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China's Milk Scandal, government policy and production decisions of dairy farmers: The case of Greater Beijing

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ABSTRACT

During the summer of 2008 China's biggest food crisis struck when it was discovered that milk suppliers were adding melamine, a colorless crystalline compound, to artificially boost the protein readings of their milk. While there was a lot of attention on the criminal investigations and post scandal industrial shake up, less is known about the impact of the Milk Scandal and policy response on the dairy farmer. The main objectives of this study are to describe the policies that were implemented by the government in response to the Milk Scandal and analyze the effect of the policies on dairy producers. To meet the objectives of the study, the paper uses a primary data set collected by the authors in 25 dairy producing villages, including 231 households, in the Greater Beijing area. The data set documents the policies that were implemented by the government as well as the response of the dairy farmers—both their participation in the dairy sector (stay in or drop out) and their herd size. Using descriptive and multivariate analyses on the changes in dairy production in the sample villages, the paper finds that, although dairy participation fell and herd sizes were reduced after the Milk Scandal, government policies did matter. Specifically, Marketing Management Policies were shown to have limited the fall in both participation and herd size. Production Management Policies had less of an effect in keeping dairy producers participating in the production of milk. The implementation of Crisis Income Management was correlated with a stronger decline in participation and herd size.

Introduction

During the summer of 2008 China's biggest food crisis struck when it was discovered that milk suppliers (in this study milk suppliers are defined as traders and milk collection stations, not small dairy farmers) were adding melamine, a colorless crystalline compound, to artificially boost the protein readings of their milk (BBC, 2008; Xinhua News, 2008a). The story which ended up affecting food supplies in scores of nations and every one of China's provinces mostly focused on thousands affected children that reportedly became sick and the alarming death toll (China Ministry of Health, 2008).

Somewhat less known is the impact of the *Milk Scandal*, as we will call it through the rest of the paper, on the dairy industry, especially on the farm sector. Mostly poor, small-scale farmers with less than 10 cows, on average, the dairy producers were the other victims (Barboza, 2008). They were not the ones to add melamine, an action which required one to execute a relatively sophisticated chemical procedure before the melamine could be dissolved in milk (Wong, 2008). But, in the wake of the crisis government regulators shut down plants, barred collection stations from buying milk, and implemented new regulations (ChinaNews, 2008). Such actions fractured supply chains and left farmers with no buyers for their output (NDRC, 2008). Even if the institutional structure on the milk collection/marketing side had been intact, it would not have mattered; distrusting consumers dramatically reduced demand and there were fewer people drinking the milk being produced (NDRC, 2008). Reports were rampant that small dairy farmers had no option but to dump their milk as government policy makers sought to rebuild the nation's dairy industry.

China's government responded on many fronts as the Milk Scandal unfolded. The most highly publicized policy efforts were targeted at restoring a marketing chain that was able to deliver safe milk to processing plants (Xinhua News, 2008a). However, there also was concern during the early stages of the Milk Scandal that poor, small farmers would be hurt (Barboza, 2008). The government was supposed to have acted on at least three fronts: (a) creating and implementing regulations on milk buying and delivery, including actions taken to invest in upgrading buying/collection stations

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(*Marketing Management Policies*); (b) creating new and upgrading existing production environments, called dairy producing complexes, that would allow for the more concentrated production and collection of raw milk (which theoretically could allow for more effective regulation and more efficient production—*Production Management Policies*); and (c) offering payments to compensate small dairy farmers for the damages that they occurred, especially because they were forced to dump their milk (henceforth, *Crisis Income Management Policies*).

There has been some attention in the literature given to these policies and their impact (Gale and Hu, 2009; Li et al., 2010; Yang et al., 2009). This literature, however, is mostly based on anecdotes and there has not been any attempt to rigorously measure if policies were actually implemented and if they had any impact on dairy producers.

Specifically, this paper has three objectives. First, we trace the patterns of dairy production before and after the Milk Scandal. Second, we describe the policies that were implemented by the government in response to the Milk Scandal. Third, we analyze the effect of the policies on dairy producers.

To meet the goals and objectives of the study, the rest of the paper is organized as follows. In the next section we provide a brief background—on the nature of China's dairy industry and a review of what happened during the Milk Scandal. The following section describes our overall methodological approach, including our data set, the definition of the variables and the econometric model. The final two sections present the results and conclude.

China's Dairy Industry and the Milk Scandal

Demand and supply of dairy has changed dramatically during the past two decades. In the 1990s, there was only one major commodity that China's consumers were under-consuming: dairy (Garnaut and Ma, 1993). The average urban resident in 1992 consumed nine kilograms per capita of dairy products, only a fraction of 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. From the mid-1990s to the mid-2000s the growth of dairy production accelerated to nearly 20% annually (Liu, 2003–2010).

By any measure, China's dairy industry mostly depends on small, poor farmers (Huang et al., 2010). 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, the average herd size per family rose only gradually (Liu, 2003–2010). In the mid 2000s more than 80% of the dairy cows were owned by small households scattered across the country (Lu and Tao, 2009). Commercialization pressures and other changes in the production environment contributed to a reversal of the number of dairy farmers since the mid-2000s (even though the total size of the herd continued to rise). According to China's Dairy Yearbook (Liu, 2003–2010), in many provinces in northern China (e.g., Liaoning, Tianjin and Hebei) between 2006 and 2007 the total number of dairy households either fell or was essentially stagnant.

To procure, transport and process China's milk, a competitive downstream segment of the dairy industry emerged (Lu and Tao, 2009). Foreign firms and large corporations, mixed with small-scale local firms, invested in 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. As dairy expanded, competition within China's major dairy markets intensified. During the 2000s inter-regional competition 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

The competition (described above) began to exert downward pressure on product prices (Lu and Tao, 2009). 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 by which they were being squeezed to milk-collection stations and dairy farmers. With feed prices going up in 2006, 40% of dairy farmers were losing money in 2006; 30% were just breaking even. In response, at the very time dairy processing firms demanded more milk to meet rising demand some farmers were culling their herds (because milking cows were unprofitable, inducing them to sell them for meat). This reduction in (or slow down in the expansion of) the dairy herd aggravated the tight milk supply in China. In early 2007 the new shortage of milk supplies threatened to push up the price of milk products. This supply-induced price pressure, however, began at exactly the same time that the government was taking actions to stem inflation. 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 dairy farmers continued to be squeezed. Enter melamine.

