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Crisis Begets Quality Upgrade

Jianqing Ruan

Xiaobo Zhang

Development Strategy and Governance Division

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AUTHORS

Jianqing Ruan, Zhejiang University
Postdoctoral Fellow, Center for Rural and Agricultural Development

Xiaobo Zhang, International Food Policy Research Institute
Senior Research Fellow, Development Strategy and Governance Division

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ABSTRACT

The quality of manufactured products made in China has improved tremendously in the past several decades. In this paper, we argue that crises are instruments for the upgrade of Chinese manufactured goods. We first develop a theoretical framework to show that a crisis, if used wisely, could present good opportunities for entrepreneurs and local governments to form collective action to improve product quality. Next, we empirically test the hypothesis using a panel data set from 1990 to 2008 covering more than 100 clusters in the Zhejiang Province of China.

Keywords: crisis, manufacturing industry, cluster, quality upgrade

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1. INTRODUCTION

The word *crisis* in Chinese contains the double meanings of danger and opportunity. Human history has been fraught with crises. Yet from a longer historical perspective, these crises often beget opportunities (Toynbee 1974; Deming 1986). The evolution of the manufacturing sector in developed countries clearly testifies this. For example, Honda was notorious for its low quality in the 1960s. After facing various quality crises, it has emerged as a global brand name. In the 1980s, the United States lifted the quota on importing Japanese cars, creating tremendous pressure for the domestic automobile manufacturers to improve car quality (Feenstra 1988). The recent massive Toyota recalls in the United States highlight that a quality crisis may force a company to undertake painful reforms that were otherwise impossible to muster in ordinary times.

The rapid surge in China's manufacturing sector further shows a strong link between crises and quality upgrade. During China's planned economic era (prior to 1977), the quality of its manufactured products was on par with other developing countries. Since China opened up in the late 1970s, its manufacturing sector has been quickly catching up with developed countries, largely thanks to rapid improvement in product quality (Alvarez and Claro 2007), which can be reflected in three aspects: (1) China's share in total world exports rose from 1.2% in 1983 to 8.0% in 2006, third only to Germany and the United States (Wu 2001; WTO 2007). (2) The number of registered trademarks in China has experienced dramatic growth; in 2005, applications for trademark registration in China exceeded 664,000, ranking first in the world (State Trademark Bureau 2005). (3) Since the 1990s, patent applications have also seen a phenomenal growth in China. All these indicate a rapid improvement in the quality of Chinese manufactured products.

How has China upgraded its manufacturing industry in such a short time? In the economics literature, most studies attribute the quality upgrade to market competition and foreign investment (Aghion and Howitt 1992; Grossman and Helpman 1991a,b; Cozzi 2007). From a business perspective, a firm must invest in research and development to maintain competitiveness. Foreign investment can facilitate technology spillover and promote market competition, thus effectively helping to improve product quality in the host country (Xu 2000; Cheung and Lin 2004; Hatani 2009). There is no doubt that China's market reform and open-door policies are important drivers behind China's fast rise up the quality ladder. Yet these two hypotheses tell little about the process of quality upgrade, such as the timing.

China's industrialization is largely cluster based (Long and Zhang 2009). Most of the previous studies do not explicitly link quality upgrade with clustering. By synthesizing the experience in the East Asian economies, Sonobe and Otuska (2006) hypothesize that a cluster evolves from a quantity expansion to a quality upgrade phase. In the initial stage of clustering development, many small and medium enterprises geographically concentrate together. Because of the easy flow of technological know-how and the fine division of labor, entry barriers are low (Ruan and Zhang 2009). Therefore, the number of firms expands quickly. This in turn creates fiercer competition. The competitive pressure forces firms in clusters to upgrade their product quality. For example, a ban from developed countries on the import of low-quality surgical instruments produced in Pakistan compelled Pakistan's surgical instruments industry cluster to take collective action and achieve quality upgrading (Nadvi 1999).

However, few empirical studies have quantitatively tested the above hypothesis. In this paper, we examine the mechanism of quality upgrade in clusters and relate it to external shocks using Zhejiang Province in China as an example. We select Zhejiang in our empirical study for several reasons. First, the number of manufacturing enterprises in Zhejiang ranks at the top among all the provinces in China. Second, Zhejiang's industrial development is cluster based. In 2004, there were 839 industrial clusters with total output topping more than 100 million Chinese yuan (Zhejiang Manufacturing Cluster Empirical Research Group 2007). In this study, we develop a conceptual model to analyze the role of crisis in quality upgrading and then test our hypothesis based on data collected in more than 100 clusters in Zhejiang.

The paper is organized as follows: Section 2 discusses the general patterns of industrial clusters and relevant crises in Zhejiang Province. Section 3 presents several case studies to illustrate the role of crisis in quality upgrading in a cluster. We develop a conceptual framework in Section 4 and test the hypothesis in Section 5. Section 6 concludes the paper.

2. INDUSTRIAL CLUSTERS AND CRISES IN ZHEJIANG PROVINCE

Cluster Development in Zhejiang

Located on the eastern coast of China, Zhejiang Province has rather limited natural resources compared with many other provinces in China. During China's planned economic era, prior to 1978, because of its proximity to the war frontier with Taiwan, the central government strategically made less public investment in Zhejiang Province than it did in many other provinces. As a result, the share of state-owned enterprises in Zhejiang Province was much lower than in many other provinces. In 1978 when economic reforms began, per capita gross domestic product (GDP) in Zhejiang was 331 yuan, ranking 13th among all provinces (National Statistics Bureau 2000). Yet by 2006, Zhejiang's per capita GDP reached 31,874 yuan, topping the nation (National Statistics Bureau 2007). Industrial development has played a key role in Zhejiang's rapid economic growth. According to the China Economic Census, in 2004, Zhejiang had the largest number of industrial enterprises among all provinces—nearly 190,000—among which are more than 40,000 industrial enterprises with an annual sales income in each of them exceeding five million yuan. The number is greater than any other province in the nation (National Statistics Bureau 2006).

