at three levels: enterprises, industry zones and cities. Several demonstration unites (enterprises, industry zones and cities) were selected and supported as "cleaner production enterprises", "eco-industry zones" and "resource-saving cities" over a period of 5 years. Meanwhile, 24 important demonstration programmes (similar to those described in this paper) were carried out in five fields - energy-saving, water-saving, efficient utilization of resources, pollution-control and cleaner production.

MUNICIPAL LEVEL

- **Regulation on Promoting the Circular Economy in Shenzhen Special Economic Zone** (深圳经济特区循环经济促进条例)

[43] UNEP, Resource Efficient and Cleaner Production, http://www.unep.fr/scp/cp/ (Accessed: 24/07/2011)

This regulation was adopted on the 14th March, 2006, at the fifth meeting of the Standing Committee of the Shenzhen Municipal People's Congress, and entered into force as of July 1st, 2006. As early as in May 2005, the in-coming regulation was listed as one of the most important annual legislative programs to be introduced to Shenzhen Municipality. The introduction of Regulation in Shenzhen SEZ actually pioneered applying the principles of the Circular Economy for the PRC. In Dec 2006 Dr. Sun Youhai, a member of the working group responsible for drafting the "Law of the People's Republic of China on Circular Economy" recommended that the NPC Standing Committee should reference to Shenzhen's legislative experience to enact the national law on the Circular Economy.[44]

Shenzhen SEZ has been at the forefront of pioneering environmental policies within the PRC for some time. For example, since 2003, Shenzhen Bureau of Trade and Industry (SZBTI), Shenzhen Environmental Protection Bureau (SZEPB), Development & Reform Bureau of Shenzhen Municipal Government (DRBSZ) and Shenzhen Bureau of Science and Information (SZBSI) began to promote cleaner production at the city level. In 2005 SZBTI selected and financed for 15 volunteer demonstration firms in 5 different industries (energy, printing and dyeing, electronic, chemical, and plating) to practice cleaner production auditing. From 2005 to 2006, SZEPB also organized cleaner production auditing in several demonstration heavy-pollution firms. Shenzhen SEZ municipal Government had also experimented with using environmental performance indices in the evaluation of political cadres before some aspects of it were incorporated into national policy in 2008 (via the 'Implementing the Accounting system for energy consumption per unit of GDP' policy explained above).

The Municipal level regulation for 'Promoting the Circular Economy in Shenzhen Special Economic Zone' used lessons learnt from policy experiences in environmental regulation from within Shenzhen, the PRC and abroad. It stresses the dominant status of the government in developing cleaner production and focuses on adopting new policies to guide and incentivise industry to foster environmental protection. The regulation consists of 7 chapters and 55 articles covering general principles of the Circular Economy, systems and measures, incentives and penalties, demonstration and popularization of measures.

- **Decision of Shenzhen Government on Completely Promoting the Development of Circular Economy** (深圳市委、市政府关于全面推进循环经济发展的决定)

The decision was maded by Communist Party of China Shenzhen Municipal Party Committee and Shenzhen municipal government on 20th Apr, 2006. It set a target of a modern, international and recycling eco-cityThe decision highlights a number of areas

[44]深圳循环经济条例可成全国立法借鉴. 深圳特区报. 2006 年 12 月 05 日.
http://paper.sznews.com/tqb/20061205/ca2520870.htm

that require more attention in order to realise this target such as: a perfect local system of policies and regulations for promoting a circular economy; a good technology innovation system for promoting a circular economy; adjusting industrial structure and distribution according to the 3Rs; strengthening the organizational ability of the government for promoting a circular economy.

- **Short-term Implementation Scheme of Shenzhen on Completely Promoting the Development of Circular Economy （2006－2008）** (深圳市全面推进循环经济发展近期实施方案)

The Implementing Scheme was issued by Shenzhen Municipal government in March, 2006. In order to promote a circular economy across the whole city, 8 tasks were planned in the short term (2006-2008). These tasks were: perfecting the system of policies and regulations for promoting a circular economy; water-saving; energy-saving and developing new renewable energy sources; intensive utilization of land; cleaner production and eco-industry; classification and recycling of solid wastes and utilization of renewable resources; eco-consumption; demonstration projects and education/awareness programmes for firms, citizens and .

- **The Eleventh Five-year Plan of Shenzhen for Development of Circular Economy** (深圳市循环经济发展"十一五"规划)

Promulgated in 2006, this Five-year Plan incorporated the 'Regulation for Promoting the Development of the Circular Economy', required that Shenzhen city must reach many key targets related to the circular economy in 2010, it also set out a vision for 2020. The five-year plan included a list of criteria upon which cadres would be evaluated on at the end of year for their promotion or career progression prospects, known as "The Comprehensive Evaluation Index System of Circular Economy**"** (described below). Many of these criteria were vague, however the mere fact that such developments were being made to the evaluation system (which previously focused primarily on GDP) was a step forward.

DISTRICT LEVEL

- **Bao'an District Government Policy on Promoting the Development of Circular Economy** (中共深圳市宝安区委深圳市宝安区人民政府关于全面推进循环经济发展的若干意见)

Bao'an District government is one of the divisions of local government responsible for establishing and implementing a circular economy system at the district level within Shenzhen. Bao'an District government policy aims to reduce environmental pollution and realize the transition of industry from being low value manufacture-oriented to becoming increasingly high value research and development-oriented. The district polices set out to drive technological leapfrogging and indigenous innovation and focus on firms, industrial clusters/ parks and also extend to covering society more widely.

- **The Plan of Bao'an District for Development of Circular Economy (2006-2020)** (深圳市宝安区循环经济发展规划 2006-2020)

Bao'an District government identify district level targets that need to be attained through implementing their local Circular Economy development measures. Utilising the criteria set out by the Municipal Government of Shenzhen in "The Comprehensive Evaluation Index System of Circular Economy" Bao'an District was mandated to reach the following key indices by 2010:

- electricity consumption per ten thousand yuan GDP must be reduced by 15% (1574 kwh per ten thousand yuan GDP in 2005)
- water consumption per ten thousand yuan GDP must be reduced by 15% (43.5 m^3 per ten thousand yuan GDP in 2005),
- industrial water consumption per ten thousand yuan industrial value added must be reduced by 5% (35.9 m^3 per ten thousand yuan GDP in 2005),
- resourceful treatment of waste water must increase to being equal to or greater than 20%,
- utilization of industrial solid waste must increase to being equal to or greater than 92% (64.5% in 2005),
- resourceful treatment of domestic refuse must increase to being equal to or greater than 45% (20% in 2005).