While a full description of the scandal is beyond the scope of this paper (and, in fact, has been done elsewhere quite succinctly—e.g., Lu and Tao, 2009), the Milk Scandal occurred when a number of milk suppliers (mostly traders and milk collection stations) began adding melamine to artificially boost the protein readings of their milk. 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).

Besides the impact on human health (that was widely reported in the popular press), one aspect of the 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 crisis, as might be expected, farmers were hit hard and by a number of different factors. First, and most directly, as the crisis was unfolding, one of the first responses of government regulators was to shut down production in suspected dairy processing firms (Ministry of Industry and Information Technology, 2008). This means that in many cases there was an immediate impact on producers since many dairy households could find no one else to procure their milk.

While the shutdown of processing firms by regulators in the immediate aftermath of the crisis 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. Production followed. Nationwide, after growth of production between 2006 and 2007 of more than 3.3 million tons (10% 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 affect small dairy farmers, we can see several regularities. First, there was an acceleration in the fall in the number of dairy farmers. In the provinces that publish time series data on the number of dairy farmers (not all provinces do), although the number of dairy farmers had begun to stagnate or fall between 2006 and 2007 (before the crisis), there was a sharp drop in the number of dairy households reported at the end of 2008, compared to 2007. In Tianjin the number of dairy-producing households fell between 2007 and 2008 by 5% (Liu, 2003–2010). In Liaoning the number of dairy-producing households fell by 23%. Second, there also was widespread reporting of farmers that were forced to discard their milk, pouring it into

landfills, fields and dry riverbeds. Finally, a crisis in the dairy sector meant a crisis for many communities and the poor farmers inside them.

Policy response

In response to both the consumer and producer crises that were triggered by the Milk Scandal, the government's top leader, Premiere Wen Jiabao, made a public announcement that addressed the crisis' many dimensions. 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 and Tao, 2009, p. 1).

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 and the entire food safety regulation is affected in China (Pei et al., 2011), in the case of the responses directed at producers they can be divided into three main types: Marketing Management; Production Management; and Crisis Income Management.

Marketing Management Policies

Marketing Management Policies were at the heart of one of the government's most immediate and longer-term restructuring response, since it was not long into the crisis that it was becoming clear that a large share of the contamination was occurring in the collection station/mid-chain marketing agency segment of the supply chain. The first part of the policy response, no doubt, was focused at containing the problem and bringing the crisis to an end on the supply side. On October 10, 2008 the State Council of China issued the "Regulation on the Supervision and Administration of Dairy Product Quality and Safety" (henceforth, the Quality Regulation) to regulate dairy production, processing and marketing. The Quality Regulation was focused mainly on the inspection of all milk buyers and collection stations. To implement the regulation, the Ministry of Agriculture, at the direction of the State Council, sent 150,000 officials to inspect the buying and preprocessing segments of the marketing chain (General Office of China's State Council, 2008). Milk stations that failed inspection were closed down (either permanently or temporarily).

The second part of the Marketing Management Policies, however, was directed at getting the supply chain running again. The government recognized milk collection stations, buyers and transportation firms that passed the inspection with a seal of approval. They immediately instituted a nationwide set of testing standards and offered training to collection station managers so milk procurement could be re-started and revitalized. On November 19, 2008, the State Council announced the "Plan for Rectifying and Revitalizing China's Dairy Industry" (henceforth, the Plan) to stabilize China's depressed dairy industry.

To execute the Plan, inspectors were placed in the collection stations with the mandate to not only ensure food safety but to begin the process of re-building the marketing linkages between producers and dairy processors. Government agencies also offered subsidized loans and gave grants to collection stations in order to bring their facilities up to standard and enhance milk quality through the marketing chain. Clearly, although China's Marketing Management Policies initially may have led to disruptions of the supply chain as some milk stations were shut down and dairy farmers found nowhere to sell milk (Barboza, 2008; China Daily, 2009), when officials put their efforts into improving the marketing and handling of those milk stations that passed inspection, a large number of them were renovated, re-invested in and enlarged. The purpose of the Plan, this second part of the Marketing Management Policies, ultimately was to help dairy processing firms get access to higher quality, safe milk from the milk stations and from the large number of smallholder dairy farmers that characterized China's production environment.

Production Management Policies

Whether warranted or not, the small farmer-dominated, fractured structure of China's dairy sector is thought to be (at least in part) at fault for the crisis—either directly or indirectly (NDRC, 2008). As a result, the government also took action to change the structure of dairy production in China. In particular, on October 10, 2008 the Hebei government issued the "The Bill for Regulating and Restructuring the Dairy Industry in Hebei province" (henceforth, Hebei Dairy Production Management Policy, 2008). According to the Bill, backyard farming in Hebei was officially put on notice: small, backyard farmers were to be phased out. Farmers were ordered to move their cows into approved complexes—both publicly and privately managed—so their production practices could be monitored and more modern production practices aimed at producing more sanitary, higher quality milk could be implemented.

To implement the Production Management Policies, dairy industry demanded the localities take three actions (Hebei Dairy Production Management Policy, 2008). First, village leaders councils and township governments were supposed to document the location of all dairy cows. Individual households with production in the home (that is, operating as backyard dairy farmers) were supposed to move their cows into the approved dairy complexes. The second part of the Production Management Policies was focused on investing in and otherwise assisting the owners and managers of the dairy complexes to expand and modernize their operations (Hebei Dairy Production Management Policy, 2008). To meet these goals, government agencies also offered subsidized loans and gave grants to the dairy complexes. Finally, efforts were made to create linkages between approved dairy buyers, approved processors and the dairy complexes (Hebei Dairy Production Management Policy, 2008). For example, officials often held meetings to sketch out partnerships between the dairy complexes and processors (and buyers).