Zhejiang's industrial development is largely cluster based (see Table 1). The phrases "one village, one product" and "one industry in one county" have been commonly used in the media to describe the concentration of industrial production in Zhejiang. In 2000, there were 529 industrial clusters with annual gross output value of more than 100 million yuan, and 149 industrial clusters with annual output value of more than one billion yuan. An average cluster among the 149 large ones generated gross output value of 3.3 billion yuan, hired more than 20,000 workers, and contained 1,400 enterprises. By the end of 2004, the number of clusters that produced more than 100 million yuan in industrial output increased to 839. These clusters included 156,500 enterprises, or 85.0% of the total in the province. The total industrial output value created by the clusters was as high as 1.547 trillion yuan, accounting for 78.6% of total provincial industrial output value, whereas total profit reached 79.4 billion yuan, amounting to 76.5% of total profit in the manufacturing sector in the province. More importantly, most of the production technologies in these clusters are labor intensive as they employed 7.48 million workers, or 85.7% of total manufacturing employment in Zhejiang (Zhejiang Manufacturing Cluster Empirical Research Group 2007). In 2007, the Chinese Academy of Social Sciences published a list of the top 100 industrial clusters in China, 36 of which were from Zhejiang (China Business Times 2007). In summary, in the past several decades, Zhejiang has followed a rather successfully cluster-based industrialization path.

Table 1. The distribution of industrial clusters in Zhejiang Province

Sector	Number of Clusters	Gross Industrial Output Value (in Hundred Millions, Chinese yuan)	Ratio of Gross Industrial Output Value of all Manufacturing Clusters (%)		Sector	Number of Clusters	Gross Industrial Output Value (in Hundred Millions Chinese yuan)	Ratio of Gross Industrial Output Value of all Manufacturi
Processing of Food from Agricultural	25	281.8	1.8		Manufacture of Textile Wearing Apparel, Footwear, and Caps	44	760.1	4.9
Manufacture of Foods	6	50.5	0.3		Manufacture of Leather, Fur, Feather, and Related Products	20	680.8	4.4
Manufacture of Beverages	10	59.2	0.4		Processing of Timber; Manufacture of Wood, Bamboo, Rattan, Palm, and Straw	18	165.6	1.1
Manufacture of Textiles	56	2669.6	17.3		Printing, Reproduction of Recording Media	32	184.1	1.2
Manufacture of Furniture	11	90.7	0.6		Manufacture of Articles for Culture, Education, and Sports Activities	18	182.8	1.2
Manufacture of Paper and Paper Products	45	396.6	2.6		Manufacture of Raw Chemical Materials and Chemical	51	988.6	6.4
Manufacture of Medicines	1	40.9	0.3		Smelting and Pressing of Ferrous Metals	6	93.5	0.6
Manufacture of Chemical Fibers	4	306.8	2		Smelting and Pressing of Nonferrous Metals	15	293.6	1.9
Manufacture of Rubber	13	80	0.5		Manufacture of Electrical Machinery and Equipment	51	1595	10.3
Manufacture of Plastics	58	854.2	5.5		Manufacture of Communication Equipment, Computers, and Other Electronic Equipment	22	672	4.3
Manufacture of Nonmetallic Mineral Products	58	624.4	4		Manufacture of Measuring Instruments and Machinery for Cultural Activity and Office	18	181.4	1.2
Manufacture of Metal Products	57	748.9	4.8		Manufacture of Artwork and Other Manufacturing	36	323.8	2.1
Manufacture of General Purpose	68	1660.2	10.7		Recycling and Disposal of Waste	3	28.9	0.2
Manufacture of Special Purpose Machinery	47	474.4	3.1		Manufacture of Transport Equipment	46	986.3	6.4

Source: Zhejiang Manufacturing Cluster Empirical Research Group (2007).

Quality Upgrade in Zhejiang

Zhejiang has witnessed not only a rapid expansion of industrial output but also impressive quality improvement. Table 2 shows the time trend of patents granted and the number of enterprises with quality certifications. In 1997, Zhejiang stipulated the Zhejiang Famous Trademark Identification and Protection Regulations. In 2006, the province had 698 well-known trademarks. By the end of 2007, the number of registered trademarks in Zhejiang Province had reached 290,000, accounting for 10% of the total registered trademarks in China. Zhejiang ranks in the first place in total number of overseas trademark registrations, well-known trademarks, agricultural trademarks, and trademark infringement cases investigated. In addition to registered trademarks, the rapid growth in the number of quality certifications also testifies to the overall quality improvement of manufactured goods in Zhejiang. The first quality certification occurred in Wenzhou, Zhejiang, in 1997. Since then, the number of quality-certified companies has steadily increased, reaching nearly 8,000 by 2006. As an important indicator of product quality and technological improvement, the number of patents granted in Zhejiang has jumped from 1,328 in 1990 to more than 50,000 in 2008.

Table 2. Number of approved patents and enterprises with quality certifications in Zhejiang Province

Year	Number of Approved Patents	Growth Rate (%)	Number of Enterprises with Quality Certifications	Growth Rate (%)
1990	1,328	—	0	—
1991	1,928	45.18	0	—
1992	2,513	30.34	0	—
1993	1,868	–25.67	0	—
1994	2,368	26.77	0	—
1995	2,276	–3.89	0	—
1996	2,632	15.64	0	—
1997	3,393	28.91	1	—
1998	4,341	27.94	5	400.00
1999	7,172	65.22	5	0.00
2000	7,495	4.50	31	520.00
2001	8,355	11.47	89	187.10
2002	10,478	25.41	106	19.10
2003	14,402	37.45	330	211.32
2004	15,250	5.89	2,181	560.91
2005	19,056	24.96	4,255	95.09
2006	30,968	62.51	7,994	87.87
2007	44,712	44.38	—	—
2008	52,924	18.37	—	—

Source: The numbers of approved patents after 2000 come from Zhejiang Intellectual Property Office (http://www.zjpat.gov.cn). The numbers of approved patents before 1999 come from National Intellectual Property Office (http://search.sipo.gov.cn/). The numbers of enterprises with quality certifications come from Zhejiang Quality and Technology Supervision Office.