5.2 'Greening' the Cadre Evaluation System

Beyond the role of legally-mandated laws and regulations, a key lever used in China's dirigiste governance tradition is the evaluation system for cadres within the Communist Party. Development of the circular economy became a more important element in the evaluation of political cadres from the initiation of the 11th Five Year Plan period (2006) and as early as 2004 the leaders of Shenzhen openly endorsed the "green GDP" and "social net welfare" approaches (which include environmental and welfare indicators) as a way of appraising cadre performance at various levels. Local governments have applied the 'green GDP' concept in different ways and the evaluation system and its scientific foundation has been contentious.[45] Despite these regional differences and the failure at settlement on a standard national framework, local 'experiments' have led to national-level debates and Shenzhen's efforts at the vanguard of bringing broader sustainability goals into party incentive structures has contributed valuable experience to the green GDP campaign.

Table 2 below illustrates the "Comprehensive Evaluation Index System of Circular Economy" – the quantitative and qualitative targets for cadres to aim for within their jurisdictions. Evaluation is on the basis of meeting these targets by the end of the planning periods. However, at the same time, GDP growth retains the dominant criterion upon which cadre's performance is judged. As will be discussed later in this

[45] Zheng, Y. & Chen, M. (2006) China promotes green GDP for more balanced development, University of Nottingham China Policy Institute Briefing Paper 16

paper, these evaluation criteria are linked indirectly to the factors driving firm behavior.

Sort		No	Core index	Details of index	Unit	Present	2010	2020
Social Foundation	Soft Environment	1	Complete degree of organization construction		-	Normal	Comparatively perfect	Perfect
		2	Complete degree of law and regulation		-	Normal	Comparatively perfect	Perfect
		3	Level of information management and technology R&D		-	Normal	Comparatively high	High
		4	Proportion of environmental protection investment in GDP		%	2.3	≥3	≥4
		5	Proportion of CE investment in GDP		%	-	≥4.5	≥5.0
	Hard Environment	6	Water circular system	Rate of urban centralized sewage treatment	%	69.3	≥75	≥95
		7		Standard-reaching rate of sewage treatment	%	50-60	≥70	≥90
		8		Repetition rate of industrial water use	%	49.8	≥75	≥80
		9		Rate of industrial waster water emission below standard	%	95.2	≥99	≥99
		10		Utilization rate of rain and flood	%	-	≥2.82	≥3.0
		11		Online control rate of key pollution sources	%	-	≥80	≥90
		12		Recycle rate of sewage treatment	%	0.1	≥20	≥40
		13		Ability of seawater utilization	%	60	≥90	≥140
		14	Energy system	Optimization rate of energy structure	%	29	≥40	≥60
		15		Rate of energy utilization and conversion	%	37	≥42	≥55
		16		Utilization rate of renewable energy	%	-	≥2	≥6
		17	Material resources circular system	Utilization of industrial solid waste	%	91.2	≥92	≥95
		18		Utilization of renewable resources	%	92	≥98	≥99
		19		Resourceful treatment of domestic refuse	%	16	≥45	≥60
		20		Harmless treatment of domestic refuse	%	81	≥95	≥100
		21	Transportation	Length of intercity electrification railway	km	21.6	≥146.6	＞365
	Development of economy	22	Industry structure	Proportion of tertiary industry added value in GDP	%	38	≥50	≥60
		23	International trade	Decline rate of export loss influenced by Green Barriers	%	-	≥50	≥90
		24		Rate of import standards corresponding to international standard	%	-	≥70	≥90
	Social life	25	Consumption mode	Decline of disposable product consumption per capita	%		≥40	≥70
		26		Popularization of energy and water saving apparatus	%		≥60	≥100

Level of development		27	Community construction	Popularization of saving-type community	%	-	≥50	≥80
	Government construction	28	Green purchase	Proportion of Green purchase in government purchase	%	-	≥40	≥60
	Resources Efficiency	29	Resource consumption level	Energy consumption per ten thousand yuan GDP	Ton of standard coal per 10,000 yuan	0.59	-10%	-15%
		30		Water consumption per ten thousand yuan GDP	m^3 per 10,000 yuan	33.8	-20%	-20%
		31		Construction land per ten thousand yuan GDP	m^2 per 10,000 yuan	16	-40%	-50%
		32		Domestic water consumption per capita	l per day per capita	282	-25%	-20%
	Environmental benefit	33	Environment pollutant load	Main pollutants discharge (SO2, COD)	%	-	-10%	-15%
		34		Safe disposal rate of hazardous waste	%	100	100	100
	Ecological Security	35	Water environment	Rate of tap water quality reaching international standards	%	-	≥40	≥85
		36		Rate of drinking water source quality reaching standards	%	96.7	≥99	≥100
		37		Rate of urban river quality reaching standards	%	46.7	≥60	≥75
		38		seawater quality reaching standards	-	Almost reach 2 grade	Almost reach target of environmental function regionization	Reach target of environmental function regionization
		39	Atmospheric environment	Excellent rate of air quality	%	94	≥98	≥99
		40	Landscape greening	public green space per capita	m^2 per capita	16	≥16	≥18
		41		Forest coverage	%	47.6	≥48	≥52
		42	Land utilization	Percentage of ecological land	%	57.8	≥60	≥60

Table 2. The Comprehensive Evaluation Index System of Circular Economy[46]

[46] Shenzhen Government (2006) The Eleventh Five-year Plan of Shenzhen for Development of Circular Economy, 95-97

6. Cleaner technology adoption: case studies and motivations for change

Of 100 interviewed enterprises, 25% adopted "cleaner production" approaches, including energy management, technology retro-fitting and investing in new and upgraded technologies. A further 60% of firms interviewed adopted "end of pipe" approaches (i.e. incompatible with cleaner production concepts), and 15% did not make any environmental improvement (as illustrated in Figure 2 below).

