Checking into China's Cow Hotels:
Have Post-Milk Scandal Policies Changed the Structure of the Dairy Sector?

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Abstract

China's Milk Scandal is well known for causing the nation's largest food safety crisis and for its effect on thousands of children. Less, however, is known about the impact on the other victim, China's small dairy farmers. Although small backyard producers were not the ones that added melamine to the milk supply, the incomes of dairy farmers fell sharply after the crisis. In response, one of the actions taken by the government was to encourage small dairy producers to check into production complexes that were supposed to supply services, new technologies and provide for easy/bulk procurement of the milk produced by the cows of the farmers. Because both farmers and his/her cows were living (and working) away from home, in the rest of the paper we call these complexes "cow hotels." In this paper we examine the dynamics of China's dairy production structure before and after the Milk Scandal. In particular, we seek to gain a better understanding about how China's policies have been successful in encouraging farmers to move from the backyard into cow hotels. We also seek to find if larger or smaller farmers respond differently to these policy measures.

Using data from a sample of farmers from dairy-producing villages in Greater Beijing, our empirical analysis finds that one year after the Milk Scandal, the dairy production structure changed substantially. Approximately one quarter (26%) of the sample checked into cow hotels after the Milk Scandal, increasing from 2% before the crisis. Our results also demonstrate that the increase in cow hotel production can largely be attributed to China's dairy policies. Finally, our results suggest that the effects of government policy differ across farm sizes; China's dairy policies are more likely to persuade larger farms to join cow hotels. Apparently, larger farms benefit more when they join cow hotels. Overall, these results suggest that during the first year after the crisis, the government policies have been effective in moving some of the backyard farmers into cow hotels (although 60% farmers remained backyard producing).

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China's Milk Scandal of 2008 struck when it was discovered that milk

suppliers (traders and milk collection stations) were adding melamine, a colorless

crystalline compound, to artificially boost the protein readings of their milk (Xin and

Stone, 2008). In July 2008 the initial reports emerged about child health cases in

Gansu Province. Two months later melamine made it for the first time to the headlines

of many of China's domestic newspapers when a connection between Sanlu Group's

baby formula and the Gansu health cases was confirmed by the Ministry of Health.

The media—both inside and outside of China—then covered the incident extensively

and it was revealed that about 300,000 children became sick (Barboza, 2008). The

Milk Scandal, as we call it in the rest of this paper, was born and before it was over it

affected food supplies in scores of nations and every one of China's provinces (Chen,

2009). Distrusting consumers dramatically reduced demand. Small dairy farmers, who

were not the ones that contaminated the milk, had no option but to dump their milk

and the income of millions of farm households was negatively affected (The

Economist, 2008).

China's government responded on many fronts as the Milk Scandal unfolded.

A series of policies were issued to both reduce the impact on small farmers in the

short run as well as to stop the flow of milk through a broken milk marketing system

and to create a new system of milk marketing in the place of the broken one. One of

the main goals of the government of China in recent years has been to raise the

income of rural households (one of the specific objectives of the Ministry of

Agriculture is to double the rural income—as of 2008—by the year 2020 with an annual increase of 6%—Xinhua News, 2010). Because of the damages suffered by farmers who were forced to dump their milk and scale back production, an *income management policy* was rolled out to support the incomes and livelihoods of producers (China News, 2008a).

At the same time, efforts were also made to regulate and restore the marketing chains that had broken down when dairy processing firms were not allowed to buy milk from many of the agents that had been operating in the pre-Milk Scandal supply chain (State Council, 2008). The overall goal of the marketing management policy was to build a supply chain that was able to deliver safe milk to processing plants. Since it was suspected that a large share of the contamination had occurred in the collection station/middle-of-the-chain marketing firms segment of the supply chain, any milk collection station that failed government inspection was closed down and unqualified buyers were banned from the market (China News, 2008b). After supply chains were purged of many of the suspected suppliers of contaminated milk, the government began to invest in upgrading buying/collection stations to restore the chain (Sohu News, 2008). In the rest of this paper, the set of policies which aimed to create and implement regulations on milk buying and delivery is called China's *Marketing Management Policies.*

Given the nature and high profile of China's Milk Scandal and vigor of the government's response, there is surprisingly little empirical evidence that is available to help us understand these policies and their impacts on the dairy industry. There are

a wide range of government documents, media reports and anecdotal studies that describe the policies (e.g., Hebei Provincial People's Congress, 2009; Chen, 2010). There are a large number of reports that track the fate of those families with children affected by the melamine-laced milk products (First Financial Daily, 2008). However, there is almost no paper that seeks to measure the impacts on the dairy producers. One exception is the work of Jia et al. (2011). They use village- and farm-level data from the Greater Beijing Region to econometrically analyze the effect of the government policies on dairy producers. Their analysis demonstrates that, although dairy participation fell and herd sizes were reduced after the Milk Scandal, Marketing Management Policies helped limit the fall of output.

Despite the importance of the paper by Jia et al. (2011) and their findings, there is no work, to our knowledge, that seeks to understand how China's policies affect the structure of production. This itself is puzzling given that one of the government's goals of its overall dairy policy was to encourage producers to organize themselves in ways that would allow for both more efficient production and more effective monitoring of quality. Before the Milk Scandal, China's dairy production was dominated by poor, small-scale farmers with fewer than 5 cows/household (Zhou et al., 2002; Huang et al., 2010). At the time of the emergence of the Milk Scandal, the small farmer-dominated, fractured structure of China's dairy sector was thought to be (at least in part) at fault for the crisis—either directly or indirectly. Indeed, one of the goals of the Marketing Management Policies was to get the supply chain to procure from larger and more reliable dairy farms (Wei, 2008). Incentives were given

to marketing agents to procure from larger dairy units. Subsidies were provided to larger dairy units to install equipments that would aid more efficient and safe marketing. Jia et al. (2011), however, does not seek to understand how China's Marketing Management Policies affected the production structure.

The absence of attention to the impact on the structure of dairy production per se is understandable because Marketing Management Policies (the main focus of the work of Jia et al., 2011) were not designed to directly change the way of raw milk production. When the first Marketing Management Policies were being rolled out, most of China's dairy cows were still in the backyards. It was for this reason that China's policy makers designed and implemented another policy that sought to directly change the production structure of China's dairy industry. In the early months after the Milk Scandal, government officials issued policy directives that ordered local officials to try to convince small, backyard farmers to move their cows into concentrated production complexes (People's Government of Hebei Province, 2008; People's Government of Shanxi Province, 2008; People's Government of Zhejiang Province, 2008, among others). At the time these complexes (the ones that existed) were both publicly and privately managed (Appendix 1, row 9-13). The reason (given in the initial policy documents) for the preference for large complexes was to provide dairy farmers with the access to modern production practices and to facilitate better monitoring of the production practices. Ultimately, the policy was designed on the assumption that when dairy cows and dairy farmers were brought to a centralized complex, it would facilitate the production of more sanitary and higher quality milk.

This paper's primary goal is to study the policy of concentrating the operations of small dairy farmers into the complexes as a way to change the structure of China's dairy industry and upgrade dairy production. These concentrated production complexes (called "*yangzhi xiaoqu*" in policy documents) provide us with the important tool to investigate structural changes. Since the creation of the complexes is implemented by requiring dairy farmers to bring their cows from their home and "check them into the complexes" in the same way people check themselves into guesthouses and lodgings when they leave home, we call these complexes "cow hotels." The complex could also be called "dairy farmer hotel" because in many cases the complex is so far from a dairy farmer's home village that he/she is unable to go back and forth two to three times a day to milk, feed and take care of his/her dairy cows. As a result, the farmer will also check himself/herself into the complex and live there.

A cow hotel is a state- or privately-owned dairy cow production and milking complex. Both milk production and collection takes place in a single, centralized location. The cows in the hotel are brought in by a number of different individual farmers who often will live inside the complex also (in a small dormitory room or stand-alone hut). A dairy complex is typically managed by a single manager that is in charge of coordinating the breeding, milking and marketing. The dairy farmers take care of their own cows and are subject to the rules and regulations of the cow hotel.

In summary, the cow hotels distinguish themselves from the traditional backyard farms in a specific way: A cow hotel is a centralized location that is

provided for the housing of larger scale of herds; farmers in many cow hotels are asked to follow uniform procedures to carry out breeding and milking and marketing their milk (Appendix 1, row 14-18). The set of policies that were implemented to facilitate and encourage farmers to join, or check into, cow hotels are thus called *Cow Hotel Policies*.