Crisis Income Management (producer subsidies)

In the initial weeks after the discovery of the crisis (e.g., in late September), in part, because regulators were not sure in what part of the supply chain was melamine being added (and, in part, due to the collapse of buyer networks because of factory closures), national government officials in some regions directed dairy farmers in China to dispose of their milk (Xinhua News, 2008b). In other regions, for example in the suburban counties and districts of Beijing, milk dumping was directed by the local government (BJNEWS, 2008). According to China's Ministry of Agriculture (MOA), it was estimated that, shortly after the Milk Scandal was disclosed, approximately 2000 tons of milk were destroyed per day in Hebei province alone (Sohu News, 2008).

Government officials were also cognizant that even if the melamine scandal could be tied back to farm-level producers, that there would be an income crisis at a time that the government was committing large amounts of resources to improve rural incomes (Huang et al., 2011). Hence, at the same time that officials were overseeing the destruction of a large share of the milk output, a policy designed to compensate producers was announced. An emergency rescue plan that amounted up to 300 million yuan was launched by the Ministry of Finance to compensate dairy farmers for losses associated with dumping (China Ministry of Finance, 2008).

Data, variables and descriptions

Data collection and the sample

Data for this study are based on two rounds of a panel survey that were conducted in 2005 and 2009 in the Greater Beijing area. Dairy production in the Greater Beijing region accounted for 14% of national production in 2004 and 16% in 2009. In addition, as we show in the paper, the growth patterns of the region are consistent with national trends (Liu, 2003–2010). 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 production and marketing of high value agricultural commodities in the area of Greater Beijing. Maps of the outer ring and location of our study area are appended in Fig. 1. Details of the survey effort is in Huang et al. (2010).

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. In total, 50 townships were randomly selected with the aid of a GIS mapping program. Within each township, four 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. In the villages in which the respondent stated that there was dairy farming (by one or more farmers in the village), we 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.

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/nondairy farmers. The 2005 household survey included 243 farmers; 63% of them were dairy farmers. For some production activities, such as participation in dairy farming and herd size, we asked households about the current year (2004) and in an earlier period (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 to assess each family's wealth. Respondents also provided information in the nature of their dairy activities, including their participation history, their herd size and location. In October of 2009 (about one year after the Scandal) we organized a second round of the village and household surveys. The same households that had been interviewed in 2005 were re-interviewed as a way of assessing the impact of the Scandal.

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. We were able to trace 231 of the original 243 sample households. 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

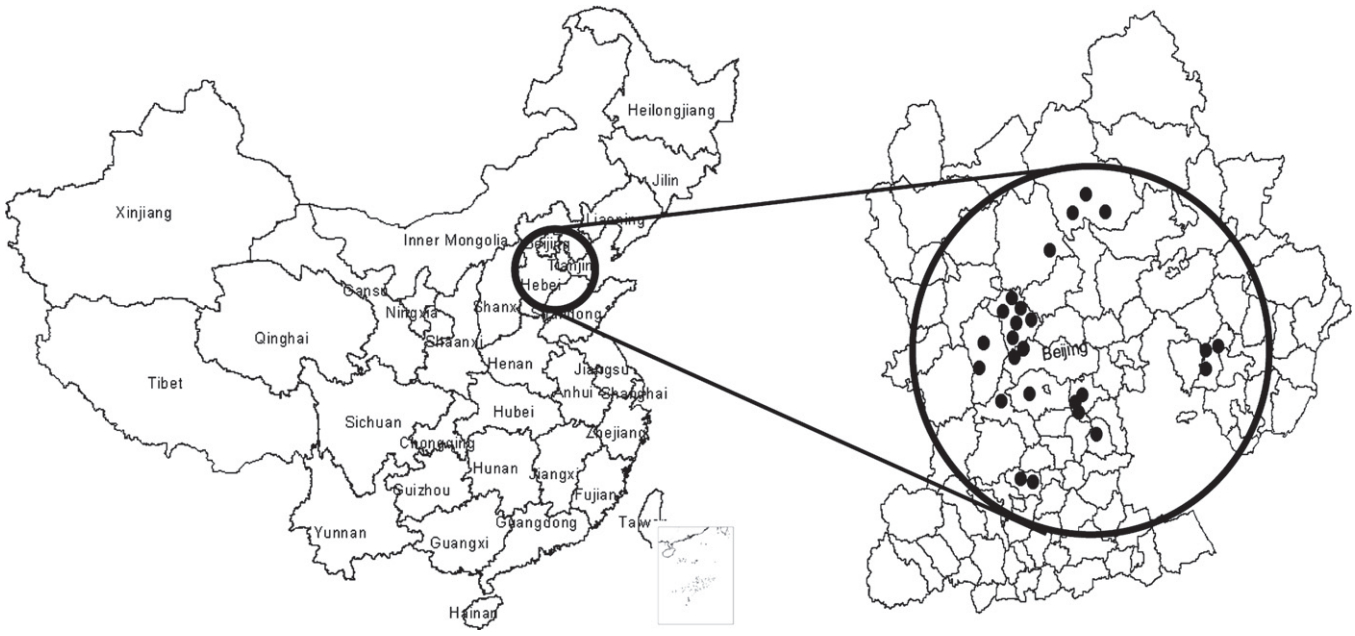

Fig. 1. Map of the study area and the location of the sample. *Note*: The left panel demarcates the out ring of our study area. The right panel presents the map of Greater Beijing and the location of sample villages.

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 Marketing Management Policies; (b) the Production Management Policies; and (c) the Crisis Income Management Policies. The timing of the policy actions were recorded on a month by month basis.

Based on the two rounds of the survey, we are able to create a panel of townships, villages and households for 2004, 2008 and 2009 that is largely representative of Greater Beijing. In total we have a total of 693 observations (3 years $\times$ 231 observations). Two observations are before the Milk Scandal; one is after the Milk Scandal. Since the Milk Scandal broke in the middle of the year, while the data from 2004 are for year end (December 2004), the information for 2008 was for a time period immediately before the Milk Scandal (September 2008).The information for 2009 was for a time period 1 year after the crisis (September 2009).

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 isolate the effect of the Scandal and the government's policy response.