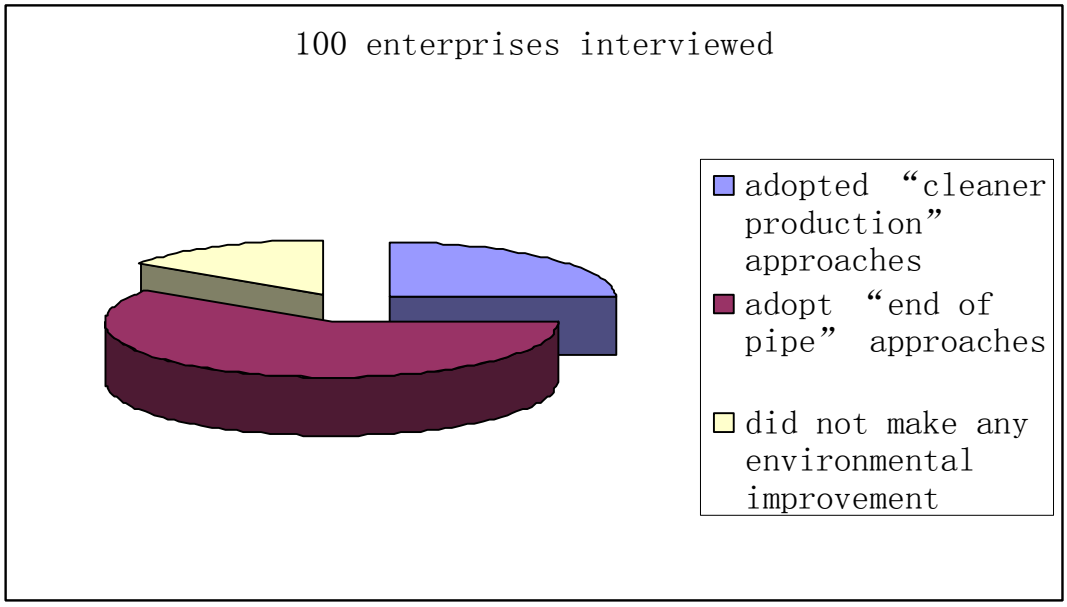

Figure 2. Behaviours of enterprises interviewed with respect to cleaner production approaches.

Although comparative data for previous decades is not available, it is clear to researchers that investment behaviour amongst firms in Bao'an district is beginning to focus more on cleaner technologies. Their motivation for these investments, and methods through which they were implemented will now be discussed, with reference to 6 case study firms that fit within the 25% of firms found to have adopted 'cleaner production' approaches. Following this, drawing on the wider survey, a comparison of the relative importance of each of the motivations highlighted by firms will lead to a discussion of the role of municipal regulations in encouraging moves towards a circular economy.

The six case study firms here are drawn from the sample of 25 firms that invested in cleaner production approaches. They have been selected to illustrate the range of technologies and methods adopted, as well as to illustrate the three main drivers for investment in cleaner production. Their product focus, motivation and methods for adopting cleaner production are described in Table 3 below.

Firm	Product focus	Primary motivation	Methods

A	Printed circuit boards	Cost-saving	Planning, management and technology construction focussing on energy saving, Sony green partner, ISO14001
B	Brewing	Cost-saving	Environmental management system, ISO14001, energy management contract (EMC)
C	Electrical Appliances	Technological upgrading/ product quality	Introduction of SIEMENS modular production and environmental standards
D	Electronic components	Technological upgrading/ product quality	Upgrading production equipment. Introduction of ROHS standard, Sony green partner certification
E	Printed circuit boards	Avoiding being fined	Introduction of ISO14001
F	Computer chassis	Avoiding being fined	End-of-pipe pollution treatment

Table 3. Overview of firms covered by the case studies in this paper

The case study firms are organised according to their primary motivation for investing in cleaner production technologies. In order of decreasing importance, firms were found by the broader survey to be motivated by the following drivers:

- Saving costs on raw materials and energy resources
- Upgrading technologies not solely based on cost-saving, but for product quality and ongoing enhanced competitiveness. In many cases this led to firms complying with international private standards or regulatory requirements.
- Avoiding fines levied for exceeding pollution limits

In many cases, the history of firms highlighted a number of these criteria. These motivations are thus not mutually-exclusive, but the categorisations here reflect those identified as being the *primary* motivations by the respective managers interviewed.

Cost-saving

Almost all the firms interviewed stated that cleaner production techniques were introduced in order to save costs and thus increase profit. The two case studies below illustrate different ways in which this was achieved.

6.1 Firm A

Firm A specialises in the production of printed circuit boards. At the time of the interviews, the company ranked 5th in terms of output volume in the world and 1st among Chinese corporations in this field.

In order to save costs, the firm has centered its adoption of cleaner production on energy-saving management and technological innovation. The energy-saving plan was made ahead of construction of the current factory, using energy-saving construction materials and equipment. An energy-saving committee was also set up, whose target

was more than 15% reduction of both electricity and water use. Several internal rules to penalize resource inefficiency and encourage efficiency were put forward, while the company also focussed on retrofitting energy-intensive equipment with energy-saving features. More information is given in Table 4.

Action	Details
energy saving plan before factory set up	Using fireproofing partition boards to reduce the loss of air-conditioned air.
	Use of energy-saving equipment. e.g. "TRANE" centrifuge with heat-reclaiming functionality. "ELLIOTT" centrifuge with gas storage capacity to reduce undulation of air pressure and consumption of electricity.
	Request suppliers to provide special designed energy and water saving equipment. e.g. Machines cut off the supply of electricity and water automatically, when raw material supply is paused for a certain time.
	Main water and electric equipments are installed with water meter or electricity meter for the convenience of analysis and management of water and electricity consumption.
Management approaches	Implementation of internal rules controlling high concentration liquid discharge and water wastage
	Implementation of internal rules for energy saving (air condition and lighting)
Energy-saving retro-fitting	Transducers are installed on pumps of water chillers. 35%-50% electricity reduction is achieved.
	Global self-motion cleaners are installed on condensers of water chillers to wipe off water scale and insure the efficiency of heat exchange. 10% electricity reduction is achieved.
	Fluorescent lamps and T8 Lamps were replaced with T5 Lamps. 25%-30% electricity reduction is achieved.
	Water recycling devices are installed on brushing machines. Along with production increase, this results in a water consumption decrease from 320 ton to 120 ton per month in average: a 62.5% saving.
	Water meters are installed on all water devices for monitoring and management. Water savings of 30 ton per day result.
	Discharged water is reclaimed and used in waste gas scrubber. This results in water-saving of 210 ton per day.
	Waste acid is reclaimed and used in place of vitriol in waste water disposal. As a result, cost of vitriol and sodium hydroxide are reduced by RMB 31000 per month.

Table 4. Details of actions taken by Firm A in order to foster cleaner production

The firm successively passed ISO14001 international environmental management system certification, as well as the Sony green partner certification and "Pengcheng (鹏城 namely Shenzhen) waste reduction" example certification.

In 2006 Firm A saved 527,000 ton water. Combined cost savings from tap water and water disposal was about RMB 3,690,000 yuan per year. Electricity use was reduced by 19,100,000 kWh per year, the cost of which represented RMB 13,850,000 yuan. Profit increases due to of internal recycling of solid waste were RMB 9,110,000 yuan and recycling of liquid waste RMB 250,000 yuan per year. In July 2007 Firm A received recognition from Shenzhen Bureau of Trade and Industry for taking the lead in achieving energy saving targets.