Although the Cow Hotel Policy documents and efforts of the government to implement the policy are clear, the question remains how effective the policies have been in convincing backyard farmers to join cow hotels. While there are benefits associated with cow hotel farming, there are obvious costs as well. Media and government reports have mostly focused on the efficiency and welfare gains of the farmers in joining cow hotels (Zhangjiakou News, 2009; The Economic Daily, 2010). Some argue that cow hotel farming could lead to productivity improvement with scale economies and upgraded facilities (Dairy Times, 2010; MOA, 2011). Importantly, since farmers are required by their contracts to sell the raw milk to the marketing division of the cow hotel (Appendix 1, row 19 and 20), it could be providing a better access to the output market (as often with larger-scale production structures) (Swinnen, 2009). However, other anecdotal studies and reports suggest that cow hotels are not always efficient (Chen and Zhang, 2010). In some hotels there is inadequate investment into the hotel's facilities, technologies and/or management; cows may be at higher risk of disease because of the increased herd size. In addition, as farmers need to take care of the cows in the hotel, they incur higher commuting costs (or the psychological costs of living away from home), compared to when their

cows are being raised in their own backyards. Using the services of cow hotels also can impose other direct and indirect costs on farmers since they often live far from their own villages (Farmer's Daily, 2010; Li, 2010).

The goal of our study is to gain a better understanding of which farmers (with what characteristics) are most likely to join cow hotels and whether the Cow Hotel Policy was effective in inducing farmers to check into cow hotels. As the benefits and costs associated with cow hotel farming (introduced above) are likely to differ for farms with different herd sizes, it could be that larger farms enjoy more efficiency gains and less per unit costs than smaller farms. Consequently, policies may exhibit heterogeneous effects on large and small farmer's propensity to join cow hotel.

To meet this goal we have three specific objectives. First, we will examine the dynamics of China's dairy production structure before and after the Milk Scandal. Second, we will attempt to measure how the two sets of policies, China's Marketing Management Policy and the Cow Hotel Policy (especially) have influenced dairy farmers to join cow hotels (and/or have failed to move them out of backyard production). Third, we will estimate the heterogeneous effects of the policies on farmers. Do larger and smaller farmers respond differently to these policy measures?

Due to limited funding and organizational resources, we restrict the scope of our study to dairy production structures in the Greater Beijing Region. It could be the case that the policies are different across regions and the effects of these policies in

our study region have limited generalizability to other regions.[1] There also are other questions that might be of equal interest. For example, it would be interesting to evaluate the effect of China's post-Milk Scandal policies on the quality of milk. Did the measures lead to higher standards of production? These questions are beyond the scope of our study, which, however, could be important topics for future research.

China's Dairy Industry and Farms

Demand and supply of dairy products have changed dramatically during the past two decades. In the 1990s there was only one major commodity that China's consumers were under-consuming: dairy. The average urban resident in 1992 consumed nine kilograms per capita of dairy products (measured in milk equivalents), only a fraction of the level in many other nations. Since that time, however, dairy demand, especially in urban areas, has exploded (Zhou et al., 2002).

As dairy demand rose, dairy production also increased sharply (Fuller et al., 2005, 2006). In the mid-1990s, China's dairy industry produced only six to seven million tons (Liu, 2003-2009). From the mid-1990s to the mid-2000s, the growth of dairy production accelerated to nearly 20 percent annually. Aggregate production rose to more than 35 million tons in 2007, a level that ranked China the third in the world after US and India.

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[1] However, for a number of reasons, we believe that it is interesting and informative to study the case of Greater Beijing. Beijing was one of the first regions that noticed urinary tract stones in infants (Chen, 2009). Moreover, although the crisis was national, the issue was ranked as the top priority on the agenda of the State Council during the first months after the Scandal in Beijing (as well as a number of other provinces). Provincial documents also show that similar policies have been designed in many other provinces to counter the crisis (People's Government of Hebei Province, 2008; People's Government of Shanxi Province, 2008; People's Government of Zhejiang Province, 2008, among others). Such documents also exist for Beijing and these show that the crisis was real and serious in Beijing (Wei, 2008). In addition, because of the fact that one of the major impacts of the crisis was the collapse of demand across China, including Beijing, the crisis was indeed nationwide (again: including Beijing).

Who was producing China's milk? By any measure, China's dairy industry heavily depended on small farmers. In the mid-1990s the average dairy household owned and milked only three cows (Zhou et al., 2002). During the following years, although the overall herd size rose steadily (to more than 12 million dairy cows in 2007), the average herd size per family rose only gradually (Liu, 2003-2009). In the mid 2000s more than 80 percent of the dairy cows were owned by small households scattered across the country (Lu, Tao and Woo, 2009).

To procure, transport and process the milk in China's economy, a huge and competitive downstream segment of the dairy industry has emerged (Lu, Tao and Woo, 2009). Foreign firms and large corporations, mixed with small-scale local firms, increased the quality of and expanded the capacity of the dairy processing sector. Although industry players with names such as Sanlu, Yili and Mengniu (domestically) as well as Nestle, Fonterra and Danone (foreign) were most prominent, there were also thousands of other firms. Competition within China's major dairy markets intensified. During the 2000s inter-regional competition in both product sales and milk sourcing also became fiercer. As this occurred, dairy firms were pressured to keep costs low, even at the expense of milk quality.

China's Milk Scandal and the Government's Response

A Harvard Business School case study written by Lu, Tao and Woo (2009) listed and described the fundamental pressures in the industry that they believe ultimately led firms to begin to use melamine in China's dairy supply chains.[1] The competition (described above) began to exert downward pressure on product prices.

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Lower prices led to falling profit margins. Facing price pressures from above, dairy companies, in turn, began to counter by transferring some of the competitive pressures to milk-collection stations and dairy farmers. Moreover, during the same period government officials across China were encouraging the large downstream dairy companies, who often were directly owned by or indirectly tied to the government, not to raise prices. The profits of the milk-collection stations and dairy farmers continued to be squeezed.

Being at the very upper end of the highly competitive dairy supply chain, there were not too many margins on which either dairy farmers or local buyers/dealers could move on to try to earn higher profits and reduce costs. There was one, however, on which some farmers and buyers/dealers tried to move. Since payment to dairy farmers and local buyers for their milk was largely based on the volume they supplied, adding water would increase their sales volume. In fact, the press reported extensively on cases in which in some places and at some times both dairy farmers and first-tier buyers in China had been found watering down milk to increase their sales volumes. In response, processing firms and their agents changed the rules of procurement. They began to set standards for the milk that they procured from dairy farmers based on the milk's protein content.

Enter melamine. To circumvent the testing (which could detect water being added to the milk), some milk suppliers (mostly traders and milk collection stations) began adding melamine to artificially boost the protein readings of their milk (Xin and Stone, 2008; Gale and Hu, 2009). This was possible, since dairies commonly

tested for protein content of milk by measuring the milk's crude protein level.

Measured this way, testing protocols were unable to detect if the total quantity of

nitrogen in milk was either protein-based (from the milk itself) or non-protein-based

(from the melamine).[2]

Why was this not picked up at the dairy processing level? Two factors suggest

that, the firms knew that their raw milk was contaminated. First, all the firms

themselves were simultaneously facing profit squeezes and pressures to increase

production. Second, the quality control system that China's Administration of Quality

Supervision, Inspection and Quarantine (AQSIQ) was in charge of was mainly based

on self-regulation. There were no third parties in charge of inspecting the quality of

China's milk supply. These two factors—temptations for higher profits (or the need to

avoid falling profits) and low probabilities of getting caught—led to China's 2008

Milk Scandal.

The Scope of the Scandal and Its Consequences

The scandal itself is defined by a long sequence of events that began with

children being tested positive for kidney stones at abnormally high rates in Gansu, a

poor province in western China, and ended with many countries across the globe and

every province in China testing dairy products for melamine and banning thousands

of products that came out of China's dairy and other food manufacturing firms.

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[2] The government policies have now focused new attention on a number of different aspects of China's dairy production and marketing chains. However, the policies do not address explicitly the ways that the inspection system is supposed to measure milk for protein content. This may have been part of the problem originally (and may still be a problem today). For instance, the Kjeldahl method is unable to detect differences between the true (organic) protein levels in milk from non-protein nitrogen ones. However, more advanced approaches (such as spectroscopy—which can) were not included explicitly into the legislation. We feel the policy implication here is clear: China's dairy inspection system should not rely on ineffective technologies, such as the Kjeldahl method.

Popular press coverage throughout the end of 2008 and 2009 focused mostly on the civil and criminal consequences of the scandal (Zhongshan News, 2009). In the end punishments for the 300,000 victims that became sick, the six confirmed deaths and billions of dollars of economic disruption were given out. Two people were executed. Another one was given a suspended death penalty. Five others received from 15 years to life imprisonment. At least seven government officials, as well as the Director of the Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) were fired or forced to resign.

One aspect of the Milk Scandal that has been much less reported on and less understood, is the impact that the Scandal had on the millions of dairy farmers. After the Milk Scandal, as might be expected, farmers were hit hard and by a number of different factors. First, and most directly, as the Milk Scandal was unfolding, one of the first responses of government regulators was to shut down production in suspected dairy processing firms. This means, of course, that in many cases there was an immediate impact since many dairy households could find no one else to procure their milk (or, if they found a buyer, the milk was only procured at a fraction of the cost of production).