Crises in Zhejiang Clusters

Zhejiang industrial cluster development has been associated with various crises. Due to lack of comprehensive statistical data for all the clusters, we have to select large and well-known clusters with publicly available information. *Zhejiang Yearbook* (National Statistics Bureau 2003) lists 149 clusters with gross output value more than one billion yuan in 2000. In addition, 36 clusters were included in the top 100 national clusters by the Chinese Academy of Social Sciences Survey in 2007. Zhejiang Bureau of Small and Medium Business also published some data on industrial clusters in Zhejiang in 2007. Some counties have no large clusters, whereas more developed regions have more than three large industrial

clusters. In this study, we selected only the top three clusters in a county or district that has more than three clusters. However, we made a few exceptions to Whenzhou and Xiaoshan by choosing four clusters because they have a predominately large number of clusters. In total, we ended up with 106 clusters in this study.

We classify crises into six categories: major accidents (e.g., fire and explosion), consumer boycott, export barriers, industrial policy regulations by the central government, price spike of raw materials used in the cluster, and financial crisis. There are no official crises-related statistical data records for industrial clusters. However, most crises are picked up by media. In addition, official documents, yearbooks, and interviews with informants also reveal helpful information on crises in different clusters. We have done our best to generate a comprehensive database on crises in these clusters by searching the keyword *crisis* and the names of all 106 clusters online, by looking through yearbooks, and by talking to informants in the Zhejiang Bureau of Small and Medium Business. However, it is possible that we may have missed a few crises in the earlier years.

Table 3 reports crises in the clusters by type and year. From 1990 to 2008, there were 92 crises in these clusters. Seventeen can be categorized as accidents and consumer boycott. For example, on October 21, 2006, Zhili Children's Garment cluster suffered an accidental fire, killing eight people and injuring five. After the accident, the upper-level government imposed strong safety regulations, requiring all the workshops to install fire exit stairs and separate production space from living areas.[1] There were 16 crises related to export barriers. For example, in 2004, Spanish consumers burned shoes made in Wenzhou because the flood of cheap shoes threatened their domestic production and their government restricted importing Chinese shoes. Other various industrial sectors also occasionally run into sudden unfavorable policy changes. For instance, in 2004, China's National Development and Reform Commission announced a new regulation imposing a minimal entry investment threshold for the automobile and motorcycle industries, which struck a heavy blow to many small automobile part suppliers in Wenling and Yuhuan. Overall, crises have occurred more frequently since 2000. The number of crises related to export barriers has seen an especially rapid increase in recent years, probably because of China's fast growth in exports. The recent global financial crisis in 2008 was a calamity for 46 clusters.

Table 3. Major crises in Zhejiang clusters

Year	Shock Types				Total
	Accidents and Consumer Boycott	Export Barriers	Macro Policy and Price	Financial Crisis	
1990	1	0	0	0	1
1995	1	0	0	0	1
1996	1	0	0	0	1
1997	1	0	0	0	1
1998	1	0	0	0	1
2001	2	0	1	0	3
2002	1	0	1	0	2
2003	1	0	2	0	3
2004	2	4	4	0	10
2005	2	11	3	0	16
2006	1	1	2	0	4
2007	2	0	0	0	2
2008	1	0	0	46	47
Total	17	16	13	46	92

Source: Data collected by authors.

[1] In many workshops, workers eat, live, and work in the same place. They are often called "three-in-one" workshops.

3. CASE STUDIES

In this section, we use three case studies to illustrate the evolutionary process of industrial clusters amid crises.

Burning Wenzhou Shoes at Wulin Gate in China

The city of Wenzhou is a major center of footwear production in China, renowned as "China's footwear capital." In 2004, the footwear cluster in Wenzhou produced 835 million pairs of shoes and employed 400,000 workers (Huang, Zhang, and Zhu 2008). However, the development process has not always been smooth. In particular, a consumer boycott stemming from a quality crisis in 1987 almost devastated the cluster.

Wenzhou's footwear production cluster began in the late 1970s. The clustering mode of production lowers the capital barriers to entry because many production steps are dispersed among different family workshops or firms (Huang, Zhang, and Zhu 2008). As a result, the number of enterprises soared, and total output expanded dramatically. Faced with price pressures, many enterprises adopted a low-quality and low-cost strategy. Some of them even started to use fake raw materials to reduce the cost of producing shoes. Their behavior damaged the reputation of the whole industry in Wenzhou because most producers at the time did not have their own brands, so consumers reckoned that all the shoes made in Wenzhou were of poor quality. Wenzhou shoes were called "day shoes," "week shoes," and "falling-heel shoes" and were almost synonymous with counterfeiting. Consumer dissatisfaction with Wenzhou shoes climaxed on August 8, 1987, when China's Hangzhou Industrial and Commercial Administration burned 5,000 pairs of Wenzhou-made shoes in Wulin Plaza of Hangzhou, and the event was broadcast on television. In April 1988, consumers destroyed a shop selling Wenzhou shoes in a large shopping center in Nanjing. Subsequently, many other cities followed suit to chase out Wenzhou shoes. Changsha, Harbin, and Zhuzhou also set fire to Wenzhou shoes in public. Shanghai, Nanjing, Wuhan, Changchun, Shijiazhuang, and Dalian city governments imposed bans on Wenzhou shoes sales. Even as far as in Russia, signs such as "No Wenzhou goods" and "Wenzhou people out of Russia" were displayed on the streets (Chen 2006).