6.2 Firm B

Firm B is a joint venture between a Chinese brewery three Japanese partners.

in, The firm established an environmental management system accordance with ISO14001: 2004 standards to focus on monitoring, pollution prevention and energy saving. It developed a series of new cleaner production processes and pollution controls. For example, adjusting boiler temperaturesand optimizing the cooling system to decrease energy consumption; cleaning and desulphurizing boiler dust before emission; and reclaiming carbon dioxide produced in the fermentation process beer-carbonation (greatly reducing carbon dioxide emissions).

In August 2006 the firm initiated an energy management contract (EMC) with Honeywell, the internationally renowned energy management firm. According to the agreement, Honeywell formulated the overall energy saving solutions, with energy management decentralization and optimization for the entire plant cutting 17% of the energy consumption annually. After implementation of the contract, crude oil consumption dropped 17% compared to the 2005 baseline and electricity consumption index fell 15%. Based on standard production of 150,000 tons of beer annually after 2007, this translates to a saving of 1,100 tons of crude oil and 2.2 million KWH of electricity - a cost-saving of RMB 500 million yuan. In addition, pollution controls will reduce annual atmospheric emissions by 75,175 kg of SO_2, 6,600 kg of nitrogen oxides, 220 million kg of CO_2, and over 330,000 kg of dust and ash. This example is interesting as the lack of expertise and technological capabilities in Shenzhen represents an important barrier to the implementation of cleaner production approaches. Institutes and intermediary organizations for R&D and information consultancy services in cleaner production technologies are rare, and some of these technologies cannot be applied quickly due to this absence of know-how. The energy management contract arrangement above overcomes this barrier.

Technological upgrading

Under the increasing pressures of market competition, some firms invested in , upgrading to advanced technologies purchased from leading international firms or developed in-house. These often delivered higher quality products and enhanced competitiveness. In doing so, they found that they realized win-wins: improved environmental performance and increased profits.

6.3 Firm C

Firm C is one of China’s backbone enterprises of the power distribution equipment industry. It maintains close cooperation with multinational firms such as SIEMENS.

Because the traditional production mode in this firm not only produced enormous pollution, but also could not effectively deal with the intense pressures of market competition, the firm adopted international advanced standards by introducing the SIVACON product line from SIEMENS in 2003 (in line with SIEMENS quality indicators). SIVACON products use standardized modular design, which can greatly increase material use efficiency. . In this case, the utilization rate of armor plate in galvanization was reported to increase from the traditional 80-85% to 98% efficiency following introduction of the new system.

Furthermore, through adoption of SIEMENS' advanced design concepts and technologies, the firm enhanced its product quality and staff capabilities. Sales increased steadily year by year. Up to October 2006, the factory had produced a total number of 1,180 SIVACON products and achieved output value of RMB 72.67 million yuan. As a result of incremental innovation, its products currently compete with foreign firms, including SIEMENS.

In 2006 the firm was awarded the "national product quality exemption" certification (国家免检产品) by the General Administration of Quality Supervision Inspection and Quarantine (AQSIQ) of the People's Republic of China. In 2006 it implemented the ISO14001 environmental management system and OHSAS18001 occupational health and safety management system certification, leading the industry in Guangdong Province. The main people responsible for the firm take the idea that the enterprise did not understand circular economy regulations at the beginning, however they later found out that the behaviour of the enterprise was in line with circular economy and cleaner production requirements.

6.4 Firm D

Firm D is a sino-foreign joint venture and a high-tech enterprise specialising in passive components including multilayer chip inductors, wire wound chip inductors, common mode chokes, varistors, NTC thermistors, LC filters, chip antennae, ASM, transformers and Tantalum capacitors.[47] In order to improve its competitiveness, the firm increased investment in upgrading its production equipment. As a result, the use of raw materials and non-renewable resources reduced by about 10% per individual product annually. Products using recycled materials increased and lead-free products were developed.

The firm is certified by the "Green Partner" scheme of SONY Corporation in Japan, and is one of a few domestic electronic components suppliers for which products comply with ROHS standards of the European Union Directive. Since April 2004, this has greatly increased the firm's competitiveness in the European and international markets. In 2006 the firm completed a clean production audit in Guangdong province,

[47] Company website, accessed 26/7/2011

and achieved the "Guangdong clean production enterprises award from the provincial government.

Avoiding being fined

A minority of firms identified as having invested in cleaner production technologies cited ‘avoiding being fined’ as their primary motivation. This raises questions about traditional conceptions of China’s ‘command-and-control’ mode of governance, and casts doubt on the importance of formal regulations in driving more environmentally-friendly patterns of development, at least in those firms interviewed.

6.5 Firm E

Firm E was established in 2001, as a larg-scale Taiwan-funded enterprise. Its main products are double-sided and multilayer printed circuit boards. Before cleaner production approaches were applied, this firm was infamous for high consumption of water and energy. Water consumption was 130,000 ton per month. Electricity consumption was 8,000,000 kWh per month. Cost of water disposal and electricity reached RMB 5500,000 yuan per month. Because the water and gas discharged did not reach the environmental standards specified in local pollution discharge regulations, the company was penalized by the then Environmental Protection Administration (now the Ministry) several times.

The firm decided to remedy this situation by investing in environmental management certification and implementing a waste reduction plan. Management systems from the ISO14000 scheme were introduced in March 2002 and the firm was certified in Feb.2004. Auditing of ISO14001 and OHSMS118001 (Occupational Health and Safety Management Systems Specification) was conducted in December 2006.

At least 75 ton water was wasted per day on the firm’s 50 production lines. The firm funded RMB 30,000 yuan to install water saving devices- in 27 product lines, saving at least 2,500 ton water per year. According to the firm’s report, the firm saved RMB 5,020,000 yuan by the application of cleaner production in the last year. 320,000 ton water and 3,000,000 kWh electricity were saved, and in one year 297 ton solid waste was reduced.

Marking a significant turn-around in its relationship with government and its public image, in 2006 Firm E obtained the title of "Excellent Cleaner Production Enterprise", (as an excellent project being awarded 50,000RMB, as per the description of the programme above) and was named "Pengcheng (鹏城 namely Shenzhen) waste reduction" example by Shenzhen municipal government.

6.6 Firm F

Firm F, a Taiwan-funded enterprise, mainly produces computer chassis and peripherals. All products are exported to the United States, Japan, Europe and other countries, with profits of about RMB 100 million yuan annually[48].

Firm F is a large resource consuming firm in Bao'an District, which has also been fined for poor environmental performance. Wastewater emissions are as high as 12-13 tons per day. The firm has in the past been fined on the basis of the pollution it has produced. In addition, the firm uses large amounts of energy, especially in the operation of stamping machines. Although the firm invested RMB 500,000 yuan and took a number of measures such as energy conservation, waste water-recycling, there was little achieved in terms of energy-saving. In order to achieve environmental standards by further lower energy consumption, the firm replaced automatic production lines with semi-automatic production lines and hired more workers. With the number of workers increased, the whole plant saved more than RMB 2,000,000 yuan on energy in 2006.