While the shutdown of processing firms by regulators in the immediate aftermath of the Milk Scandal hurt farmers, this effect paled in comparison to the ultimate cost. With consumer confidence in the quality of all domestically-produced dairy products low, consumer demand for dairy products plummeted (NDRC, 2008). Production followed. Nationwide, after growth of production between 2006 and 2007

of more than 3.3 million tons (10 percent year on year growth), production stagnated

between 2007 and 2008 and fell between 2008 and 2009 (China Dairy Statistical

Report, 2010).

What was the nature of the fall in production and its impact on

dairy-producing communities? While it is difficult using national level data to assess

exactly how production fell and small dairy farmers were affected, we can see several

regularities. First, there was an acceleration in the fall in the number of dairy farmers.

In Tianjin the number of dairy-producing households fell between 2007 and 2008 by 5

percent (Liu, 2003-2009). In Liaoning the number of dairy-producing households fell

by 23 percent. Second, there also was widespread reporting of farmers that were

forced to discard their milk, pouring it into landfills, fields and dry riverbeds

(Ministry of Finance, 2008). Finally, a crisis in the dairy sector meant a crisis for

many poor communities and the poor farmers inside them. The progress that the

government had made over the past several years in raising farm incomes was

threatening to be reversed (State Council of Central Committee of Communist Party

of China, 2008, 2009).

Policy Response

In response to both the consumer and producer crises that were triggered by the

Milk Scandal, the government's top leader, Premier Wen Jiabao, made a public

announcement that addressed many dimensions of the crisis. In particular, he

committed his government to revamping the policy environment, "… the crisis has

revealed the shortcomings of government supervision [and policy] … The situation

must be rectified immediately" (Lu, Tao and Woo, 2009). One of the main goals of the policy response was to change the production structure of China's dairy industry to make it more modern and more capable to adopt new technologies that could produce high quality milk (People's Government of Hebei Province, 2008).[3] The target of this policy was focused on increasing the size of dairy farms and reducing the dependence of the sector on small backyard farms (Chen, 2010).

In fact, the Wen government kept its promise of rapid policy response. As is often associated with China's policy making environment, when there is a crisis, the government responds and does so in many different dimensions. Although the total list of policy responses is quite long, in the case of the responses directed at producers they can be divided into two main types: Marketing Management Policy and the Cow Hotel Policy (see the introduction for the discussion on these policies). In the rest of this paper we seek to understand the effectiveness of these policies in changing the production structure of the dairy industry.

Data

Data for this study are based on a panel survey that was conducted in 2005 and 2009 in the Greater Beijing area. In 2005 dairy production data at the village- (or community-) and household-levels were collected as part of a larger survey effort (the Greater Beijing Horticulture and Livestock Survey), which investigated the

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[3] To strengthen their inspection capabilities, China's General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) issued a statement "Determination of melamine in raw milk and dairy products" (GB/T 22388—2008) on Oct. 7th, 2008. This announcement stated that milk inspectors should use one of three measurement techniques: high performance liquid chromatography (HPLC), liquid chromatogram mass-spectrography (LC-MS/MS) and/or gas chromatography mass-spectrography (GC-MS) to test melamine.

production and marketing of high value agricultural commodities in the area of

Greater Beijing.[2]

In the first year of the survey, 2005, the authors relied on a spatially-based

sampling strategy to choose the 50 townships and 200 villages from which we would

collect information of dairy production at the community level (and which would

ultimately be used to choose our dairy households. To sample villages, a GIS

sampling approach was begun by delineating the Greater Beijing into five concentric

circles with the geographical center of Beijing (Tian'anmen). The concentric circles

were further divided into 10 wedges by drawing 10 "spokes" (140 kilometers in

length) from the center (viz. Tian'anmen) to the edge of the outermost circle. Each

wedge was defined by two spokes that created a 36 degree angle. The spokes cut

every concentric circle into 10 arcs, creating a total of 50 arcs. On every 36 degree arc,

one randomly selected point was marked. The township geographically located

linearly closest to the randomly selected point was included in our sample population.

In total, 50 townships were randomly selected with the aid of a GIS mapping program.

Within each township, 4 villages were then randomly selected to create a sample

population of 200 villages.

In each of the sample villages an enumeration team, led by the authors,

conducted a community survey. To do so, the authors interviewed village leaders

about the changes in the community's horticultural and livestock (including dairy)

economy between 2000 and 2004. During the sit-down questionnaire survey, village

leaders recounted the general information of communities and the production of the

village's major high-value commodities. In the case that dairy farming was identified, the authors labeled the village as a *dairy village* and further asked detailed questions (namely, percentage of dairy farmers, average herd size, the distribution of households with different herd size, the distance to the nearest collection station/dairy processing firm, the number of milk stations in local village and in neighborhood villages, etc.). The authors eventually identified 25 dairy villages and 175 non-dairy villages from among the 200 sample villages.

After the conclusion of the community survey (and identification of the dairy villages), the first round of our household dairy survey in 2005 was conducted in the 25 dairy villages. To execute the survey several steps were taken. First, in each village all households were divided into two groups based on whether or not they owned cows. In other words, all households were labeled as a *dairy farmer* (or *dairy household*) or *nondairy farmer* (or *nondairy household*). Second, we devised a sampling scheme that was used to draw a sample of dairy and nondairy farmers. In villages where the number of dairy farmers was more than 50, 20 farmers were randomly selected — 14 dairy households and 6 nondairy households. In the cases of villages in which the number of dairy farmers was higher than 7 but lower than 50, the authors randomly sampled 10 farmers in total—7 dairy farmers and 3 nondairy farmers. When the total number of dairy farmers in a village was lower than 7, the authors surveyed all the dairy farmers. The 2005 household survey include 243 farmers in total; 63 percent of them were dairy farmers. For some basic production

activities, such as participation in dairy farming and herd size, we asked households about both the current year (2005) and a point of time four years earlier (2000). During the 2005 household survey, in different blocks of the survey farmers were asked about their individual, household and dairy characteristics. Enumerators collected information on the age, education level and employment history of each household member. The value of the household's assets was collected in an attempt to assess each family's wealth. Respondents also provided information in the nature of their dairy activities, including their participation history distinguishing backyard farming, cow hotel farming and non-dairy activities, their herd size and location if they are dairy farmers.

In October of 2009 (about one year after the Scandal) we organized a second round of the village and household surveys. The idea was to track the evolution of the dairy producers, their activities and the policies that they faced in the same villages and same households that had been interviewed in 2005 as a way of assessing the impact of the Scandal.[3]

To the greatest extent possible our strategy in the second round was to ask the same respondents the same questions (complemented with questions specific to the Milk Scandal). To do so, we began with a second round of the community survey. Enumerators asked the village leaders (which in more than half of the villages were the same) the same set of questions as they did in the first round.

The household survey was also repeated. The same information that was collected in 2004 was collected again. In addition, and in order to be able to more

precisely pin down the effect of the Milk Scandal, we asked farmers to recount their dairy production activities for the year before the crisis in 2008 (pre-Scandal dairy activities) and at the time of the survey for 2009 (post-Scandal dairy activities). A section was added on their perceptions about the way that the government's post Milk Scandal policies affected their dairy operations.

Finally, in addition to repeating the village and household surveys we also conducted a survey of the officials that were in charge of dairy policies at the township level (in each of the sample townships). In total the 25 villages in our sample were located in 15 townships. In these 15 township surveys we were mainly interested in documenting the exact dates that dairy policy actions were issued from county officials to township leaders that were placed in charge of dairy production in each township. The questions were organized in a way that allowed us to pinpoint the policy efforts and timing of a.) the Production Management Policies; and b.) the Marketing Management Policies. The timing of the policy actions were recorded on a month by month basis.

Based on the two rounds of survey, we are able to create a panel of townships, villages and households. We include all 121 dairy households in our sample in August 2008, which refers to a baseline before the Scandal. The panel continues with the month end of September in 2008 when the Scandal was exposed on the public media and October when a set of national interventions as a prompt response to the crisis which was disclosed. The data is then followed by month January, May, and September in 2009. Therefore, in total we have 726 observations.

Definition of Variables

The data described in the preceding section are used to produce information

to meet our objective of tracking dairy production before and after the Milk Scandal.

To do so, we need to create variables tracking dairy production and post-Milk

Scandal policies and their implementation after the Scandal. We also need to create a

number of other variables that might affect dairy production in order to be able to

improve the estimation efficiency of the effects of the government's policy response.

Dependent Variables: Farm Organization

We use three dependent variables to indicate, respectively, whether a farmer

has checked himself into a cow hotel, continues to operate as a backyard producer or

has dropped out of dairy production. The dummy variable, *Cow Hotel Producer*,

equals 1 if at the end of the time period the farmer joined a cow hotel, and equals 0

otherwise. Similarly defined, the dummy variable, *Backyard Producer*, equals 1 if

the farmer continued to produce as a backyard farmer at the end of the time period,

and equals 0 otherwise. Finally, the dummy variable, *Exited the Dairy Sector*, equals

1 if the farmers left dairy production between the start and the end of the time period,

and equals 0 otherwise.