Dairy production—dependent variables

The dependent variables in our analysis are created from our panel data and are fairly straightforward. Using data from the 2004, 2008 and 2009 household surveys, the first variable, *Dairy Participation*, is created for each household as a dummy variable. The variable is defined for each household for each year, 2004, 2008, and 2009 (that is, there are three observations for each household). If a household was producing dairy in 2004 and 2008, but stopped producing right at the time of the crisis and did not produce in 2009, the value of Dairy Participation for that households would be 1, 1, 0.

The other dependent variable is *Herd Size*. This is also a household-level variable that varies across the years for each household. Herd Size is a variable that is a number that is greater than or equal to 0 since it is measured as the number of dairy cows owned by each household at the "end" of the year (December in 2004; and September in 2008 and 2009).

Policy variables—the key independent variables of interest

To create a variable to measure the implementation of the *Marketing Management Policy* in each sample township, we asked each township official-cum-respondent whether they 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 promise of subsidies for the stations. The variable, Marketing Management Policy, is defined as the accumulated number of months between the first month that the policy was implemented and the last month of the study period.[1] For example, if the townships had not received a policy document, the value of the variable for will be 0. If the township received a policy document during the very first month, October 2008, the value of the variable is 12 (which is equal to the number of months between October 2008 and September 2009). If the township did not receive a document until December, the value of the variable is 10. Hence, the value of Marketing Management Policy in 2009 is between 0 and 12. The value for the variable for 2004 and 2008, by definition (since there was no Marketing Management Policy during these years), is 0.

To create the variable for measuring the production management policies, we asked a similar set of questions. The variable, *Production Management Policy* (as is the case of Marketing Management Policy) is defined as the accumulated number of months between the first month that the policy was implemented and the last month of the study period. We asked the township respondent whether they received a policy directive directing the township to begin to move backyard dairy operations into dairy complexes. Like the case of Marketing Management Policy, the value of Production Management Policy in 2009 is between 0 and 12. The value for the variable for 2004 and 2008, by definition also is 0.

To create a variable for the effort exerted by each township government in executing *Crisis Income Management Policies*, we asked township leaders to tell us exactly the initial time (by month) that they were mobilized to provide subsidies to dairy farmers to compensate them for milk that they poured out (for whatever reason). We documented either "yes" when farmers in the township received a payment during the period of time between September 2008 and September 2009; or "no" when no payments were made. The approach creating the variable Crisis Income Management Policy is similar to the way we created the other policy variables. Specifically, Crisis Income Management Policy is a variable that is also equal to the accumulated number of months between the first month that the policy (providing funds to compensate farmers in the township for dumping) was implemented and the last month of the study period. Hence, like the case of the other policy variables, Crisis Income Management Policy in 2009 ranges between 0 and 12. Also as in the case above, the value for the variable for 2004 and 2008, by definition is 0.

Control variables

We also need to create a number of other variables that might affect dairy production in order to be able to isolate the effect of the Scandal and the government's policy response. Our longitudinal data include information from three years, 2004, 2008, and 2009. To examine the impact of the Milk Scandal on participation and herd size in Greater Beijing, we include a variable, Dummy for Year 2009. It is a dummy variable and equals to one for the months after September 2008 (and equals to 0 in months before September 2008). Its interpretation is: holding other variables constant, what happens to participation and herd size after the Milk Scandal.

From the block of the survey data that collected information by household member, we created two household-level variables that are used in the analysis. The variable age is measured as the age of the household head. The education variable, education, is a measure of the number of years of educational attainment of the

[1] Modeling this policy (and the other policies) as the number of months since the implementation of the policy at the township level may be a relatively simplistic way of modeling the policy's full impact. It ignores the expectations and the responses time of households. Unfortunately, modeling and measuring expectations and response times is beyond the scope of this paper. We recognize that the actual implementation may happen at another time and that complicated expectations may mean that our analysis is missing some of the policy's actual effect.

household head. This measure does not include years in pre-kindergarten programs or repeated grades or short term training programs.

We also created one additional control variable from the asset block of the household survey form. To measure household wealth, we collected and aggregated the value from the 2005 survey of the households housing assets, furniture and other durable consumption assets. The sum of these categories is *household wealth*. *Asset value per capita* is created by dividing household wealth by the total number of household members. We only use asset value per capita in the analysis.

Finally, the block of the community survey that enumerated information on dairy farming in the entire village and access to local dairy processors allowed us to create two control variables at the community level. We asked the village leader (the respondent for the community survey form) in the 2005 wave of the survey to tell us the number of households and the number of dairy farms that existed in the village in the year prior to the survey, 2004. During the 2009 version of the survey we asked the village leader to tell us the same information that was asked of him (or his predecessor) during the previous survey (the number of households and the number of dairy farms that existed in the village). In this case, we asked the respondent to tell us the information for 1 year before the crisis (September 2008) and 1 year after the crisis (namely, from September 2008 to September 2009). Based on the village leaders' survey, we created a variable of the *share of households with dairy farms in the village* as a way of holding village-level experience in dairy production. During the surveys, the leader was also asked to estimate the distance between the village office and the nearest dairy processor (henceforth, *distance to the nearest dairy processor*). All variables are measured in the current years (2004, 2008 and 2009).

Descriptions of dairy production and policy implementation in Greater Beijing

Dairy production and herd size

The nature of production of dairy farmers in our sample between 2000 and 2009 demonstrates that our sample of producers appears to be following the same production trends as dairy farmers throughout China. Along with the rapid rise in demand for the milk in the early 2000s, farmers in our sample villages greatly increased their participation rates and saw their herd sizes expand between 2000 and 2004 (Table 1, rows 1 and 2). From 35.3% of households in the village in 2000 the number of household participating in dairy production rose to 61.7% by 2004 (column 2). The average herd size, while still small in both years, was growing (from 2.9 cows per household in 2000 to 5.6 cows per household in 2004—column 3).

Increased competition in the dairy industry and other factors in the economy (e.g., rising wage rates and increased availability of off farm employment) also appear to be affecting the nature of dairy production in our sample villages between 2004 and 2008, the year immediately before the Milk Scandal (Table 1, rows 2 and 3). In the same way that participation in the dairy sector was falling in Liaoning and Tianjin between 2006 and 2007 (Liu, 2003–2010), participation by households in the dairy villages in our sample fell between 2004 (61.7%) and 2008 (52.4%—column 2). Herd size, however, continued to rise between 2004 (5.6 cows/household) and 2008 (9.3 cows/household) (column 3).