On the positive side, the crisis triggered an opportunity for enterprises and local government to work together to improve product quality in the industry. Facing the threat of being wiped out by the crisis, local business communities and government took a series of collective actions to improve product quality to save the industry. Wenzhou District Footwear Association, the first footwear association in Wenzhou, was established by a group of footwear industry veterans in June 1988. The association included more than 370 enterprises. It called for all the members to mind their product reputation and improve product quality (China Footwear Information Network 2007). It established various regulations to curb vicious competition, punish producers of poor-quality products, and restore trust among its members. For example, the association set up a new intellectual property rights committee to protect and promote the launch of new products and inhibit the spread of fake products. It blacklisted enterprises with a bad reputation and shamed them with all its members.

Furthermore, local governments took serious administrative actions. Led by the Lucheng district government of Wenzhou City, the Bureau of Quality and Technical Supervision, the Administration of Industry and Commerce, and several other related agencies jointly established the Lucheng Footwear Quality Management Office. All the shoes produced in Wenzhou must be certified by the office. The office began inspecting enterprises regularly and sampling their products. If the products meet quality standards, the office issues a certificate. However, if a firm fails the quality test, their products are banned from sale. When enterprises renew their production license with the Administration of Industry and Commerce, they must provide the quality certifications for their products (Li 2006). In 1993, the Wenzhou municipal government proposed a strategy to create a regional brand, requiring that all shoes made in Wenzhou be marked, "Made in Wenzhou." Otherwise the product will not be allowed to ship out of Wenzhou. In addition, the government also began providing various incentives to encourage local

enterprises to create brands. For example, if a firm receives the title of "China Famous Brand" for its products, the government will award one million yuan to the firm (Li 2006). Moreover, the association and local governments worked together to regulate the advertisements. Those enterprises that are blacklisted by the association for their bad reputation are banned from posting advertisements of any form in Wenzhou.

Quality Crisis in the Puyuan Sweater Industrial Cluster

Puyuan Township is located in northern Zhejiang Province, between Hangzhou and Shanghai. Historically, Puyuan was an important silk production center. In 1976, a collectively owned enterprise, the Puyuan Tanhua (Weaving) Production Cooperative, purchased three hand-loom weaving machines and began to produce cashmere sweaters. The gross output value of the cooperative soared from 28,000 yuan to 300,000 yuan in just one year, prompting the group to devote all of its production capacity to cashmere sweaters by the end of 1977 (Chen 1996). Like the Wenzhou footwear cluster, the Puyuan sweater industrial cluster suffered similar quality crises between 1995 and 1996. In 1995, many merchants boycotted sweaters made in Puyuan because of their bad reputation. This greatly depressed the market demand for Puyuan sweaters. In late 1995 and in 1996, the whole textile industry fell into a recession. Meanwhile, the Puyuan sweater market was plagued with serious management problems. The market was established by quite a few stakeholders, but the property rights were not clearly defined. The stakeholders had disputes as to how to set up rent rates, allocate revenues, and share the cost of maintenance. Owing to the disagreement, the market lacked crucial public investment and performed poorly in many necessary services. Disgruntled with the poor service, some shops closed doors, and some merchants voted with their feet by moving to another sweater market in the nearby Honghe Township.

Realizing the seriousness of the problem, the local government and entrepreneurs took a series of measures to respond to the crisis. One key initiative was to reform the management structure of the sweater market to provide better service to the merchants. Another important strategy was to improve product quality. Similar to the Footwear Quality Management Office of the Wenzhou shoe crisis, a quality control office was established to regularly inspect the sweater product quality. In addition, the market added a new Quality Product Street, in which only well-known brands are allowed to sell. Having a brand on sale in the Quality Product Street sends a strong signal of quality premium. With these measures in place, Puyuan quickly reversed its reputation for bad quality.

The above two cases share some common features: First, crises damaged the reputation of the clusters and drove down demand for their products. Second, crises also provided an opportunity for the private and public sectors to work together to take a series of actions, such as establishing business associations, inspecting product quality, protecting brands, and punishing bad apples, so as to improve product quality.

The Disappearance of the Insulated Mug Cluster in Yongkang

The previous two cases show that crises may provide an opportunity for a cluster to upgrade product quality. However, not all the clusters survive from crises. The insulated mug cluster in Yongkang provides such an example.

Historically, Yongkang has been known as a hardware town. In early 1995, Mr. Cheng Wenquan, the owner of Yongkang Wanshida Company, started to produce insulated mugs by imitating Japanese products. The mugs turned out to be very popular in the market. An insulated mug that cost only 60 yuan to make was sold for 200–300 yuan. Other businessmen quickly learned the news and began to produce insulated mugs as well. By December 1995, the number of enterprises producing insulated mugs reached more than 1,300, and more than 2,000 production lines were installed in just one year. The gross output value of insulated mugs in Yongkang was estimated to be as high as 1.5–1.7 billion yuan. The quick expansion in supply placed great pressure on price. Soon the price dropped to 15–20 yuan, far below the production cost. As a result, many enterprises ran into great difficulty selling the mugs and had to

stockpile them. By February 1996, the monthly output plummeted to only 1/8 of the peak level. By the end of 1996, only a few companies survived, and the insulated mug cluster had virtually disappeared (Qiu 1999; Zhu 2004).