On the surface, Firm F reduced environmental pollution through an alteration of its production process, and has achieved economic benefits, just as Firm C did. In effect, however, their approaches are fundamentally different. Through upgrading to advanced high-tech production processes, Shenkai Firm C achieved more energy-efficient and production without raising other costs. In this instance by comparison, Firm F substituted energy costs for cheap labor costs. If labor costs increase, the enterprise will still face the dilemma of choosing between improving economic benefits and complying with environmental protection standards. Therefore, Firm F's actions are not a good example of socially-sustainable, cleaner production methods and do not represent a solution to long-term sustainable development. Based on considerations of avoiding strict punishment or saving energy, other factories in Shenzhen have adopted labour-intensive processes rather than more energy-efficient technologies.

7. Discussion - Influence of regulation, along with other motivations for firm behaviour

Through this investigation of enterprises adopting cleaner technologies, we find that the various drivers of changes, ranked according to their importance by researchers are: costing saving (most important), technological upgrading, avoiding being fined, attraction of subsidies, good relations with government, brand recognition and public relations. Formal regulation therefore plays a small but significant role (through the threat of fines), however 'softer' forms of regulation also appear to drive change, especially through the possibility of maintaining good relationships with government by acting in the interests of specific local plans and more general cadre evaluation criteria. However, these factors influence firm behaviour less than traditional profit-

[48] Interview with employee of Weixun Computer Company, date, place

oriented motives, which have driven innovation and upgrading and had positive environmental benefits (especially in terms of resource use) as an indirect side-effect.

7.1 Costing-saving

Enterprises can be seen within a neoclassical approach as rational actors with an aim of minimising costs, and the induced innovation hypothesis originally put forward by Hicks [49] has often been applied to explain technical change in environmental economics. [50, 51] Within the environmentally-stressed locality of Shenzhen (described above), it is clear that limited resource pressures are likely to act to drive innovation in directions that promote efficiency. Whilst it is difficult to provide conclusive evidence of the relationship between investment and savings, given the limited scope of this particular study and the absence of clear, longitudinal data, there is no doubt that in the cases covered, enterprises have saved on resource costs as a result of investing in cleaner production approaches.

The economic interest of cost-saving can be seen as the first and most important objective identified by firms, and as shown most clearly by the case studies of Firms A and B,. In both cases, firms used both investment in environmentally-conscious technologies (e.g. in firm A's development of a new factory), as well as management techniques (e.g. introduction of ISO14001 by both firms A and B, and firm B's EMC with Honeywell) and retrofitting (e.g. firm A's replacement with energy efficient lightbulbs and fitting of water recycling components). There was limited evidence of indigenous/ independent innovation for cleaner production in the cases outlined here.

Apart from direct cost-saving, the evidence points to additional benefits from these kinds of investments. For example, Firm A's resulting receipt of the 'Sony Green Partner' award acts as a powerful signal to other potential clients wishing to focus on a more environmental supply chain.

7.2 Technological upgrading for product quality

Technological upgrading is often highlighted in Chinese policy statements as a route to increased competitiveness, key to the process by which domestic firms are gradually 'going out' to become multinationals in their own right. In the study in question, firms C and D instigated upgrading programmes in order to improve the quality of their products. At the same time, this led indirectly to cleaner production, with resource-efficiency, cost-saving and pollution reduction coming as an additional result.

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[49] Hicks, J. (1932) The Theory of Wages, London, MacMillan

[50] Newell, R. G., Jaffe, A. B. & Stavins, R. N. (1998) 'The Induced Innovation Hypothesis and Energy-Saving Technological Change' NBER Working Paper 6437, Cambridge MA, National Bureau of Economic Research

[51] Frans Oosterhuis (Ed) (2006) 'Innovation dynamics induced by environmental policy', IVM Report E-07/05, Amsterdam, The Netherlands
http://ec.europa.eu/environment/enveco/policy/pdf/2007_final_report_conclusions.pdf

In the case of Firm C, more advanced technologies were imported from the European Union, where environmental controls have traditionally been more stringent. As shown in other sectors[52], 'transfer of technology' from foreign firms has traditionally one of the key routes to raising environmental performance.

More than 70% exports of Shenzhen are electric and electronic products, and EU is one of the most important household appliance markets of Shenzhen. On 13 Feb, 2003, the EU issued two directives: the Waste from Electric and Electronic Equipment (WEEE) Directive was enforced on 13 Aug, 2005, whilst Restrictions of certain Hazardous Substances (ROHS) Directive was enforced on 1 July, 2006. Operators such as Firm D benefitted from accessing the European market (in terms of compliance with the ROHS Directive) as a result of their upgrading. The ISO 14000 scheme represents the international standard for environmental management, and compliance with standards within this scheme came as a result both of investment in new hardware and management systems themselves in Firms A and E. As well as overseas regulations, it is noticeable that the efforts of international firms to green the supply chain (e.g. through the Sony and Siemens standards discussed above) have played a significant role in driving improvements and upgrading. It is also notable that similar requirements have not yet been put on these suppliers by domestic firms.

7.3 Avoiding being fined

The impacts of environmental regulation on firm competitiveness have been debates for two decades, but notwithstanding considerable evidence for 'win-wins', there is still ongoing debate around the purported relationship between tougher environmental standards and enhanced competitiveness (described by the so-called 'Porter Hypothesis' some twenty years ago[53]). Shenzhen's environmental regulations take many forms – by no means limited to those focussing on 'cleaner production' and the 'circular economy' described here. Although the motivations above appear to act independently of formal regulation (in terms of environmental laws or standards), some firms acted in order to avoid formal censure by the municipal government (i.e. being fined)

Discussions of environmental regulations in China have often focussed on the differences between Chinese 'environmental law' and that seen in Western countries, and highlighted the difficulties of implementation by the State Environmental Protection Agency (now Ministry) against a background of corruption and a bureaucracy with fundamental structural limitations[54], however the presence of at

[52] Sims-Gallagher, K. (2006) 'China Shifts Gears: Automakers, Oil, Pollution, and Development', MIT Press
[53] Ambec, S., Cohen, M.A., Elgie, S. & Lanoie, P. (2011) The Porter Hypothesis at 20: Can Environmental Regulation Enhance Innovation and Competitiveness? Washington DC, Resources for the Future
[54] Economy, E. (2004) 'The River Runs Black: The Environmental Challenge to China's Future', Ithaca NY, Cornell University Press

least some firms citing this motivation demonstrates that the Shenzhen government is implementing regulations seriously. This does not remove the need for continuous improvements in building good governance and the rule-of-law, however demonstrates that in this geographical jurisdiction, at least, some progress is being made. Other work in China has pointed to close relationships between local government and firms, leading to a more collaborative approach than the sometimes adversarial regulator-private sector relationships seen in the West.