Our data shows that between 2008 and 2009, the years before and after the Milk Scandal, the participation in the dairy sector fell sharply and herd size dipped (Table 1, rows 3 and 4). Although participation from 2004 to 2008 was already falling (as discussed above), losing 9% points of farmers in the sample villages over a 4 year period (a decline of 2.2% points per year on average), between 2008 and 2009 there was a further reduction in participation in dairy farming from 52.4% to 45.0% (column 2). This fall of 7% points occurred in a single year, suggesting that at least part of it was due to the Milk Scandal. Descriptive evidence that the Milk Scandal did affect production is more apparent in herd size. After a monotonic rise in herd size for at least the previous decade (from 2.9 in 2000 to 9.3 in 2008), in 2009 the average number of cows per household fell (column 3).

Table 1
Participation of sample households in dairy production and herd size in rural villages in Greater Beijing area, 2000–2009. *Source*: Authors' survey.

Year	Total sample	Dairy participation (%)	Herd size
2000	243	35	2.9
2004	243	62	5.6
2008	231	52	9.3
2009	231	45	8.6

Implementation of the policies

Our data show that while officials in China's government may have been negligent in allowing the Milk Scandal to occur in the first place, once it surfaced, action was taken quickly across widespread areas of our sample areas. It is not surprising that no policy action penetrated to towns to combat the crisis in September 2008, the month that the Scandal broke. It took officials several days to understand its magnitude and begin to get a handle on the nature of the problem.

Leaders moved fast in rolling out each of the policies and the policies reached similar number of towns (Table 2). In the case of Marketing Management Policies, for example, nine townships had received policy directives for marketing management by October 2008, 1 month after the onset of the Milk Scandal (row 1, column 2). Ultimately, all but three townships received Marketing Management Policy directives (row 1, column 7). In the case of Production Management Policies, the roll out was slightly slower (though still fast); by October 2008 eight townships (instead of nine as in the case of Marketing Management Policy) had received Production Management Policy directives (row 2, column 2). In the case of Crisis Income Management Policies, according to our interviews, while dairy farmers were dumping milk as early as the last week of September, none had yet received compensation for the dumping in September (row 3, column 1). By October, however, less than a month after the onset of the Milk Scandal, township leaders in 10 of the 15 towns had received Crisis Income Management policy directives (row 3, column 2). One township was slower to receive directives, receiving them between January and March (row 3, columns 4 and 5). In the case of four townships, local leaders never received any Crisis Income Management Policy directive (row 3, column 7).

Policy implementation and farmers' response: descriptive statistics

Descriptive cross-tabulations that relate the rollout of the policies in the sample townships to the response of dairy farmers show that the effect of the policies on dairy participation and herd size differs across policies (Table 3).

Marketing Management and Production Management policies seem to have limited drops in dairy participation and cuts in herd size. According to our data, the reductions in participation (column 5) and herd size (column 8) were less for those townships that rolled out Marketing Management Policies earlier and were greater in the case of those townships that did not (rows 1–3). Although a little less clear for the case of herd size, it is clear that in townships in which Production Management Policies were rolled out earlier,

Table 2
Number of townships that received policy directives for Marketing Management, Production Management and Crisis Income Management policies in Greater Beijing between September 2008 and September 2009. *Source*: Authors' data.

Policy directive	2008				2009		
	September	October	November	December	March	June	September
Marketing Management Policies	0	9	10	11	12	12	12
Production Management Policies	0	8	9	12	13	14	14
Crisis Income Management Policies	0	10	10	10	11	11	11

Note: The number of surveyed township is 15. The number for each month is the number of townships that have received one of the policy directives during or before that month. For example, the 11 in row 1, column 5, means that 11 of the 15 townships in the sample had received a policy directive about Crisis Income Management by March 2009 or before.

Table 3
Change of dairy participation and herd size by townships in Greater Beijing Township policies by September of 2009 and change of participation of dairy farming and herd size in 2009 over 2008.

	No. of sample towns	No. of HH[b]	Dairy participation (%)			Herd size (number of dairy cows)		
			September 2008	September 2009	Change[c]	September 2008	September 2009	Change
Marketing Management Policies[a]								
0	3	47	26	13	−13	16	13	−3
1–10	2	53	51	47	−4	7	6	−1
11–12	10	131	63	56	−7	9	9	−0
Production Management Policies[a]								
0	1	10	70	60	−10	12	11	−1
1–10	5	101	60	54	−6	7.7	7.4	−0
11–12	9	120	45	37	−8	11	10	−1
Crisis Income Management Policies[a]								
0	4	20	15	15	0	7	10	3
1–10	1	9	11	0	−11	10	0	−10
11–12	10	202	58	50	−8	9	8	−1

[a] The Crisis Income Management, Marketing Management and Production Management Policy variables are all defined the same. To create the variables we asked township leaders to tell us exactly when the initial time (by month) that they were mobilized to provide subsidies to dairy farmers to compensate them for milk that they poured out (for whatever reason). We documented either "yes," farmers in the township received a payment during the period of time between September 2008 and September 2009; or "no," no payments were made. To create the variable (e.g., Crisis Income Management Policy), we set the variable equal to the accumulated number of months between the first month that the policy was implemented and the last month of the study period. Hence, the values of the variables in 2009 are between 0 and 12. The value for the variable for 2004 and 2008, by definition is 0.

[b] The number of households in this table refer to all 231 farmers survey in this study.

[c] The figures in this column is the number of percentage point differences. It is the difference between the numbers in the previous two columns.

participation fell less than those townships in which Production Management Policies were not executed (rows 4–6).

In contrast to the other policies, Crisis Income Management seemed to have no effect or even seemed to be associated with declining participation and reduction of herd sizes (rows 7–9). In townships in which the Crisis Income Management Policy was rolled out earliest, there was a fall in participation of dairy production (by 11% points for those in that started in December 2008 to March 2009—row 8, column 5; by 8% points for those that started even earlier in October 2008—row 9, column 5). In contrast there was no drop in participation in those townships that did not have a Crisis Income Management Policy implemented. The same trends were found in the case of herd size (rows 7–9, column 8).