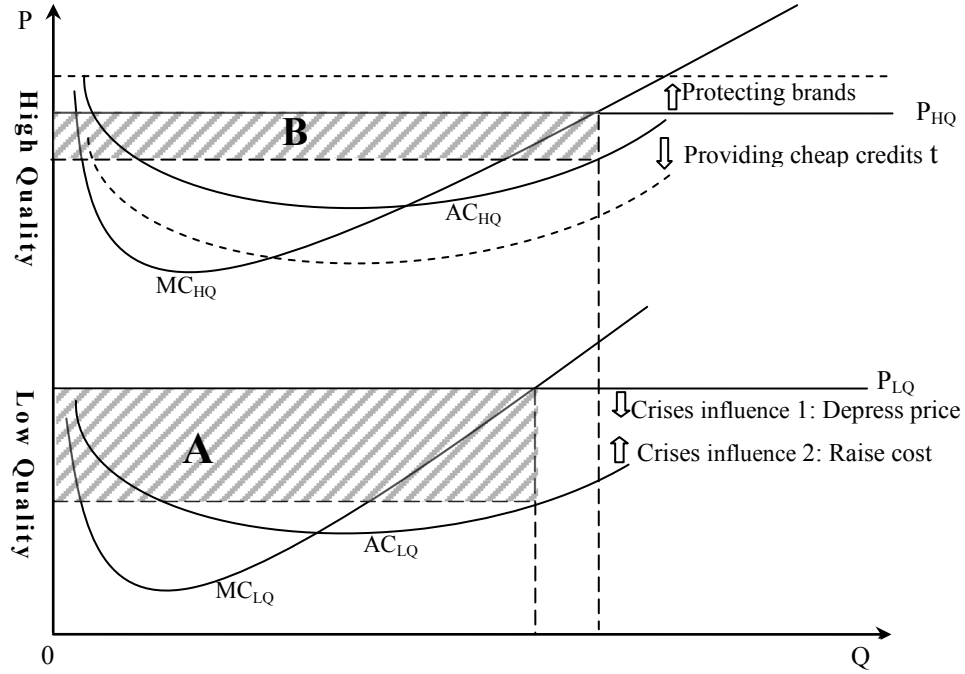
Compared with the first two cases, the crisis of Yongkang's mug cluster emerged too fast for the local government and entrepreneurs to take collective action to cope with the challenge. Another reason that the local government did not take prompt action is that Yongkang produced many different types of hardware and appliances. The underlying technologies for insulated mug production can be easily reconfigured to produce other hardware goods. With such latitude, the local government did not feel the pinch to take prompt collective action to upgrade the quality of mugs.

These three cases reveal the nature of quality upgrade processes in clusters. Crises often follow the expansion of production in a cluster. However, on the one hand, a major crisis may present precious opportunities for local governments and entrepreneurs to undertake collective action and upgrade product quality; on the other hand, a crisis may lead to the collapse of a cluster.

4. THEORETICAL FRAMEWORK

Drawing on the insights from the several case studies, we present a simple conceptual model in this section to discuss the relationship between crises and quality upgrade in industrial clusters. We assume each cluster makes one product of low or high quality. Enterprises in a cluster choose whether to produce low- or high-quality products. Compared with that of low-quality goods, production of high-quality goods requires higher fixed and variable costs (Berry and Waldfogel 2004). The costs include but are not limited to registering trademarks, investment in research and development, more expensive high-end equipment, the training costs of skilled workers, and more expensive raw materials prices associated with higher quality. The difference between the two types of firms can be reflected in the average and marginal cost curves as shown in Figure 1. If consumers can distinguish the high-quality and low-quality products and the market is competitive, the price of a high-quality product should be higher than that of a low-quality one.

Figure 1. Crises and quality upgrade



Source: Drawn by authors.

For a given product, a firm maximizes its output at the point where the marginal cost equals price. The corresponding profit amounts to the product of the difference between price and average cost and the quantity of sales. In Figure 1, if a firm chooses low-quality production, its profit equals area A, whereas area B reflects the profit in the case that the firm specializes in high-quality products. Suppose that at the beginning all businesses engage in low-quality production. An enterprise always evaluates the option of switching to the high-quality product by comparing areas A and B. However, the decision also depends upon the overall quality reputation of the cluster. Due to information asymmetry, consumers may have a problem distinguishing the high-quality products from low-quality products from the same cluster. If, on average, the cluster leaves a bad quality image with consumers, many enterprises may want to stick to the low-quality production as it would be very difficult for an individual producer to change the quality image of the whole cluster. If consumers pay the same price for high-quality and low-quality products, it would be impossible for enterprises' investment in quality upgrade to pay off. Therefore, if an enterprise wants to switch to a high-quality product, it must find ways to signal the quality premium of its product. For

example, it can set up specialty stores, purchase advertisements in the media, and hire lawyers to fight counterfeiters. All these will drive up average cost and diminish profit margins (a smaller area B in Figure 1). In theory, it pays to make a reputational investment in the long run (Klein and Leffler 1981; Shapiro 1983), but facing uncertainty and credit constraints, most enterprises prefer to stay put in low-quality products. In other words, the whole cluster may be stuck in a low-quality equilibrium.

Now let's examine how a crisis affects quality upgrade decisions. There are many types of crises, such as export barriers, consumer boycott, and major accidents. Despite the different nature inherent in the crises, their impact on a cluster is similar: many enterprises producing low-quality products will be weeded out by the harsher environment, and those remaining in business may face a lower profit margin. This can be reflected by a shrinking area A in Figure 1. Some crises may reduce consumer demand and depress prices, whereas some crises, such as a rising price of raw materials, may result in the escalation of production costs.

Next, in the model, we introduce the role of local governments. Some scholars have argued that China's rapid economic growth stems largely from the intercounty competition associated with a decentralized fiscal and centralized political system (Maskin, Qian and Xu 2003; Cheung 2008). In China, local officials' promotion to a large degree hinges upon their performance in promoting local economic development. Therefore, in areas with industrial clusters, local officials have a strong incentive to foster cluster development. The two most commonly observed ways of promoting cluster development are to establish markets and undertake generic promotion of the clusters. When markets are nearby, enterprises can significantly cut marketing and purchasing costs. The generic promotion of the cluster attracts more merchants, benefiting all the producers. These interventions can either lift up the price curve (P_{HQ}) or lower the average cost curve (AC_{HQ}) of individual firms. However, all these initiatives cost money. Thus the local governments have to calculate the benefit-cost ratio of their interventions. Their tax revenues are directly determined by the enterprises' profit.