The research methodology used in this study did not allow a systematic investigation of regulatory compliance, or the interaction between compliance and competitiveness in the longer term. Fines are necessary to guarantee the lowest environmental quality, but are insufficient as policy instruments to promote ongoing improvements in cleaner production (compliance-plus), which are necessary for the realisation of the circular economy. If a firm's behaviour no longer breaks pollution regulations, the firm is not incentivised by fines to adopt further improvements towards cleaner production. Furthermore, the command-and-control mode of regulation may impel enterprises to seek eluding approaches. For example, in the case of Firm F, the costs caused by a decline in resource efficiency are compensated for by low labour costs. In some factories, workers' living and working conditions are bad, so more intrinsic incentive regulations are necessary to change the actions of firms from the more passive end-of-pipe mode to active and ongoing approaches to cleaner production.

7.4 Subsidies

Shenzhen has offered specific subsidies to encourage investment in advanced cleaner technologies. However, only 20 of the 89 experimental units in Bao'an submitted their cleaner production projects with applications for government subsidies.

Every experimental unit could attract almost 100,000 yuan in subsidies, which was reported to be too little for it to make significant cleaner production investments. This is evident from the scale of investments outlined in most of the firms described above. Because the funds provided by government were limited and commercial banks rarely provide loans for such risky investments, up-front costs remain a barrier to many cleaner production projects with potentially high environmental benefit. Researchers suggested to the government that subsidising a smaller number of high quality projects would be a more effective use of government funds than offering smaller volumes of support to many firms.

7.5 Good relationship with government or public image

In order to encourage more factories to adopt circular economy, the city and district government provided demonstration enterprises titles, conferring awards and awarding subsidies (e.g. Firms A, B, and D). Despite the publicity that such programmes offered, these approaches were not cited as influencing the behaviour of

many firms. However, a number of firms cited the role of successful implementation of cleaner production projects (especially as part of government programmes) as contributing to an ongoing good relationship with the government. In the longer term, this could in theory provide opportunities for firms to influence government policy, circumvent bureaucracy and anticipate government decisions in order to plan more effectively, again linking to the more 'co-operative' approach of firms and government working together to realise shared aims.

7.6. Continuing barriers to the adoption of cleaner production

Despite the range of motivations for investing in cleaner technologies and practices, several barriers to the adoption of cleaner production approaches exist, and have hindered firms from improving their environmental performance in Shenzhen. One reason is that directors of such firms are short-sighted, and do not recognize the benefits brought by cleaner production such as saving cost and improving product quality in the long run. The other reason is that the cost in promoting cleaner production is high. Without help in funds and technologies, enterprises have no ability to adopt cleaner production (with wastewater treatment as a good example). There are many small-medium enterprise in Bao'an, each of which has an annual profit of just hundreds of thousands or several million yuan. It is difficult for them to invest in water recycling projects requiring tens of thousands to hundreds of thousands of yuan.

Regulation obviously has a broader role to play in overcoming these barriers, however regulations are subject to framings that differ between regulators and various other actors in the socio-techical system.[55] In the case of municipal regulations in Shenzhen, laws and regulations are more instructive and less directing. Taking the "Regulation on Promoting Circular Economy in Shenzhen Special Economic Zone" as an example, the regulation stipulates setting up special funds to finance circular economy projects. But the process of setting up special funds is complex, and it is not certain that the funds can operate effectively. Regulation indicates government purchase will favour products and services according with circular economy principles. According to the present bidding regulations for government purchase, more than 3 enterprises need to participate. But in reality, enterprises according with the principles of the circular economy are not abundant enough. At the same time, because the cost of investing in cleaner production/circular economy – derived products is often higher, dealing with government audits is also a problem.

In comparison to the enterprises described above, many firms in Bao'an district did not adopt cleaner production at all, but left to relocate to inland China (e.g. Wuhan) and South-East Asian countries. Most of them were enterprises focussing on lower-technology industries, such as toys, moulded plastic and printed circuit boards. The

[55] Van Zwanenberg, P. F., Ely, A. & Smith, A. (2011) Regulating Technology; Global Harmonisation and Local Realities, EarthScan

main reason for enterprise migration was that environmental and labour costs are cheaper and environmental controls relatively looser in inland China than in Shenzhen. District government officials are usually not overly concerned about the migration of traditional enterprises in this way, as it accords with the government's longer-term goals to upgrade industry and improve environmental quality. Regulation in this sense is thus a tool for sign-posting and encouraging broad-scale shifts in the kinds of directions of development deemed appropriate and attractive by the government. At the same time, an awareness of multi-level impacts of these regulations and co-ordination between different countries and regions is necessary to prevent 'races to the bottom' and 'pollution havens'[56] from appearing.

7. Future research priorities

Suggestions for future work include a more explicit focus on the interactions between firms and other actors within society, attention to the role of technology in wider socio-technical transitions, the requirements for building indigenous innovation capabilities necessary to promote the circular economy and an appreciation of the complex systems of multi-level governance within China (as highlighted by a number of UK and Chinese scholars working in the area of innovation for sustainable development.)[57]

7.1 Understanding the interactions between firms and other actors in society

Because the market economy in China is still in the process of transition (although this is more advanced in Shenzhen than in some other parts of the country), the position of government in promoting the circular economy will remain dominant for some time. Technological optimization and economic rationality is a prominent assumption in policy-making by the Shenzhen municipal government, and negotiation is neglected in that process. The roles of stakeholders and citizens will become more significant as China's governance reforms continue and policy approaches move from a command and control mode towards a market-inducing/social shaping/ modulating mode.[58]

The current, linear process through which the government has supported projects for the circular economy is described in Figure 3 below.