Independent Variables of Interest: Policy Variables

We asked township leaders to tell us exactly the initial time (by month) that

they were mobilized (by upper level policy makers) to move backyard dairy

operations into cow hotels. The variable, Cow Hotel Policy, is generated from this

information as a dummy variable that equals 1 if the policy has been implemented and equals 0 if it has not been implemented.

To create a variable to measure the implementation of the *Marketing Management Policy* in each sample township, we asked each township leader whether he/she had ever received a policy document (from the county government) that did any of the following: a.) ordering the township to begin inspections of milk procurement stations; or b.) upgrading milk procurement stations in the townships with promises of subsidies for the stations. The approach that we used to create the variable, Marketing Management Policy, is similar with the approach that we used to create the variable Cow Hotel Policy. Specifically, Marketing Management Policy is a variable that equals 1 if the policy has been implemented and 0 if it has not been implemented.

Control Variables

We also used our data to create a number of control variables. The variable *Herd size* is a household-level variable indicating the number of cows that the household owned before the Scandal. It is a number that is greater than or equal to 0. The variable *Education* equals the number of years of educational attainment of the household head. The variable *Age* is measured as the age of the household head. The variable *Percentage of off-farm labor* is measured by dividing the accumulated days of household members working off-farm over the total working days of them. To measure household wealth, we collected and aggregated the value of the housing assets, furniture and other durable consumption assets. *Asset value per capita* is

created by dividing household wealth before the Scandal by the total number of household members. Finally, we also created the variable *Dairy training* to indicate whether any member of the household has participated in dairy training before the Scandal. The variable equals 1 if at least one member received training and equals 0 if none of them had any training.

Finally, we create two control variables at the community level. The village leader was asked whether there were villagers working in dairy firm before the Scandal. Based on this information, we created the variable of *Villager in dairy firm* which equals 1 if there were at least one villager who had been working in a dairy firm and 0 if no one had worked in dairy firms before the time of the survey. In addition, we also asked the village leader (the respondent for the community survey form) to tell us the total number of households and the number of dairy farms in the village before the Scandal. We created a variable of *Percentage of dairy households in the village* as an indicator for dairy production in the village.

Dairy production structures in Greater Beijing before and after the Milk Scandal

Our data show that in October 2008, one month after the Milk Scandal and the initial month of government policies, the proportion of cow hotel producers rose sharply (Table 1). Before the Milk Scandal (August 2008) and the month when the Scandal broke out (September 2008), only 2% of all 121 dairy households were producing in cow hotels (row 1 and 2).[4] One month later, it increased to 17% (row 3). The flow to cow hotels continued after October, but at a slower rate: one year after the Milk Scandal the share of farms in cow hotels was 26% (row 6). Consistently,

backyard producers decreased from 98% in August 2008 (row 1) to only 60% in September 2009 (row 6). Some of them moved to cow hotels (26%) and others dropped out of dairy production (14%—row 6).[4]

Our data also show that once the Milk Scandal surfaced, government action was taken swiftly across many of our sample areas (Table 2). It is not surprising that no policy action penetrated to towns to combat the crisis in August and September 2008, since the Scandal had just broken out in September. By the end of October, however, 8 out of 14 townships had received policy directives for the Cow Hotel Policy and had started implementation (Table 2, row 1). In the following months, the Cow Hotel Policy spread to other townships. The directive to move dairy cows into cow hotels were announced in all townships but one in our sample by the end of September 2009 (row 1). The Marketing Management Policy was rolled out as quickly as the Cow Hotel Policy: 9 of the township leaders told us during the survey that they had received policy directives in October 2008 (row 2). Interestingly, no new townships received this policy in the following months (row 2).

Descriptive cross-tabulations that relate the rollout of the policies in the sample townships to cow hotel production show that both of the policies seem to be associated with the increase in cow hotel production (Table 3). In the one township where the leader had not received Cow Hotel Policy directives by the end of September 2009, no cow hotel production was found (row 1). In the townships that were targeted by the Cow Hotel Policy, an abrupt increase of cow hotel producers was

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[4] According to our data, 90 percent of farmers who exited dairy production sold their cows to other farmers; only 10 percent of the farmers that exited dairy production decided to slaughter their cows.

found. The proportion of cow hotel producer increased from 2% in September 2008 to 18% in October (row 2).

A similar pattern is found for Marketing Management Policy. Cow hotel production increased much faster in the townships that been covered by the Marketing Management Policy than in the townships that had not been the target of the marketing policies. In October 2008 cow hotel producers increased from 1% to 20% in the townships with the marketing policies; in contrast, there was no increase in the townships without them (row 3 and 4). Possibly due to the more widespread (albeit more gradual) Cow Hotel Policy (which reached a number of townships that the Marketing Management Policy did not), in the later months cow hotel production rose gradually slightly to 9% by May 2009 and 13% by September 2009 (row 3) in the townships without the Marketing Management Policy.

The other evidence that we get from our data is that the trend of cow hotel production is consistent for our sample townships before the policies were implemented (Table 3). Although the townships with different dairy production and marketing policies started off with slightly different ratios of cow hotel production, the ratios do not change in the two months preceding the policies (Table 3, August and September 2009). In other words, township-level time-varying variables seem to have little impact on cow hotel production, though it does underline the importance to include township fixed effects to account for a different starting point in our multivariate analysis.

Table 4, however, shows that the policies seem to have different effects on producers with different pre-Scandal herd sizes. Given that producers were in areas that were targeted by the Cow Hotel Policy, larger producers appear to be more likely to join cow hotels (the percentages of cow hotel producers in the group with herd sizes equal to or smaller than 5, larger than 5 and smaller than 11, and larger than 10 are, respectively, 16%, 24% and 50% —row 2). Similarly, the Marketing Management Policy appears to have a stronger effect on larger producers; the percentages for the three groups of herd size are 18%, 28% and 46%—row 4.

Finally, Table 5 shows that some of the pre-Scandal household characteristics seem to be associated with production structures as well.[5] For example, households which joined cow hotels seem to have, on average, younger household heads, fewer household assets and have worked less off-farm before the Milk Scandal (row 5-10). In contrast, households which continued backyard production seem to have older household heads with more household assets (row 3-8).

Although the descriptive statistics provide us with interesting evidence of the changes in production structures and how the policies may have contributed to these changes, they are of little help in disentangling the effects of the two policies, the effect of the dairy crisis and other confounding factors. For example, due to the overlap in timing and areas of the two policies (and the dairy crisis), it is impossible to satisfactorily attribute the part of increase in cow hotel production to each of the

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[5] We do not include the post-Scandal characteristics as controls because they may be affected by the policies that were implemented to counter the Milk Scandal. If these characteristics are also correlated with the production decisions of farmers (that is, if the farmer moved his/her dairy cows into the cow hotel), they might not act as efficiency-enhancing control variables in our regressions (Angrist and Pischke, 2008).

two policies without multivariate analysis. Therefore, we include all the policy

variables and the control variables in the multivariate analysis in the next section.

Econometric analysis

In this section we present a comprehensive econometric analysis to examine

the impact of government policies on dairy production structures. We first discuss our

estimation approach. We then present and discuss the results.

Baseline specification

In estimating the impact of policies on the structure of dairy production, we

use a fixed effects estimation approach to control for non-time varying township

effects and include a large set of household-level characteristics to improve the

efficiency of the analysis.

In particular, in this paper we estimate the following linear probability model:

$$E\ [y_{ijt}=1|P_{jt}{}^C,P_{jt}{}^M,\ Crisis_t,\ X_{ijt},\ Trend_t]=\delta_1 P_{jt}{}^C+\delta_2 P_{jt}{}^M+\beta Crisis_{t+}\gamma'X_{ijt}+\mu Trend_t+\lambda_j \qquad (1)$$

where y_{ijt} is the dependent variable for household i in town j and in month t. In the

first regression, it is a dummy variable that takes the value of 1 if the household is a

cow hotel producer and 0 if the household is not a cow hotel producer. In the second

regression, it equals 1 if the household is a backyard producer and equals 0 if it is not

a backyard producer. In the third regression, it equals 1 if the household has exited the

dairy sector and equals 0 if it still engages in dairy production. The Cow Hotel Policy

is represented by $P_{jt}{}^C$ and the Marketing Management Policy is represented by $P_{jt}{}^M$.