Causality is not always clear. It may be that those areas in which the dumping of milk was most severe, losses in profits highest, and reduction in demand sharpest would be the places in which there would be the greatest pressures on farmers to reduce participation and/or cull their herds. With the economic stress that would have caused, it is likely that the disruption would have created enough policy attention that it was in these townships that officials were asked to roll out Crisis Income Management Policies. Such an explanation would be consistent with the patterns of Crisis Income Management Policy timing and changes in participation and herd size.

In the next section, we further analyze the restructuring process by econometrically estimating the impact of the policies on dairy participation and herd size, while controlling for several other factors.

Econometric specification and estimation

Econometric model and specification

To complement our qualitative insights and to econometrically quantify the effect of the government's policies, we estimate a model based on the firm growth literature, following the approach of Dries and Swinnen (2004) who study the impact of external changes on participation and herd size in Polish dairy production. The firm growth literature starts from the 'law of proportionate effects' or Gibrat's law, stating that firm growth rates are independent of initial firm size. Following Evans (1987), Hart and Oulton (1996), Hall (1997) and Dries and Swinnen (2004) the farm growth relationship is specified as follows.

$$S_{it} = [F(.,S_{i0})]^d (S_{i0})(1 + v_{it}) \quad (1)$$

where S_{it} and S_{i0} denote the size of farm i respectively at time t, the current period and t_0, the initial period. $F(.,S_{i0})$ is a function of size and some other variables and d is the time interval over which growth is measured or in other words, $d = t - t_0$. Finally, v_{it} is the proportionate rate of growth between t_0 and t. If d is small and we express Eq. (1) in logarithms, we obtain the following general growth function.

$$[ln(S_{ijkt}) - ln(S_{ijk0})/d] = ln[F(.,S_{i0})] + u_{it} \quad (2)$$

Using (2), we estimate the impact of policies on changes in farm size with the following model (*Model 1*):

$$[ln(S_{ijkt}) - ln(S_{ijk0})/d] = a_0 + a_1 * Policy_{lkt} + a_2 * Z_{ijkt} + a_3 * ln(S_{ijkt0}) + e_{ijkt} \quad (3)$$

where S_{ijkt} *and* S_{ijk0} denote the farm size of household i in village j and township k, respectively at time t and in the initial period. In the basic model (Model 1) the variable, $Policy_l$ (l = 1 or 2 or 3), is one of the three variables of interest that measures the implementation of policy, Marketing Management $Policy_{lkt}$ (l = 1), Production Management $Policy_{lkt}$ (l = 2) or Crisis Income Management $Policy_{lkt}$ (l = 3 in township k). The matrix, Z_{ijkt}, is a set of control variables for household i in village j and township k in year t that is composed of three household-level variables—age, education and asset value per capita and two village-level variables (village j in township k), the share of households with dairy farms in the village and the distance to the nearest dairy processor. The symbol e_{ijkt} is the error term which includes all unobserved variables and random noise.

From Tables 2 and 3 it is clear that the three policy variables are correlated. Because of this and in order to isolate the marginal impact of one policy, holding the other policies constant, we include all three township policies in a single equation. We call this *Model 2*.

Because of the possibility that there are non-time varying unobserved variables at the village and township level, we specify the following to account for them (*Model 3*):

$$[ln(S_{ijkt}) - ln(S_{ijk0})/d] = a_0 + a_{11} * Policy_{1kt} + a_{12} * Policy_{2kt} + a_{13} * Policy_{3kt} + a_2 * Z'_{ijkt} + a_3 * ln(S_{ijkt0}) + \delta_{jkt} + e_{ijkt} \quad (4)$$

where the variables in Model 3 are the same as in Model 2 except Z'_{ijkt} that include all Z_{ijkt} and a set of 24 village dummies. The inclusion of the village dummies accounts for non-time varying observed and unobserved village and township effects and will help isolate the effect of the individual policy variables on dairy production.[2]

Estimating these models using OLS regression techniques will only take into account the growth of farms that still exist at the end of the period that we consider. Such analysis based on a sample of surviving farms only, may be biased due to sample attrition. Instead, we use a two-step Heckman model of firm survival and growth (Weiss, 1999). First, a selection equation is estimated by maximum likelihood as an independent probit model to determine which farms have still participate using information from the whole sample of farms. A vector of inverse Mills ratios (estimated expected error) can be generated from the parameter estimates. Changes in farm size are observed only when the selection equation equals 1. Then, for the farms that still participate, changes in herd size (growth) is regressed on the explanatory variables and the vector of inverse Mills ratios from the selection equation by least squares. Therefore, the second stage reruns the regression with the estimated expected error included as an extra explanatory variable, removing the part of the error term correlated with the explanatory variables and avoiding the bias.

The dependent variables in the two estimations are Participation and changes in Herd Size, respectively.

Regression results

Table 4 presents the regression results for the impact of government policies on the participation by farmers in dairy production and the change in herd size. The signs on the 2009 year dummy (row 4) are as expected and consistent with the descriptive statistics, although the effect is significant only in the first model (columns 1 and 2). Dairy participation was already falling between 2004 and 2008 and this fall accelerated in 2009. Similarly, the average herd size fell in 2009. The dairy crisis had a negative impact on the participation of farmers in dairy production and average herd size.

The estimated coefficients for the initial (2004) herd size (row 5) are positive and significant for participation in all models (columns 1, 3, 5, 7, 9), and negative and significant for the herd size in all models (columns 2, 4, 6, 8, 10). This implies that larger farmers were more likely to continue as dairy farmers but have reduced their herd size more than small farmers.

When examining the impact of our independent variables of interest, the policy variables, we see that the effects are consistent whether modeling the impact of the three policies simultaneously (as we do in columns 7 through 10—from equations 2 and 3 in the paper) compared to using one policy variable at a time (as we do in columns 1 through 6—from equation 1). The results are robust to these changes in specification.

Our results suggest that Marketing Management Policies have been the most effective policy in the government's arsenal to stop the decline of dairy production. The coefficients in row 1 indicate that Marketing Management Policy had positive and significant effects on participation (columns 1 and 7) and herd size (columns 2 and 8) for models 1 and 2.