[56] Eskeland and Harrison (2003) "Moving to Greener Pastures? Multinationals and the Pollution Haven Hypothesis" Journal of Development Economics 70, 1– 23
[57] Ely, A. (2010) Report on an international workshop on 'UK-China Innovation for Sustainability and Equitable Development', held at Tsinghua University School of Public Policy and Management, 19th March 2010, Beijing
[58] Berkhout, F. and A. Gouldson (2003) 'Inducing, shaping and modulating: perspectives on technology and environmental policy' in Berkhout, F., Leach, M. and I. Scoones (eds) Negotiating Environmental Change Edward Elgar, Cheltenham

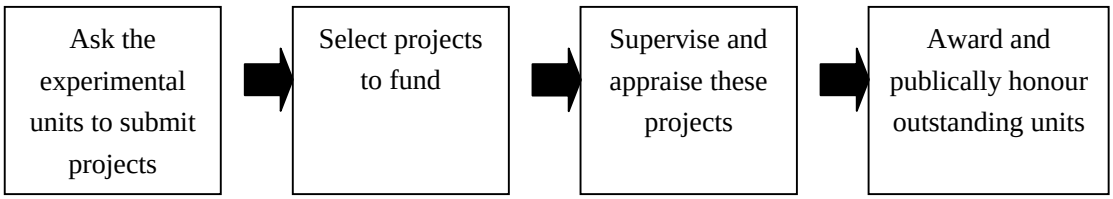

Figure 3. The linear 'cleaner production' policy process adopted by Bao'an District Government during the 11th Five Year Plan

There is no feedback from citizens or enterprises about the effect of policies and no recognition of the role of groups of stakeholders (industry organisations, research bodies, consumer groups, users/citizens and environmental organisations where they exist) in the process of technology selection or adoption. Future governmental initiatives in this area could open up the process of project selection and appraisal to broader perspectives, and also involve invite feedback from such stakeholders on possible future policy approaches, enabling a more networked approach to governance as illustrated in Figure 4 below.

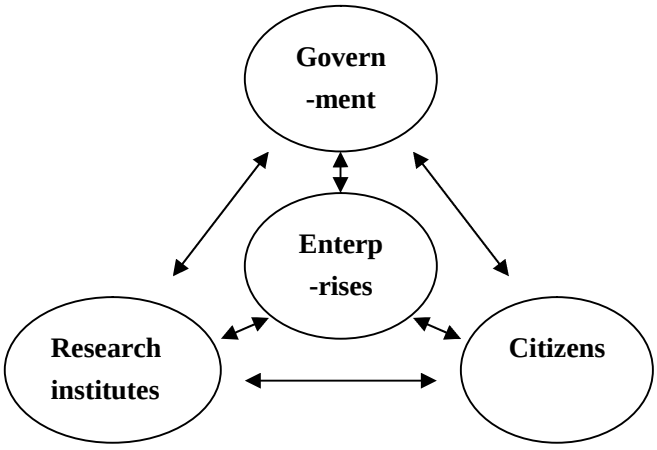

Figure 4. Interactions between firms and other actors in society

A similar focus on government-driven policy (at the expense of multiple perspectives) also extends into the research process. The role of university researchers in the programme that formed the basis for this study was just as technological consultants - they only had a voice in the technology examination, rather in the selection of candidate firms and methodologies for the project. At the same time, it would be difficult for researchers to gain access to firms to study cleaner production without the support of government, and thus research institutions are unable to conduct such studies independently. Researchers at Tsinghua University believe that studying the interactions between firms and other stakeholders in a more systematic way would be an improvement. For example, the researchers think it is a good idea to investigate the situation of all enterprises in adopting environmental protection technologies - especially SMEs and not just large firms. If researchers' ideas are accepted by

officials, the enterprises will cooperate with the researcher's investigation, leading to higher quality evidence for future policy-making.

Citizens, an important stakeholder, are missing in the current policy-making process. The government's approach to citizen participation is limited to environmental education and popularization, a necessary first step but insufficient to enable citizens to have an influence on the direction of technological development. Possible ways forward could be to introduce consensus conferences or citizens' juries around various technological options (thus complementing the current educational approaches but also allowing for two-way communication between the government and citizens)[59]. Other scholars have pointed to the general failure of the Chinese government to recognise the importance of social shaping of technology.[60] In the eyes of policy makers and citizens, technology is a complicated black box which is in driven solely by engineers from enterprises and experts from research institutes. Beyond the current approaches of environmental education and popularization, the role of citizens in selecting policy instruments and (directly or indirectly) technological options could be enhanced, and this in itself could provide a rich focus for future research.

7.2 Investigating the role of cleaner technology in wider socio-technical transitions in Shenzhen

As described above, the role of technology within system innovation[61] and broader socio-technical transitions has been a growing topic of research in the West (especially in Northern Europe) over the past decade.[62] Drawing on theories of evolutionary economic change[63] scholars have used a number of (primarily historical) case studies to illustrate the interactions between firms, industry, policy, technology, culture, science, markets/ user preferences within socio-technical regimes.[64] How can such frameworks enlighten our understanding of transitions in Shenzhen, and what lessons could the application of these kinds of theory provide for enhancing such frameworks?

For example, Smith, Stirling and Berkhout present a heuristic typology (illustrated by Figure 5 below) that differentiates transition contexts as a function of degree of

[59] These are among a number of tools and methodologies discussed by Ely, A. V., Van Zwanenberg, P. F. & Stirling, A. C. (2011) New Models of Technology Assessment for Development, STEPS Centre Working Paper 45, Brighton, STEPS Centre

[60] Shen and Williams (2005) A Critique of China's Utilitarian View of Science and Technology *Science Technology Society* 10: 197-223

[61] Elzen, B., Geels, F., Green, K. (Eds.), 2004. System Innovation and the Transition to Sustainability: Theory, Evidence and Policy. Edward Elgar, Cheltenham.

[62] Smith, A., Voß, J.-P. & Grin, J. (2010) Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. Research Policy, Vol. 39 (4) 435-448.

[63] Nelson, R.R. & Winter, S.G. (1982) An evolutionary theory of economic change, Cambridge MA: Harvard University Press.

[64] Geels, F.W. (2002), Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study, *Research Policy*, 31 (8/9), 1257-1274

coordination to selection pressures and the locus of adaptive resources.[65] Could it be that the Shenzhen experience (or in other parts of China), taking place within the state-led context described above, are more consistent with the 'purposive transition' context than less co-ordinated transitions based on internal resources? Or are the findings of this study, that formal regulations (and perhaps to some extent government action more generally) are barely significant as a driver for the transition towards a circular economy, pointing towards a less co-ordinated 'emergent transformation' context? Targeted research looking at a number of case studies within the Chinese context could help to clarify such questions, to hone and strengthen the transitions frameworks used by primarily European scholars and to provide a shared theoretical basis for sustainable transitions as analysed by researchers from both China and the West.