We also include a variable $Crisis_t$ which takes on value 0 before September 2008, the

critical month of the breakout of the Milk Scandal, and it takes on value 1 after the

critical month. The Crisis variable is used to capture the effect of crisis on the structure of dairy production. The vector X_{ijt} includes a series of control variables such as pre-Scandal household and village characteristics (as defined in the previous section). We insert a time trend $Trend_t$ which measures the number of months since August 2008 to capture the common trend. We also include township fixed effects, λ_j, in order to take account of the township unobservables that may be correlated with non-time varying township policies and other factors (which might influence dairy production structures).

We choose to use a linear probability model for the estimation for a number of reasons. First, the linear probability model (the model we use) and a logit (or probit) model (which we do not use), in general, produce similar estimates. The main difference is that the linear probability model is less efficient than limited dependent variable esimators. However, the linear probability model has the key advantage of having straightforward interpretations of the regression coefficients. In producing estimates from the linear probability models, we compute and use Huber-White heteroskedasticity-robust, clustered (at the individual level) standard errors and allow efficiency improvement in standard errors.

Alternative specification (interaction with herd size)

As discussed in the introduction, it is possible that the policies affect small and large farms differently. To explore the heterogeneous effects of policies on farms that differ in herd size, we estimate the following alternative specification:

$E\ [q_{ijt} = 1 | P_{jt}^{C},\ P_{jt}^{M},\ Crisis_t,\ X_{ijt,}\ Trend_t]$

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$$= \delta_1 P_{jt}{}^C + (P_{jt}{}^C \times Size_{ijt}) + \delta_2 P_{jt}{}^M + (P_{jt}{}^M \times Size_{ijt}) + \beta Crisis_t + \gamma\, X_{ijt} + \mu\, Trend_t + \lambda_j \qquad (2)$$

where, in addition to the variables that are included in equation (1), we also include

two interaction terms (between pre-Scandal herd size and the two policy variables:

$P_{jt}{}^C \times Size_{ijt}$ and $P_{jt}{}^M \times Size_{ijt}$).

Results

Tables 6-11 report the estimation results. Tables 6, 7 and 8 report estimates for

the coefficients from Equation (1), the basic results. Table 9, 10 and 11 report them

for Equation (2), the heterogeneous analysis. Table 6 and 9 show the estimation

results for the dependent variable which takes the value of 1 if the household is a

producer living/working in a cow hotel. Table 7 and 10 show the results for the

dependent variable which takes the value of 1 if the household is a backyard producer.

Table 8 and 11 show the results for the dependent variable that equals 1 if the

household has exited dairy production at some point of time between the outbreak of

the Milk Scandal and the survey. Due to the closeness of the timing of the Scandal

and the implementation of the two policies, we include different combinations of the

three variables of interest in each set of regressions (for the same dependent variable)

to check the robustness of our estimates.

Impact of the Policies on the Structure of Production

Our results show that the Cow Hotel Policy, which sought to mobilize

backyard producers to check into cow hotels, in fact, increases the probability of

farmers to join a cow hotel (Table 6). The size of the coefficient suggests that the

policy efforts of the government increased the probability of dairy producers being in a cow hotel by 11% (column 10, row 1). Interestingly, the Marketing Management Policy, which regulates milk buying and delivery, increases the cow hotel production even more, by 23% (Table 6, column 10, row 2). The estimates are robust and highly significant across all specifications. The only exception is in the regressions where we include both sets of policy variables—the variable measuring the Cow Hotel Policy and the variable measuring the Marketing Management Policy. When including both policy variables, the coefficients change slightly with different combinations of these variables in the regressions (Table 6, row 1 and 2).

Our results also demonstrate that the Cow Hotel Policy reduces backyard production by 10% (Table 7, column 10, row 1). The coefficient is robust across the ten specifications (Table 7, row 1). However, the Marketing Management Policy does not seem to affect backyard production (Table 7, column 10, row 2). The coefficient of this policy varies when we include or exclude the variable of dairy crisis. This almost certainly indicates a high level of correlation between these two variables. In this specification, the coefficient on the Marketing Management Policy variable is nearly zero. If this measures the true effect, it means that Marketing Management Policy has not been effective in reducing backyard dairy production.

Finally, consistent with the findings of Jia et al. (2011), the Marketing Management Policy reduces the probability of dairy farmers to exit dairy sector (Table 8). The size of the coefficient reveals that the policy reduces the fall in the household's participation in dairy production by 23% (column 10, row 2). The

magnitude in Jia et al. (2011) is similar (their estimation is 27%). In contrast, the Cow Hotel Policy does not exhibit any impact on quitting dairy production. However, there is a lot of variation in the sign of the variable and its robustness across specifications (Table 8, row 1).

Farm Size and Policy Effects

Our results also suggest there are heterogeneous effects. The most significant differences across households are found when we look at the effect of the Marketing Management Policy on the structure of the dairy production. The interaction terms between the policy and herd size suggest that larger farms are more likely to shift from backyard production to cow hotels if the Marketing Management Policy is implemented in the local township (Table 9, column 10, row 4; Table 10, column 10, row 4). The coefficient indicates that, given this policy, by having one more cow in the backyard, the probability that the household will check into cow hotels rises by 1% (Table 9, column 10, row 4; Table 10, column 10, row 4). The estimates are robust across all specifications.

Interestingly, the Cow Hotel Policy does not show heterogeneous effects on checking into cow hotels or quitting backyard production (Table 9-11, row 2). A possible explanation is that this policy is meant to move all backyard producers into cow hotels once a local cow hotel is established. Farms of different herd sizes face the same intervention if the local township received policy directives for Cow Hotel Policy.

Conclusions

In the immediate aftermath of the Milk Scandal of 2008, China's government responded to the crisis by issuing a series of policies. The overall goal of these dairy policies was to encourage producers to organize themselves in ways that would allow for both more efficient production and more effective monitoring of quality. For example, the Cow Hotel Policy ordered local officials to try to convince dairy farmers to check into the centralized complexes—cow hotels, which in theory, would facilitate more efficient production of more sanitary and higher quality milk. The Marketing Management Policy was designed to regulate and restore the supply chain and facilitate the procurement of milk from larger and more reliable dairy farms.

Given the nature and high profile of the government policies, there is surprisingly little empirical evidence on their impacts on the dairy production structure. Therefore, the goal of our study was to gain a better understanding of which farmers (with what characteristics) were most likely to join cow hotels and whether the Cow Hotel Policy (and/or the Marketing Management Policy) was effective in inducing farmers to check into cow hotels (and, if the policy was the driving force in changing the production structure of the dairy industry in Greater Beijing).

In summary, we found that one year after the Milk Scandal, the dairy production structure changed substantially. Approximately one quarter (26%) of our sample had checked in the cow hotels (increasing from 2% in August 2008). Despite the policy efforts of the government, 60% of the sample dairy farmers decided to continue with backyard production (decreasing from 98% in August 2008); 14% of dairy farmers decided to quit dairy production.

Our results also demonstrated that the increase in cow hotel production could largely be attributed to the Cow Hotel Policy and the Marketing Management Policy. The Cow Hotel Policy was shown to increase the probability of farmers to join a cow hotel by 11%. The driving force of the change, however, seemed to be the Marketing Management Policy, since it was shown to increase the cow hotel production by 23%.

Moreover, our results suggested that the effects of government policy differed across farm sizes. When policy makers implemented the Marketing Management Policy, larger farms in our sample were more likely to join cow hotels and less likely to maintain backyard production. Why is this? It is likely because the policy provided incentives to milk marketing enterprises to procure from larger dairy units (complexes such as the cow hotels). When the marketing incentives were added to the profit-loss mix, it appears that larger farms benefited more than smaller farms (if they join cow hotels). It might also be that the cost of joining a cow hotel is lower for larger farms.

These hypotheses regarding the higher benefit for larger farms are consistent with other information obtained during the survey. In our interviews, farmers often complained about bad management at some cow hotels, delays in the payment for milk, unstable feed costs (as well as the costs for other inputs) and (perhaps above all) the high opportunity costs of travelling far from home to take care of the cows. In our sample, for example, 60% of farmers who did not join a cow hotel indicated that "the

cow hotels are too far" or "there are no cow hotels in their village." Nearly 10% stated simply that "their herd size is too small."

Overall, these results suggest that during the first year after the crisis, the government policies have been effective in moving some of the backyard farmers into cow hotels (although 60% farmers remained backyard producing). Policy and research questions remain, however, about what will happen to the cow hotels in the long run, as the dairy industry recovers from the crisis shock. Is this production structure sustainable? Will the number of cow hotel producers continue to grow? Will the smaller farms be more interested in joining cow hotels? Are quality and safety improved for products of cow hotels? These are important issues for future study.

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Table 1. The structure of dairy production in rural villages in the Greater Beijing area before and after the Milk Scandal (August 2008-September 2009).

	Sample size[a]	Backyard producers (%)[b]	Cow hotel producers (%)	Exited the dairy sector (%)
Aug. 2008 [c]	121	98	2	0
Sep. 2008 [c]	121	98	2	1
Oct. 2008 [c]	121	79	17	3
Jan. 2009 [c]	121	74	20	7
May. 2009 [c]	121	65	24	12
Sep.2009 [c]	121	60	26	14

Note:

[a] The total sample size is 121, which include all the households who engaged in dairy production in August 2008.