This means that ceteris paribus China's attempts to revive the marketing system seems to have been effective in keeping dairy farmers from dropping out at too high of a rate. Given the mean values of the Marketing Management Policy in 2008 and 2009 were zero and 8.85, respectively, the estimated coefficient for the Marketing Management Policy (0.02, columns 1 and 7) implies that the Marketing Management Policies increased the rate of participation by farmers in our sample regions by 17% in 2009 over 2008 (namely, 0.02 × 8.85 = 0.17). In other words, without China's Marketing Management Policy, our results suggest that the participation rate of farmers in dairy production would have fallen by 17% more in 2009.

Similarly, the Marketing Management Policy kept herd size from dropping any more than it did. The estimated coefficient for the Marketing Management Policy in the Herd Size equation ranged from 0.05 to 0.06, which implies that the Marketing Management Policy kept herd size from decreasing ranged from 60% (0.05 × 12, column 8) to 72% (0.06 × 12, column 2) for the whole sample.[3]

If we add village dummies, the signs (magnitudes) of the coefficients and the levels of significance are lower for the Marketing Management Policy (columns 9 and 10).[4] While one interpretation may be that marketing policies have not been that effective in encouraging dairy participation, since the policy variables are all township-level variables, the falling significance could also be related to the small amount of variability in the number of villages/towns that are used in producing the results. In the Herd Size equation, the coefficient is nearly significant at the 15% level (column 10).

The other policy variables have little impact on dairy participation. The sign of the coefficients of the Production Management Policy variable (row 2, columns 3, 7, 9) and of the Crisis Income Management Policy variable (row 3, columns 5, 7, 9) is insignificant. Our results demonstrate that in our Greater Beijing sample, both policies are not effective in terms of encouraging dairy producers to participate in dairy production (or not drop out). The

[2] Although we control for unobserved non-time varying effects, because we do not have an Instrumental Variable available (that is correlated with the Policy variables, but uncorrelated with Participation, or Herd Size, except through the effect of the Policy variables), we cannot control for any time-varying unobservables.

[3] The Greater Beijing was in the center area where the milk scandal was first disclosed and the production was affected heavily. Thus, the large effects of policies on preventing from the collapse of dairy production in Greater Bejing might not be the same elsewhere in China.

[4] When we run the model with household fixed effects, the results do not change much. Results are available from the authors on request.

Table 4
Results of multivariate analysis using Heckman two-step models in Greater Beijing in 2008 and 2009.

	Participation (1)	Herd size (2)	Participation (3)	Herd size (4)	Participation (5)	Herd size (6)	Participation (7)	Herd size (8)	Participation (9)	Herd size (10)
Marketing Management Policies	0.02***	0.06***					0.02***	0.05**	0.01	0.04
	(3.06)	(2.62)					(2.96)	(2.51)	(0.89)	(1.27)
Production Management Policies			−0.01	−0.01			−0.01	−0.00	0.01	0.00
			(0.88)	(0.65)			(0.56)	(0.20)	(0.70)	(0.07)
Crisis Income Management Policies					0.00	−0.05**	0.00	−0.04*	−0.00	−0.05*
					(0.32)	(2.16)	(0.17)	(1.82)	(0.24)	(1.79)
Dummy for year 2009	−0.20***	−1.00***	0.06	−0.26	−0.06	0.24	−0.16	−0.43	−0.22	−0.16
	(3.02)	(4.14)	(0.59)	(1.26)	(0.54)	(0.81)	(0.90)	(0.94)	(0.88)	(0.29)
Previous herd size in 2004 (*log*)	0.12***	−0.17*	0.13***	−0.22**	0.13***	−0.21**	0.12***	−0.16*	0.13***	−0.26**
	(28.18)	(1.83)	(30.16)	(2.35)	(29.15)	(2.32)	(27.63)	(1.72)	(6.66)	(2.52)
Age	0.00	−0.00	0.00	−0.00	0.00	−0.00	0.00	−0.00	0.00	−0.00
	(0.03)	(1.29)	(0.06)	(1.09)	(0.09)	(1.29)	(0.04)	(1.44)	(0.03)	(0.90)
Education	0.01	−0.02	0.01	−0.03*	0.01	−0.03**	0.01	−0.03*	0.00	−0.02
	(1.37)	(1.56)	(1.32)	(1.86)	(1.41)	(2.00)	(1.32)	(1.72)	(0.02)	(0.95)
Asset value per capita	−0.00**	0.00	−0.00***	0.00	−0.00***	0.00	−0.00***	0.00	−0.00***	−0.00
	(2.57)	(0.22)	(2.91)	(0.54)	(2.76)	(0.54)	(2.62)	(0.09)	(2.70)	(0.66)
Share of dairy farms in the village	0.01***	−0.00	0.01***	−0.00	0.01***	−0.00	0.01***	−0.00	−0.00	−0.01
	(4.64)	(0.48)	(5.54)	(0.43)	(5.53)	(0.53)	(4.63)	(0.44)	(0.15)	(0.70)
Distance to the nearest dairy processor	−0.00**	0.00	−0.00*	0.00	−0.00	0.00	−0.00*	0.00	−0.00	−0.00
	(2.08)	(1.10)	(1.68)	(1.51)	(1.59)	(0.86)	(1.96)	(0.61)	(0.51)	(0.20)
Village Dummies	No	No	No	No	No	No	No	No	Yes	Yes
N	462	462	462	462	462	462	462	462	462	462

Note: Absolute values of *t*-ratio in parentheses.
* Statistically significant at the 10% level.
** Statistically significant at the 5% level.
*** Statistically significant at the 1% level.

coefficients are insignificant regardless of the model.

However, in the Herd Size equation the policies have different effects. The coefficients on the Production Management Policy variable are also insignificant in the case of the regressions for Herd Size (row 2, columns 4, 8, 10). In contrast, our results in all models suggest a significant but negative correlation between Crisis Income Management Policy and the change in herd size (row 3, columns 6, 8, 10). These results are consistent with the descriptive statistics. When considering the fact that Crisis Income Management Policy may have been focused on those areas that were hit the hardest, it is perhaps not surprising that the sign is negative.