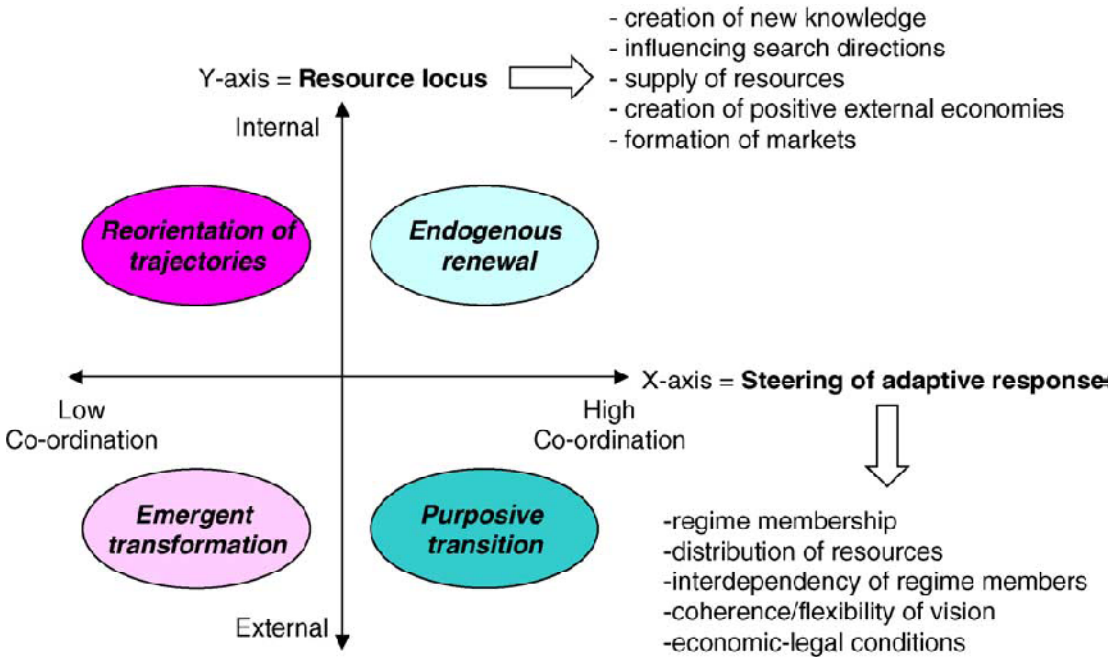

Figure 5. Transition contexts as a function of degree of coordination to selection pressures and the locus of adaptive resources (from Smith, Stirling & Berkhout 2005)[66]

Similar concerns were highlighted by researchers at a workshop held in Beijing in March 2010, although to date further research projects this area have not been developed.[67]

7.3 Building indigenous innovation capabilities

[65] Smith, A., Stirling, A. & Berkhout, F. (2005) The Governance of Socio-Technical Transitions. *Research Policy* 34, 1491-1510.
[66] Smith, A., Stirling, A. & Berkhout, F. (2005) The Governance of Socio-Technical Transitions. Research Policy 34, 1491-1510.
[67] Ely, A. (2010) Report on an international workshop on 'UK-China Innovation for Sustainability and Equitable Development', held at Tsinghua University School of Public Policy and Management, 19th March 2010, Beijing

Bell (2009) has described the importance of innovation capabilities (by which he simply means "the capabilities needed to imagine, develop and implement innovations in the goods and services an economy produces and in how it produces them") in enabling moves towards more environmentally sustainable forms of development.[68] Drawing on work by innovation scholars studying innovation primarily in Latin America and South-East Asia, he outlines various ideas around different types of learning, with a focus on those enabling what approximates to the idea of 'indigenous innovation' goal central to China's innovation policies. Similar studies of learning within Chinese firms are rare, especially in the English language literature. Fu (2008) has emphasized the importance of enhancing local absorptive capacity and complementary assets in the local innovation system in order for Chinese coastal areas to benefit from foreign FDI. However, he admits that his study "provides little information on whether FDI has promoted the indigenous innovation capability of the developing countries", noting that many firms withhold world-class technologies due to fears over lax enforcement of intellectual property rights.[69] Shenzhen is responsible for 40% of China's invention patents and a centre of indigenous innovation in the country[70], however as illustrated in this study, the capacity for learning has not translated to indigenous innovation in cleaner production technologies (whereas it certainly has done in other specific 'environmental' technologies such as solar PV, electric vehicles). The reasons behind these differences, and the ways in which policies and can be put in place to enhance more diffuse learning in cleaner production approaches are of vital research interest.

7.4 Investigating Multi-level Governance for Cleaner Production and the Circular Economy - in China and Internationally

China, as a federal state, displays numerous levels of governance, inter-secting with a separation of responsibilities between party officials and bureaucrats from different ministries. From the outside, the interaction between policy-making and implementation in the centre (Beijing) and that at provincial and sub-provincial levels is mindboggling. Multi-level governance approaches (including the study of policy networks and their influence on policy stability and change) have been employed in the European Union, where scholars have argued that new theoretical approaches are required due to the changing pressures on national regulatory systems brought by globalisation.[71] Similar theoretical approaches might be applicable to studying environmental or innovation policies in China, as well as their interaction with international frameworks.

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[68] Bell, M. (2009) Innovation Capabilities and Directions of Development, STEPS Working Paper 33, Brighton, STEPS Centre

[69] Fu, X. (2008) Foreign Direct Investment, Absorptive Capacity and Regional Innovation Capabilities: Evidence from China Oxford Development Studies, Vol. 36, No. 1, March 2008, pages 89-110

[70] Shenzhen Bureau of Trade and Industry, advertisement in Financial Times China Special, November 24th 2008 page 3

[71] Coleman, W.D. & Perl, A. (1999) Internationalized policy environments and policy network analysis. Political Studies, Vol. 47 (4) 691-709

As well as understanding the interactions between multiple levels of governance, an appreciation of the different interests, priorities and – more broadly - framings of regulation at global, national and local levels is vital for informing workable policy. For example, the use of green GDP measures within the cadre evaluation system (described above) is an important step forward, however faced with problems of poverty and unemployment, which could reduced by enhancing GDP growth from environmentally-damaging industry, local governments are often pressured to forego circular economy opportunities.[72] Research in other areas has pointed to the need for 'regulatory reach' that does not only deliver well-implemented regulations on the ground, but also policies that are flexible enough to cater for seemingly irreconcilable framings in diverse contexts throughout the world.[73] As China continues to open up to the rest of the world – financially – technologically and politically, future collaborative research on the interactions between these interlinked dynamics, and the ways in which emerging economies including but not limited to China influence global governance systems, will be a key contribution to the 'peaceful rise' and a future of equitable, sustained prosperity in East and West.

[72] Zheng, Y. & Chen, M. (2006) China promotes green GDP for more balanced development, University of Nottingham China Policy Institute Briefing Paper 16

[73] Van Zwanenberg, P. F., Ely, A. V. & Smith, A. G. (2011) Regulating Technology: Global Harmonisation and Local Realities, London, EarthScan