[b] The figures in this table are all month-end data.

[c] Each row of three percentage figures should add up to 100. All farmers (who were in dairy production before the Milk Scandal) must be in one (and only one) of the three categories (engaged in backyard production; producing in a cow hotel; exited from dairy production). Some rows add to 101 or 99 because of rounding.

Source: authors' own survey (2009).

Table 2. Townships that have received policy directives for Cow Hotel Policy and Marketing Management Policy in Greater Beijing between August 2008 and September 2009.

Policy variables	Number of townships[a]	Number of townships that have received the policy directives in or before the following months[b]					
		Aug. 2008	Sep. 2008	Oct. 2008	Jan. 2009	May. 2009	Sep. 2009
Cow Hotel Policy	14	0	0	8	12	13	13
Marketing Management Policy	14	0	0	9	9	9	9

Note:

[a] The total township size is 14, which include all the townships that have dairy farmers in August 2008.

[b] The figures in this table are all month-end data.

Source: authors' own survey (2009).

Table 3. Percentage change of cow hotel producers in Greater Beijing by month in which policies were implemented in the township from August 2008 to September 2009.

Policy variables	No. of townships	No. of households	Cow hotel producers (%)[c]					
			Aug. 2008	Sep. 2008	Oct. 2008	Jan. 2009	May. 2009	Sep. 2009
Cow Hotel Policy [a]								
No	1	7	0	0	0	0	0	0
Yes	13	114	2	2	18	24	25	27
Marketing Management Policy [b]								
No	5	23	4	4	4	4	9	13
Yes	9	98	1	1	20	27	28	29

Note:

[a] In order to give a rough comparison between the townships in which the policies were implemented and the ones in which they were not, the Cow Hotel Policy takes its value in September 2009 (the last period of our sample). Therefore, "No" indicates that the township government had not received policy directives by September 2009 and "Yes" indicates that the township government had received policy directives by September 2009.

[b] The Marketing Management Policy is created in the same way as the Cow hotel Policy (see the note above).

[c] The figures in this table are all month-end data.

Table 4. Percentage of cow hotel producers by township policies in September 2009 and pre-Scandal herd size terciles.

Policy variable	No. of households	Cow hotel producers (%) by terciles of pre-Scandal herd size [c][d]		
		Herd size ≤5	Herd size >5 and ≤10	Herd size >10
Cow Hotel Policy [a]				
No	7		0	0
Yes	114	16	24	50
Marketing Management Policy [b]				
No	23	11	0	33
Yes	98	18	28	46

Note:

[a] In order to give a rough comparison between the townships in which the policies were implemented and the ones in which they were not, the Cow Hotel Policy takes its value in September 2009 (the last period of our sample). Therefore, "No" indicates that the township government had not received policy directives by September 2009 and "Yes" indicates that the township government had received policy directives by September 2009.

[b] The Marketing Management Policy is created in the same way as the Cow hotel Policy (see the note above).

[c] The figures in this table are all month-end data.

[d] In this table, we look at how farms with different herd sizes have responded to the different policies that have been implemented in response to the Milk Scandal. This is done by linking farm size with post-Scandal production structures (cow hotel, backyard production and quitting dairy production) given the specific policies that farmers were exposed to.

Table 5. Percentage of backyard producers, cow hotel producers and those that exited the dairy industry by pre-Scandal characteristics in Greater Beijing area.

	Categories below and above the median	No. of households	Cow hotel producers (%)	Backyard producers (%)	Exited the dairy sector (%)
Herd size (number of cows)					
1	≤7	67	18	66	16
2	>7	54	35	54	11
Education (years)					
3	≤6	51	29	57	14
4	>6	70	23	63	14
Age (years)					
5	≤35	62	29	58	13
6	>35	59	22	63	15
Asset value per capita (1000 yuan)					
7	≤1.14	60	30	57	13
8	>1.14	61	21	64	15
Percentage of off-farm labor					
9	≤25%	62	29	58	13
10	>25%	59	22	63	15
Dairy training					
11	No	86	20	65	15
12	Yes	35	40	49	11
Villagers in dairy company					
13	No	76	33	53	14
14	Yes	45	13	73	13
Percentage of dairy households in the village					
15	≤15.7	62	23	53	24
16	>15.7	59	29	68	3

Note: We do not include the post-Scandal characteristics as controls because they may be affected by the policies that were implemented to counter the Milk Scandal. If these characteristics are also correlated with the production decisions of farmers (that is, if the farmer moved his/her dairy cows into the cow hotel), they might not act as efficiency-enhancing control variables in our regressions (Angrist and Pischke, 2008).

Table 6. Results of multivariate analysis estimating the effect of Cow Hotel and Marketing Management policies on cow hotel production in Greater Beijing from August 2008 to September 2009 (OLS with township fixed effects).

	Dependent variable: Cow hotel producer, =1 yes, =0 no										
		1	2	3	4	5	6	7	8	9	10
1.	Cow Hotel Policy: (Yes=1;No=0)		0.16*** [4.50]		0.09*** [3.18]	0.11*** [3.27]		0.16*** [4.47]		0.09*** [3.16]	0.11*** [3.25]
2.	Marketing Management Policy: (Yes=1;No=0)			0.20*** [4.86]	0.17*** [4.55]	0.23*** [4.54]			0.20*** [4.83]	0.17*** [4.53]	0.23*** [4.52]
3.	Herd Size						0.00 [1.28]	0.00 [1.28]	0.00 [1.28]	0.00 [1.28]	0.00 [1.28]
4.	Dairy crisis (1=months after Sept. 2008; 0=months before)	0.16*** [4.69]				-0.09** [-2.44]	0.16*** [4.66]				-0.09** [-2.43]
5.	Education (years)						0.00 [0.16]	0.00 [0.16]	0.00 [0.16]	0.00 [0.16]	0.00 [0.16]
6.	Age (years)						-0.00** [-2.00]	-0.00** [-2.00]	-0.00** [-2.00]	-0.00** [-2.00]	-0.00** [-2.00]
7.	Percentage of off-farm labor						-0.21** [-2.53]	-0.21** [-2.53]	-0.21** [-2.53]	-0.21** [-2.53]	-0.21** [-2.52]
8.	Asset value per capita (1000 yuan)						-0.04*** [-3.15]	-0.04*** [-3.15]	-0.04*** [-3.15]	-0.04*** [-3.15]	-0.04*** [-3.15]
9.	Dairy Training						0.08 [1.55]	0.08 [1.55]	0.08 [1.55]	0.08 [1.55]	0.08 [1.55]
10.	Villagers in dairy company						-0.05 [-0.33]	-0.05 [-0.33]	-0.05 [-0.33]	-0.05 [-0.33]	-0.05 [-0.33]
11.	Percentage of dairy households in the village						0.01 [1.19]	0.01 [1.19]	0.01 [1.19]	0.01 [1.19]	0.01 [1.19]
12.	Time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13.	Township effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14.	N	726	726	726	726	726	726	726	726	726	726
15.	R²	0.32	0.32	0.33	0.34	0.34	0.39	0.39	0.41	0.41	0.41

Note: t-statistics in brackets; * significant at 10%; **significant at 5%; ***significant at 1%. The regression model that includes variables that measure both the Cow Hotel Policy and the Marketing Management Policy (as well as a full set of control variables) is shown in the last column of the table.

Table 7. Results of multivariate analysis estimating the effect of Cow Hotel and Marketing Management policies on backyard production in Greater Beijing from August 2008 to September 2009 (OLS with township fixed effects).