If all firms are in a low-quality equilibrium, the total local government revenue is $r\sum_{i=1}^{n} A_i$, where r is tax rate. If instead all the enterprises produce high-quality goods, the revenues collected by local governments amount to $r\sum_{i=1}^{m} B_i$. A cost is required for the industry to upgrade their product quality. Before a crisis, firms may not have an incentive to voluntarily upgrade their product quality owing to the extra cost. Local governments are not certain about promoting quality upgrade as it is unclear whether there is a net gain in revenue or not ($r\sum_{i=1}^{m} B_i - r\sum_{i=1}^{n} A_i$ positive or negative). Given the sunk cost of public interventions and the uncertainty of resultant revenue flows, the local governments are less likely to aggressively advocate cluster quality upgrade in normal times.

However, a crisis may reshape the perceived benefits and costs of both entrepreneurs and government officials for proposed reforms (Drazen and Grilli 1993). Normally, crises drive down profits of most firms in a cluster. Consequently, the local governments observe a drop in total revenue ($r\sum_{i=1}^{n} A_i$). This will change governments' benefit-cost calculations of their interventions to upgrade cluster quality. Inaction may lead to the loss of revenue streams and the collapse of the cluster. Therefore, in the event of a crisis, governments are more likely to take bold actions. Similarly, amid crises, enterprises must find a way to survive. When the option of continuing low-quality production is eliminated by a crisis, the pressure to climb the quality ladder builds. On the one hand, they are more likely to allocate a larger share of their limited capital resources to improve product quality. On the other hand, they may be more willing to accommodate governmental interventions, such as product quality inspection, brand protection, and banning of counterfeits, even though these measures may increase average production cost. In other words, in a cluster, crises may foster collective action (Schmitz 1997). However, it takes time to form collective action. If a crisis comes too rapidly, as with the insulated mug cluster in Yongkang, the public and private sectors may fail to take prompt collective action to weather the crisis.

5. EMPIRICAL ANALYSES

In this section, having presented the case studies and conceptual framework, we empirically test the impact of crises on quality upgrade in clusters using data in Zhejiang Province in the period of 1990–2008.

Among the 106 clusters in our sample, most clusters are at the county level in Zhejiang, but some are at the township level (one level below the county). However, because the township-level data is not systematically available, we use the county-level data to measure variables related to clusters in our analysis. Dependent variables include patents per capita, quality certifications per capita, and share of professional and technical personnel in total population. These three variables are in logarithm. The patent data since 2000 come from the Zhejiang Intellectual Property Office, while the data prior to 2000 are obtained from the website of China Intellectual Property Office. The number of firms with quality certification is from Zhejiang Bureau of Quality and Technical Supervision. On the right-hand side, we include a set of control variables—economic development level, foreign direct investment (FDI), population density, share of industrial sector in total GDP, share of state-owned enterprises, a variable measuring crisis, and year and county fixed effects. Except for crisis data, all the data are gathered from various issues of *Zhejiang Statistical Yearbook* (National Statistics Bureau 1991-2009). Some data are missing from the provincial yearbooks. We tried to replace the missing values with figures found in county statistical yearbooks or government documents as much as possible. However, we still had to interpolate a few variables. From 1990 to 1992, the provincial yearbook did not report the GDP for the industrial sector. We use the ratio of gross industrial output value in total gross output value to total GDP to estimate the missing GDP in the industrial sector. In 1992, the gross industrial output values in a few counties were missing. We interpolate them with the average values in 1991 and 1993. We use the share of the number of State Owned Enterprises (SOEs) in 1991 to replace the missing value in 1990. In 1999 the provincial yearbooks stopped reporting the number of SOEs at the county level, as most of the restructuring of SOEs had finished; therefore, we set the share of the number of SOEs to zero since 1999.

Because our data are at the county level, we define cluster-related crises also to be at the county level. If a crisis occurs at year t, we set year t and all the years thereafter as 1 and all the years prior to year t as 0. If a county has multiple crises, we count the year of the earliest crisis as the beginning year of the crisis variable. In total, we have gathered 92 crises from 1990 to 2008.

Regressions Analyses

We first regress the number of patents per capita in logarithm on the crisis variable and other control variables. Because it takes time for a patent application to be approved, in the regression we lag the patent variable by one year. Table 4 reports the regression results. The first regression (R1) does not include year and county fixed effects; in R2 we include county fixed effects; in R3 we further add a time trend variable on top of R2; and in R4 both county and year fixed effects are included. The models fit well. In particular, the R^2 in regression R4 is as high as 0.83. All four regressions clearly show that the coefficient for the patent variable is highly statistically significant and positive. The coefficients for other variables across the four specifications are less robust than for the crisis variable.

Table 4. Crises and number of patents

	Patents Per Capita in Logarithm			
	R1	**R2**	**R3**	**R4**
Lagged one-year crisis	0.693***	0.851***	0.570***	0.307***
	(8.754)	(9.693)	(8.051)	(4.501)
Per capita GDP	0.887***	0.754***	–0.092	0.210
	(8.950)	(7.644)	(–1.624)	(1.044)
Population density	–0.732	–7.103***	–12.528***	–10.489***
	(–0.901)	(–2.956)	(–5.818)	(–5.212)
Per capita foreign investment	0.016	0.057**	0.002	0.041***
	(0.584)	(2.193)	(0.128)	(2.681)
The proportion of secondary industry	1.111***	1.059**	0.481**	–0.132
	(3.446)	(2.334)	(2.251)	(–0.680)
The proportion of SOEs	–0.959*	–2.046***	0.635*	2.523***
	(–1.857)	(–4.178)	(1.811)	(4.977)
Time trend	—	—	0.185***	—
	—	—	(16.346)	—
County fixed	no	yes	yes	yes
Year fixed	no	no	no	yes
Adj-R^2	0.592	0.761	0.798	0.829
AIC	3,400	2,768	2,549	2,340
Number of observations	1,314	1,314	1,314	1,314

Source: Calculated by authors.
Note: Robust t-statistics are in parentheses. The symbols *, **, and *** represent significance at 10%, 5%, and 1%, respectively.
SOEs: State Owned Enterprises. AIC: Akaike information criterion.