Summary and conclusions

China was seriously hit by Milk Scandal in 2008. In the aftermath of the onset of the Scandal, dairy production fell substantially. According to national statistics and our own data, between 2008 and 2009 dairy participation fell. Herd size declined.

Although the Milk Scandal depressed production in early 2009, production recovery also has been rapid. This paper shows the importance of government policy in fighting the crisis. According to both the descriptive and multivariate analysis, in towns in which leaders were given direction to implement Marketing Management Policies, dairy participation fell less and herd size reductions were smaller.

Interestingly, the other two policies, Crisis Income Management Policy and Production Management Policies did not have a positive effect on dairy production. Production Management Policy did not have any impact, according to our regression analysis. This may not be surprising, since we were mainly measuring the short term impact. It very well could be that Production Management Policies will be found to have more significant long term implications on the structure of dairy production (more commercial farms that are inside government- and private-sponsored dairy complexes) and milk safety.

There appears to be no significant relationship between Crisis Income Management Policy and farmers' participation, but Crisis Income Management Policy is negatively correlated with farmers' herd size. In other words, herd size fell more where Crisis Income Management Policies were implemented. This result, however, could have appeared because such policies were mainly implemented in the hardest hit areas. These are issues that need further study.

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Appendix A

See Table A1.

Appendix B

See Table B1.

Table A1
Timeline of the events in China's 2008 Milk Scandal, July–September, 2008. *Sources*: (1) Wikipedia, Timeline of the 2008 Chinese Milk Scandal. http://en.wikipedia.org/wiki/Timeline_of_the_2008_Chinese_milk_scandal. (2) Lu and Tao (2009). Sanlu's Melamine-Tainted Milk Crisis in China *Harvard Business Review* (June 11).

- *16 July*: Gansu Province reports to the Ministry of Health that local hospitals had identified an increase in the incidence of kidney ailments among babies in the months earlier, and that most victims had consumed Sanlu's baby formula
- *24 July*: The bulletin board of the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) indicated a rare occurrence of kidney stones in children – all causally traced to Sanlu milk formula – was flagged by a urologist in a paediatric hospital
- *8 September*: the New Zealand Prime Minister Helen Clark notified Beijing officials alerted directly
- *11 September*: A *Dongfang Zaobao* reporter, Jian Guangzhou, reported the connection between Sanlu's baby formula and infant kidney stones to the Chinese public. This was the first time that Sanlu was identified as being responsible for the cases on a public media; the Ministry of Health confirmed the report in a press briefing that evening; World Health Organization notified
- *12 September*: US-FDA Issues Health Information Advisory on Infant Formula; Sanlu Group admits that its milk powder was contaminated with melamine
- *12 September*: The central government ordered sanlu to stop all its production lines and sales
- *13 September*: Production halted at Sanlu; nineteen people are arrested
- *15 September*: Beijing confirms two babies dead. Vice-President of the Sanlu Group apologises to the public
- *16 September*: Milk powder from 22 Chinese companies tested positive for melamine, Sanlu tops the rankings
- *17 September*: Director of Sanlu is detained on criminal charges; Shijiazhuang Mayor Ji Chuntang resigns; Health Minister Chen Zhu declares toll of "more than 6200 children, and that more than 1300 others, mostly newborns, remain hospitalized with 158 suffering from acute kidney failure"
- *17 September*: China distributed over 5000 inspectors to 1548 dairy enterprises across the county to investigate quality control of raw milk and inputs
- *19 September*: Melamine found in ordinary milk from three well-known dairies. One of the firms involved - Mengniu dairy issues blanket recall on all its products
- *21 September*: Chinese premier Wen Jiabao makes a PR visit to sick infants; Nestlé pure milk contaminated
- *22 September*: Toll of ill babies rises to 53,000, and the death toll to at least four; Li Changjiang, minister in charge of the AQSIQ, is forced to resign after the State Council publishes inquest concluded that he was responsible for the "negligence in supervision"; Local Party Secretary Wu Xianguo is dismissed; Taiwan bans Chinese milk products
- *23 September*: Other countries start to test Chinese dairy products or remove them from shops; Malaysia bans Chinese milk candies, chocolate; Tanzania suspends milk imports from China; Two toll of victims mount to 54,000 children, 4 dead
- *24 September*: 3 more children in HK and Macau sick; Indonesia bans Chinese milk imports; Tesco withdraws White Rabbit Creamy Candies
- *25 September*: South Korea bans Chinese food; 2-year-old girl is first suspected victim in Taiwan; Vietnam bans milk imported from China; The EU bans Chinese baby food with milk traces. Sales of White Rabbit Creamy Candy are halted after tests detect melamine
- *26 September*: Chile withdraws Chinese dairy products; India bans Chinese dairy products for 3 months; Taiwan reports 5 new melamine victims; Taiwanese Health minister resigns over melamine tolerance levels
- *26 September*: Sanlu's president and three other top executives at Sanlu were detained. They were Sanlu's vice-president Wang, the general manager Hang Zhiqi, and the director of Sanlu's milk resource department, Wu Jusheng
- *27 September*: Hong Kong finds traces of melamine in HJ Heinz baby food; Indonesia finds melamine in M&Ms (Mars Inc) and Oreos (Nabisco)
- *29 September*: Cadbury recalls products in Asia after tests find traces of melamine. Reports say 22 people have been arrested in Hebei province, suspected of introducing melamine into the supply chain

Table B1
Descriptive statistics of major variables in 2004, 2008, 2009 used in the analysis. *Source*: Authors' survey data.

Variables	Mean	Std. dev.
Participation	0.54	0.49
Herd size	4.29	7.65
Time trend	4	2.16
Dummy for year 2009	0.33	5.47
Crisis Income Management Policies	3.61	3.39
Marketing Management Policies	2.95	4.96
Production Management Policies	3.42	5.08
Age	37.43	12.09
Education	6.53	2.32
Asset value per capita	19.51	35.22
Share of dairy farms in the village	11.13	13.98
Distance to the nearest dairy processor	21.34	27.01

Note: Total number of observations is 693.

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