Dependent variable: Backyard producer, =1 yes, =0 no

		1	2	3	4	5	6	7	8	9	10
1.	Cow Hotel Policy(Yes=1;No=0)		-0.18*** [-4.20]		-0.14*** [-3.32]	-0.10** [-2.28]		-0.18*** [-4.18]		-0.14*** [-3.30]	-0.10** [-2.27]
2.	Marketing Management Policy (Yes=1;No=0)			-0.15*** [-3.21]	-0.09** [-2.09]	0.00 [-0.04]			-0.15*** [-3.19]	-0.09** [-2.08]	-0.00 [-0.04]
3.	Herd size						-0.00 [-0.08]	-0.00 [-0.08]	-0.00 [-0.08]	-0.00 [-0.08]	-0.00 [-0.08]
4.	Dairy crisis (1=months after Sept. 2008; 0=months before)	-0.18*** [-4.76]				-0.12 [-1.64]	-0.18*** [-4.74]				-0.12 [-1.63]
5.	Education (years)						0.02* [1.75]	0.02* [1.75]	0.02* [1.75]	0.02* [1.75]	0.02* [1.75]
6.	Age (years)						0.01** [2.52]	0.01** [2.52]	0.01** [2.52]	0.01** [2.52]	0.01** [2.52]
7.	Percentage of off-farm labor						0.08 [0.67]	0.08 [0.67]	0.08 [0.67]	0.08 [0.67]	0.08 [0.67]
8.	Asset value per capita (1000 yuan)						0.04*** [3.17]	0.04*** [3.17]	0.04*** [3.17]	0.04*** [3.17]	0.04*** [3.16]
9.	Dairy Training						-0.06 [-1.19]	-0.06 [-1.19]	-0.06 [-1.19]	-0.06 [-1.19]	-0.06 [-1.19]
10.	Villagers in dairy company						-0.05 [-0.27]	-0.05 [-0.27]	-0.05 [-0.27]	-0.05 [-0.27]	-0.05 [-0.27]
11.	Percentage of dairy households in the village						-0.00 [-0.64]	-0.00 [-0.64]	-0.00 [-0.64]	-0.00 [-0.64]	-0.00 [-0.64]
12.	Time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13.	Township effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14.	N	726	726	726	726	726	726	726	726	726	726
15.	R^2	0.29	0.29	0.29	0.29	0.30	0.35	0.35	0.35	0.35	0.36

Note: t-statistics in brackets; * significant at 10%; **significant at 5%; ***significant at 1%. The regression model that includes variables that measure both the Cow Hotel Policy and the Marketing Management Policy (as well as a full set of control variables) is shown in the last column of the table.

Table 8. Results of multivariate analysis estimating the effect of Cow Hotel and Marketing Management policies on quitting dairy production in Greater Beijing from August 2008 to September 2009 (OLS with township fixed effects).

Dependent variable: Exited the dairy sector, =1 yes, =0 no

		1	2	3	4	5	6	7	8	9	10
1.	Cow Hotel Policy (Yes=1;No=0)		0.02 [0.83]		0.05 [1.31]	-0.01 [-0.32]		0.02 [0.74]		0.05 [1.54]	-0.01 [-0.34]
2.	Marketing Management Policy (Yes=1;No=0)			-0.05 [-1.55]	-0.08 [-1.58]	-0.23*** [-6.78]			-0.05** [-2.26]	-0.08** [-2.32]	-0.23*** [-2.99]
3.	Herd size						-0.00** [-2.34]	-0.00** [-2.34]	-0.00** [-2.34]	-0.00** [-2.34]	-0.00** [-2.34]
4.	Dairy crisis (1=months after Sept. 2008; 0=months before)	0.02 [1.27]				0.21*** [4.86]	0.02 [1.07]				0.21*** [2.89]
5.	Education (years)						-0.02** [-2.40]	-0.02** [-2.40]	-0.02** [-2.40]	-0.02** [-2.40]	-0.02** [-2.40]
6.	Age (years)						-0.00 [-1.32]	-0.00 [-1.32]	-0.00 [-1.32]	-0.00 [-1.32]	-0.00 [-1.32]
7.	Percentage of off-farm labor						0.13 [1.41]	0.13 [1.41]	0.13 [1.41]	0.13 [1.41]	0.13 [1.41]
8.	Asset value per capita (1000 yuan)						-0.01 [-0.91]	-0.01 [-0.91]	-0.01 [-0.91]	-0.01 [-0.90]	-0.01 [-0.90]
9.	Dairy Training						-0.01 [-0.39]	-0.01 [-0.39]	-0.01 [-0.39]	-0.01 [-0.39]	-0.01 [-0.39]
10.	Villagers in dairy company						0.10 [1.27]	0.10 [1.27]	0.10 [1.27]	0.10 [1.27]	0.10 [1.27]
11.	Percentage of dairy households in the village						-0.00 [-0.95]	-0.00 [-0.95]	-0.00 [-0.95]	-0.00 [-0.95]	-0.00 [-0.95]
12.	Time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13.	Township effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14.	N	726	726	726	726	726	726	726	726	726	726
15.	R²	0.13	0.13	0.13	0.14	0.16	0.19	0.19	0.19	0.20	0.22

Note: t-statistics in brackets; * significant at 10%; **significant at 5%; ***significant at 1%. The regression model that includes variables that measure both the Cow Hotel Policy and the Marketing Management Policy (as well as a full set of control variables) is shown in the last column of the table.

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Table 9. Results of multivariate analysis estimating the heterogeneous effects of Cow Hotel and Marketing Management policies on cow hotel production in Greater Beijing from August 2008 to September 2009 (OLS with township fixed effects).

	Dependent variable: Cow hotel producer, =1 yes, =0 no						
		1	2	3	4	5	6
1.	Cow Hotel Policy (Yes=1;No=0)	0.15*** [2.97]	0.07* [1.66]			0.08** [2.54]	0.11*** [3.02]
2.	Cow Hotel Policy * Herd size	0.00 [0.53]	0.00 [0.49]			0.00 [0.47]	0.00 [0.70]
3.	Marketing Management Policy (Yes=1;No=0)			0.08 [1.47]	0.09 [1.54]	0.05 [0.93]	0.12* [1.90]
4.	Marketing Management Policy * Herd size			0.01*** [3.03]	0.01*** [3.03]	0.01*** [3.08]	0.01*** [3.08]
5.	Herd size	0.00 [1.09]	0.00 [1.14]	0.00 [0.46]	0.00 [0.46]	-0.00 [-0.15]	-0.00 [-0.35]
6.	Dairy crisis (1=months after Sept. 2008; 0=months before)		0.11*** [3.70]		-0.01 [-0.68]		-0.10** [-2.57]
7.	Education (years)	0.00 [0.16]	0.00 [0.16]	0.00 [0.20]	0.00 [0.20]	0.00 [0.20]	0.00 [0.20]
8.	Age (years)	-0.00** [-1.99]	-0.00** [-1.99]	-0.00* [-1.72]	-0.00* [-1.72]	-0.00* [-1.71]	-0.00* [-1.71]
9.	Percentage of off-farm labor	-0.21** [-2.53]	-0.21** [-2.52]	-0.20** [-2.50]	-0.20** [-2.50]	-0.20** [-2.50]	-0.20** [-2.50]
10.	Asset value per capita (1000 yuan)	-0.04*** [-3.12]	-0.04*** [-3.12]	-0.03*** [-3.08]	-0.03*** [-3.08]	-0.03*** [-3.06]	-0.03*** [-3.05]
11.	Dairy Training	0.08 [1.55]	0.08 [1.55]	0.07 [1.47]	0.07 [1.47]	0.07 [1.47]	0.07 [1.47]
12.	Villagers in dairy company	-0.05 [-0.32]	-0.05 [-0.33]	-0.07 [-0.52]	-0.07 [-0.52]	-0.07 [-0.52]	-0.07 [-0.52]
13.	Percentage of dairy households in the village	0.01 [1.18]	0.01 [1.18]	0.01 [1.47]	0.01 [1.47]	0.01 [1.46]	0.01 [1.46]

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14.	Time trend	Yes	Yes	Yes	Yes	Yes	Yes
15.	Township effects	Yes	Yes	Yes	Yes	Yes	Yes
16.	N	726	726	726	726	726	726
17.	R²	0.39	0.40	0.43	0.43	0.43	0.44

Note: t-statistics in brackets; * significant at 10%; **significant at 5%; ***significant at 1%.

The regression model that includes variables that measure both the Cow Hotel Policy and the Marketing Management Policy (as well as a full set of control variables) is shown in the last column of the table.

In this table, we look at how farms with different herd sizes have responded to the different policies that have been implemented in response to the Milk Scandal. This is done by linking farm size with post-Scandal production structures (cow hotel, backyard production and quitting dairy production) given the specific policies that farmers were exposed to.

Table 10. Results of multivariate analysis estimating the heterogeneous effects of Cow Hotel and Marketing Management policies on backyard production in Greater Beijing from August 2008 to September 2009 (OLS with township fixed effects).