Table 5 presents the results on quality certifications. Since quality certification did not take place until 1997, we restrict our sample to 1997–2006 in regressions on this variable. Normally, it takes less time to obtain quality certifications than to apply for a patent. Thus, we run two sets of regressions, one with current and one with lagged crisis variable. Similar to the previous table, we consider four specifications for each crisis variable. In regression R1–R4, the current crisis variable is used; whereas in R5–R8, the lagged crisis variable is included. Regardless of whether current or lagged crisis variables are used in the regressions, the coefficients for the crisis variables are statistically significant at the 1% level in all the regressions. Per capita GDP is positively related to the number of quality certifications. Interestingly, the share of industrial GDP in total GDP is highly negative, probably due to its high collinearity with the per capita GDP variable. FDI has nothing to do with the number of quality certifications in any of the regressions.

Table 5. Crises and number of quality certifications

	Number of Enterprises with Quality Certifications in Logarithm							
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**
Current crisis	1.379***	0.894***	0.889***	0.599***	—	—	—	—
	(9.298)	(7.750)	(7.709)	(6.658)	—	—	—	—
Lagged one-year crisis	—	—	—	—	1.272***	0.745***	0.742***	0.465***
	—	—	—	—	(7.920)	(6.163)	(6.172)	(4.927)
Per capita GDP	1.833***	3.873***	3.642***	1.926***	1.899***	4.000***	3.689***	1.925***
	(13.405)	(31.696)	(10.633)	(6.836)	(13.745)	(33.082)	(10.546)	(6.707)
Population density	–10.257***	32.228***	31.294***	26.458***	–9.774***	32.954***	31.694***	26.589***
	(–7.171)	(5.632)	(5.114)	(5.140)	(–6.670)	(5.884)	(5.307)	(5.300)
Per capita foreign investment	0.044*	–0.008	–0.011	–0.038*	0.043	–0.008	–0.012	–0.041*
	(1.681)	(–0.359)	(–0.487)	(–1.718)	(1.463)	(–0.341)	(–0.507)	(–1.742)
The proportion of secondary	–3.457***	—7.517***	—	—6.203***	—3.335***	—8.026***	—7.682***	—6.459***
	(–7.206)	(–7.905)	(–7.743)	(–7.661)	(–6.658)	(–8.459)	(–8.118)	(–7.826)
The proportion of SOEs	–1.071*	2.909***	3.118***	0.846	–1.121*	3.012***	3.291***	0.933
	(–1.862)	(6.329)	(6.239)	(1.501)	(–1.862)	(6.437)	(6.481)	(1.633)
Time trend	—	—	0.032	—	—	—	0.042	—
	—	—	(0.711)	—	—	—	(0.938)	—
County fixed	no	yes	yes	yes	no	yes	yes	yes
Year fixed	no	no	no	yes	no	no	no	yes
Adj-R^2	0.550	0.824	0.824	0.887	0.528	0.817	0.817	0.883
AIC	2,249	1,632	1,634	1,319	2,284	1,661	1,662	1,342
Number of observations	730	730	730	730	730	730	730	730

Source: Calculated by authors.
Note: Robust t-statistics are in parentheses. The symbols *, ** and *** represent significance at 10%, 5%, and 1%, respectively.

Table 6 repeats Table 5 but replaces the dependant variable with the share of professional and technical personnel in the total population. Because the provincial yearbook did not report this variable until 1995, the regressions are for the period 1995–2008. The findings for the crisis variable are still held. Crisis is positively correlated to the number of technical staff. This suggests that crises may induce firms to hire more highly skilled laborers to upgrade their product quality. Coefficients for GDP and share of industrial GDP have the same signs as in Table 5. The coefficient for SOEs is highly significant in all the regressions.

Table 6. Crises and share of professional and technical personnel in total population

	Share of Professional and Technical Personnel in Total Population (Logarithm)							
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**
Current crisis	0.166***	0.348***	0.347***	0.337***	—	—	—	—
	(4.192)	(7.357)	(7.309)	(6.920)	—	—	—	—
Lagged one-year crisis	—	—	—	—	0.153***	0.300***	0.300***	0.299***
	—	—	—	—	(3.622)	(6.110)	(6.067)	(5.817)
Per capita GDP	0.703***	0.682***	0.679***	0.687***	0.711***	0.719***	0.698***	0.704***
	(18.631)	(15.634)	(6.180)	(5.443)	(18.971)	(16.877)	(6.269)	(5.537)
Population density	–3.338***	–5.502***	–5.514***	–5.410***	3.300***	5.420***	–5.493***	–5.426***
	(–7.477)	(–5.791)	(–5.516)	(–5.053)	(–7.419)	(–5.541)	(–5.353)	(–5.028)
Per capita foreign investment	0.046***	0.014	0.014	0.010	0.045***	0.014	0.014	0.009
	(4.790)	(1.220)	(1.212)	(0.866)	(4.745)	(1.202)	(1.176)	(0.715)
The proportion of secondary industry	–1.322***	–2.256***	–2.253***	–2.232***	1.306***	2.425***	–2.406***	–2.359***
	(–9.064)	(–6.282)	(–6.043)	(–5.894)	(–8.932)	(–6.788)	(–6.461)	(–6.248)
The proportion of SOEs	0.842***	0.410***	0.415**	0.622**	0.838***	0.451***	0.476**	0.663**
	(4.999)	(3.002)	(2.181)	(2.318)	(4.988)	(3.269)	(2.494)	(2.423)
Time trend	—	—	0.000	—	—	—	0.003	—
	—	—	(0.033)	—	—	—	(0.195)	—
County fixed	no	yes	yes	yes	no	yes	yes	yes
Year fixed	no	no	no	yes	no	no	no	yes
Adj-R^2	0.613	0.730	0.730	0.731	0.612	0.724	0.724	0.727
AIC	1,059	761	763	767	1,064	783	785	785
Number of observations	1,021	1,021	1,021	1,021	1,021	1,021	1,021	1,021

Source: Calculated by authors.
Note: Robust t-statistics are in parentheses. The symbols *, **, and *** represent significance at 10%, 5%, and 1%, respectively.