	Dependent variable: Backyard producer, =1 yes, =0 no	1	2	3	4	5	6
1.	Cow Hotel Policy (Yes=1;No=0)	-0.18*** [-3.35]	-0.10* [-1.96]			-0.16*** [-3.09]	-0.13** [-2.56]
2.	Cow Hotel Policy * Herd size	0.00 [0.02]	0.00 [0.07]			0.00 [0.53]	0.00 [0.68]
3.	Marketing Management Policy (Yes=1;No=0)			-0.04 [-0.66]	0.12 [1.18]	0.02 [0.34]	0.11 [1.09]
4.	Marketing Management Policy * Herd size			-0.01** [-2.46]	-0.01** [-2.45]	-0.01*** [-2.63]	-0.01*** [-2.62]
5.	Herd size	-0.00 [-0.13]	-0.00 [-0.18]	0.00 [1.42]	0.00 [1.42]	0.00 [0.66]	0.00 [0.44]
6.	Dairy crisis (1=months after Sept. 2008; 0=months before)		-0.13*** [-3.52]		-0.19*** [-2.66]		-0.12 [-1.58]
7.	Education (years)	0.02* [1.75]	0.02* [1.75]	0.02* [1.74]	0.02* [1.74]	0.02* [1.73]	0.02* [1.73]
8.	Age (years)	0.01** [2.52]	0.01** [2.52]	0.01** [2.27]	0.01** [2.27]	0.01** [2.26]	0.01** [2.26]
9.	Percentage of off-farm labor	0.08 [0.67]	0.08 [0.67]	0.07 [0.63]	0.07 [0.63]	0.07 [0.63]	0.07 [0.63]
10.	Asset value per capita (1000 yuan)	0.04*** [3.16]	0.04*** [3.16]	0.04*** [3.08]	0.04*** [3.07]	0.04*** [3.06]	0.04*** [3.06]
11.	Dairy Training	-0.06 [-1.19]	-0.06 [-1.19]	-0.06 [-1.14]	-0.06 [-1.13]	-0.06 [-1.13]	-0.06 [-1.13]
12.	Villagers in dairy company	-0.05 [-0.27]	-0.05 [-0.27]	-0.03 [-0.15]	-0.03 [-0.15]	-0.02 [-0.14]	-0.02 [-0.14]
13.	Percentage of dairy households in the village	0.00	0.00	0.00	0.00	0.00	0.00

		[-0.64]	[-0.64]	[-0.82]	[-0.82]	[-0.83]	[-0.83]
14.	Time trend	Yes	Yes	Yes	Yes	Yes	Yes
15.	Township effects	Yes	Yes	Yes	Yes	Yes	Yes
16.	N	726	726	726	726	726	726
17.	R^2	0.35	0.36	0.36	0.37	0.37	0.37

Note: t-statistics in brackets; * significant at 10%; **significant at 5%; ***significant at 1%.

The regression model that includes variables that measure both the Cow Hotel Policy and the Marketing Management Policy (as well as a full set of control variables) is shown in the last column of the table.

In this table, we look at how farms with different herd sizes have responded to the different policies that have been implemented in response to the Milk Scandal. This is done by linking farm size with post-Scandal production structures (cow hotel, backyard production and quitting dairy production) given the specific policies that farmers were exposed to.

Table 11. Results of multivariate analysis estimating the heterogeneous effects of Cow Hotel and Marketing Management policies on quitting dairy production in Greater Beijing from August 2008 to September 2009 (OLS with township fixed effects).

	Dependent variable: Exited the dairy sector, =1 yes, =0 no	1	2	3	4	5	6
1.	Cow Hotel Policy (Yes=1;No=0)	0.04 [1.18]	0.03 [0.83]			0.08* [1.71]	0.02 [0.49]
2.	Cow Hotel Policy * Herd size	-0.00 [-1.50]	-0.00 [-1.52]			-0.00 [-1.63]	-0.00** [-2.23]
3.	Marketing Management Policy (Yes=1;No=0)			-0.04 [-0.94]	-0.21** [-2.42]	-0.07 [-1.35]	-0.23** [-2.59]
4.	Marketing Management Policy * Herd size			-0.00 [-0.66]	-0.00 [-0.66]	-0.00 [-0.40]	-0.00 [-0.40]
5.	Herd size	-0.00 [-1.46]	-0.00 [-1.45]	-0.00** [-2.04]	-0.00** [-2.04]	-0.00 [-1.03]	-0.00 [-0.33]
6.	Dairy crisis (1=months after Sept. 2008; 0=months before)		0.01 [0.67]		0.20*** [2.84]		0.22*** [3.03]
7.	Education (years)	-0.02** [-2.40]	-0.02** [-2.40]	-0.02** [-2.40]	-0.02** [-2.39]	-0.02** [-2.39]	-0.02** [-2.39]
8.	Age (years)	0.00 [-1.33]	0.00 [-1.32]	0.00 [-1.34]	0.00 [-1.34]	0.00 [-1.33]	0.00 [-1.33]
9.	Percentage of off-farm labor	0.13 [1.42]	0.13 [1.42]	0.13 [1.41]	0.13 [1.41]	0.13 [1.42]	0.13 [1.42]
10.	Asset value per capita (1000 yuan)	-0.01 [-0.92]	-0.01 [-0.92]	-0.01 [-0.93]	-0.01 [-0.93]	-0.01 [-0.93]	-0.01 [-0.94]
11.	Dairy Training	-0.01 [-0.40]	-0.01 [-0.39]	-0.01 [-0.37]	-0.01 [-0.37]	-0.01 [-0.38]	-0.01 [-0.38]
12.	Villagers in dairy company	0.10 [1.26]	0.10 [1.26]	0.10 [1.28]	0.10 [1.28]	0.10 [1.25]	0.10 [1.25]
13.	Percentage of dairy households in the village	0.00 [-0.95]	0.00 [-0.94]	0.00 [-0.98]	0.00 [-0.98]	0.00 [-0.95]	0.00 [-0.94]

14.	Time trend	Yes	Yes	Yes	Yes	Yes	Yes
15.	Township effects	Yes	Yes	Yes	Yes	Yes	Yes
16.	N	726	726	726	726	726	726
17.	R^2	0.19	0.19	0.19	0.22	0.20	0.22

Note: t-statistics in brackets; * significant at 10%; **significant at 5%; ***significant at 1%.

The regression model that includes variables that measure both the Cow Hotel Policy and the Marketing Management Policy (as well as a full set of control variables) is shown in the last column of the table.

In this table, we look at how farms with different herd sizes have responded to the different policies that have been implemented in response to the Milk Scandal. This is done by linking farm size with post-Scandal production structures (cow hotel, backyard production and quitting dairy production) given the specific policies that farmers were exposed to.

Appendix 1. Descriptive statistics of the cow hotels in the Greater Beijing in September 2009.

		Mean	Std. Dev.	Min	Max
1	Total herd size	795.6	789.8	150	2400
2	Herd size per household	28.6	28.1	10	100
3	Geographic source of farmers (%)				
4	Within local village	52.3	36.4	0	96
5	Neighborhood villages in local town	26.2	20.6	2	55.93
6	Other towns in county	11.4	14.4	0	36.36
7	Other counties	2.3	6	0	18.18
8	Investment per farm (1000 yuan)	151.3	175.7	23.82	600
9	Invested by (%)				
10	Private person	61.4	46.8	0	100
11	Dairy farmers	6.7	20	0	60
12	Dairy processing firms	0	0	0	0
13	Government	19.7	28.1	0	67
14	The cow hotel standardizes (%)				
15	Concentrated feed	67	50	0	100
16	Breeding	44	53	0	100
17	Quarantine and disease control	100	0	100	100
18	Waste management	22	44	0	100
19	Milk procurement (%)				
20	Contract with cow hotel farmers	100	0	100	100
21	Test raw milk safety	78	44	0	100
22	Sales (%)				
23	Written contract with buyers	100	0	100	100
24	The buyer sends staff for supervision	100	0	100	100
25	The buyer tests the safety of raw milk	100	0	100	100

Note: The number of cow hotels in our sample is 9 by the time of our survey.

[1] In this section, we primarily review the Lu and Tao (2009) case study which seeks to explain, among other things, why milk suppliers (traders and milk collection stations) began to add melamine to the milk supply. We include this as part of the background for the uninformed reader to allow him/her to better understand the full context of our study. In some sense, however, the story by Lu and Tao should be considered a hypothesis. The motivation, goal, approach and findings of this paper do not rely on why melamine was added (or even who added). We are focused on what happened after the melamine was added, discovered and the fallout from the scandal sent the dairy industry into crisis.

[2] Details of the Greater Beijing Horticulture and Marketing Survey can be found in Huang et al. (2010).

[3] In executing the second round of the panel survey we were able to trace 231 of the original 243 sample households. This implies that the attrition rate was only five percent. For panel surveys that are fielded four years apart, such an attrition rate is low. Glewwe and Jacoby (2000) reviewed panel surveys conducted in developing countries and found that in the case of many panel surveys that are fielded four years and more apart, attrition rates range from 6% to 43%. To make sure that the absence of the five percent of the households did not create any selection bias in our sample, during the survey to the best of our ability we documented the reasons for not being able to find the households for the re-survey. Among the 12 households that dropped out, four had moved out of the village (to the city); four households were engaged in off-farm activities that kept them out of the village most of the year (e.g., as long distance truck drivers); and four households had disappeared due to the death (or severe illness) of the household head. Of the 12 households that had dropped out, four were dairy households in 2004. In an analysis of the differences of the characteristics between households that had dropped out and those that remained in the sample, our data show that the surveyed/attrited households do not differ in terms of education and age of head, asset value per capita or land per capita.

[4] A few cow hotels were self-organized by dairy producers before the Scandal. In late 1980s, the initial type that is similar with cow hotels emerged in some villages where livestock production has reached certain scale (China Livestock Press, 2005). It evolved into the current type only after 2000.