Tables 4–6 examine the impact of shocks on quality upgrade without distinguishing their types. In principle, it is possible that different types of shocks may have different impact on the outcome of quality upgrade. To address this concern, Table 7 presents the estimates of the four types of shocks listed in Table 3 on three measures of quality upgrade. For the first three types of shocks—major accidents or consumer boycott, export barriers, and macro policy and price—we use their one-year lag in the

regressions. Because the quality certifications variable is available only up to 2006, we cannot evaluate the financial crisis in 2008 on this variable. Similarly, we cannot take a lag for the other two outcome variables as they are available until 2008. Instead, we use the financial crisis variable in the current year. Several features emerge from the table. First, the four types of shocks have a consistent positive impact on the number of patents as shown in the significant coefficients in most specifications for this variable except for two (the coefficients for the marco policy and price and global financial crisis variables in regression R4). Second, unfavorable macro policies and sudden price escalation contribute positively to improvement in all three quality measures. Third, major accidents / consumer boycott and export barriers have a more muted impact on the number of quality certifications than other on quality indicators. The coefficients for the three shock variables are not significant after including fixed effects or time trend. Fourth, the recent global financial crisis has an insignificant impact on the number of professional and technical staff. However, this result is likely due to the use of the current shock variable. It may take time for a firm to adjust hiring decisions when facing a crisis.

Table 7. Impact of different types of shock on quality upgrade

Types of shock	Number of Patents				Number of Quality Certifications				Share of Professional and Technical Staff			
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**
Major accidents or consumer boycott	0.506***	0.701***	0.481***	0.283***	0.783***	0.075	0.083	0.120	0.070	0.149*	0.149*	0.141*
	(5.032)	(5.823)	(4.769)	(2.985)	(3.994)	(0.418)	(0.461)	(0.771)	(1.282)	(1.829)	(1.827)	(1.724)
Export barriers	0.779***	0.991***	0.743***	0.381***	2.236***	0.885***	0.895***	0.120	0.228***	0.325***	0.329***	0.336***
	(7.235)	(7.132)	(5.996)	(3.114)	(13.093)	(6.235)	(6.458)	(0.771)	(3.272)	(4.437)	(4.499)	(4.392)
Marco policy and price	0.521***	0.528***	0.183**	0.045	1.231***	0.906***	0.892***	0.518***	0.130**	0.228***	0.227***	0.217***
	(5.289)	(5.125)	(2.094)	(0.529)	(4.601)	(4.873)	(4.778)	(3.972)	(1.994)	(3.188)	(3.087)	(2.767)
Global financial crisis in 2008	1.081***	0.856***	0.531**	0.149	—	—	—	—	0.211	0.092	0.094	0.147
	(7.332)	(3.903)	(2.533)	(0.699)	—	—	—	—	(0.900)	(0.460)	(0.469)	(0.692)
Time trend	no	no	yes	no	no	no	yes	no	no	no	yes	no
County Fixed	no	yes	yes	yes	no	yes	yes	yes	no	yes	yes	yes
Year Fixed	no	no	no	yes	no	no	no	yes	no	no	no	yes

Source: Calculated by authors.

Note: Since the quality certification data are available only up to 2006, the 2008 financial crisis is not applicable to the regresssions on this variable. For the first three types of shocks, we take a lag for the shock variables. Because our data for patents and professonal staff are up to 2008, we cannot take a lag for the 2008 financial crisis variable. Instead, we use its current value. The symbols *, **, and *** represent significance at 10%, 5%, and 1%, respectively.

6. CONCLUSION

The quality of products manufactured in China has improved significantly in the past several decades. In this study, we aim to understand the mechanism of the quality upgrading process. Crises reshape both entrepreneurs' and local governments' perceived payoffs and costs regarding proposed reform measures. When facing a harsh external environment, the public and private sectors are more likely to take collective action to improve product quality. Using data from 106 industrial clusters in Zhejiang Province, we empirically examine the impact of crises on quality upgrade. We find that in general after crises, the number of patents, the number of enterprises with quality certification, and the share of professional and technical staffs in the clusters all show a significant uptick. Crises do imply an opportunity for upgrading product quality in clusters.

However, the positive correlation between crises and quality upgrade does not mean one can expect crises to automatically solve all quality problems. Only if crises can be successfully addressed can they become the catalyst for an institutional change (Deming 1986; Edgar 2006). If collective action is not taken in a timely manner, crises may instead destroy a cluster. The collapse of the Yongkang insulated mug cluster is a vivid example of this.

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INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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IFPRI HEADQUARTERS

2033 K Street, NW
Washington, DC 20006-1002 USA
Tel.: +1-202-862-5600
Fax: +1-202-467-4439
Email: ifpri@cgiar.org

IFPRI ADDIS ABABA

P. O. Box 5689
Addis Ababa, Ethiopia
Tel.: +251 11 6463215
Fax: +251 11 6462927
Email: ifpri-addisababa@cgiar.org

IFPRI NEW DELHI

CG Block, NASC Complex, PUSA
New Delhi 110-012 India
Tel.: 91 11 2584-6565
Fax: 91 11 2584-8008 / 2584-6572
Email: ifpri-newdelhi@cgiar.org