

## COLLECTIVE REPUTATION IN TRADE: EVIDENCE FROM THE CHINESE DAIRY INDUSTRY

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*Abstract*—The existence of collective reputation implies an important externality. Among firms trading internationally, quality shocks about one firm's products could affect the demand of other firms from the same origin country. We study such a reputation spillover in the context of a large-scale scandal that affected the Chinese dairy industry in 2008. Leveraging detailed firm-product level administrative data and official quality inspection reports, we document sizable reputation spillovers on uncontaminated firms. We further investigate potential mechanisms that could mediate the strength of collective reputation, including information accuracy, observability of the supply chain, and prior export experience.

### I. Introduction

IN markets with information frictions, quality shocks about one firm's products may impose an externality on other firms selling similar products. In such settings, when an incident damages the group's reputation, firms can become trapped in a low-trust–low-quality equilibrium, and new entrants may inherit the damaged reputation of their predecessors. Tirole (1996) formalizes the theory of collective reputation. Empirically, how important is collective reputation, and what are the potential mechanisms that mediate its effects? We study collective reputation in the context of trade and development. In international markets, producers from the same origin country are often viewed as a group: for example, we refer to Swiss watches, French wines, and “made-in-China” products. For firms in developing countries, which are mostly positioned at the lower end of the value-added chain and export mainly nonbranded products, a long international supply chain can make it particularly difficult to trace products to an individual producer. As a result, collective reputation becomes especially important in determining firms' export performance. In fact, rising safety and quality con-

cerns regarding goods from developing countries in recent years can significantly hinder firms from penetrating high-end markets.<sup>1</sup> In a recent survey of over 600 manufacturing firms in China, firms report lack of reputation and mistrust as one of the main challenges in exporting to global markets.<sup>2</sup> Therefore, understanding how collective reputation spreads within an industry or a geographic area is important for informing trade and development policies.

We exploit a large-scale quality scandal that affected the Chinese dairy industry in 2008. Similar to many industries in developing countries and emerging markets, the Chinese dairy industry was dominated by a large number of small and nonestablished players that exhibited rapid growth prior to the scandal. Using administrative data on quality inspections conducted by the Chinese government following the scandal, we identify the firms and the products at each firm that failed inspections (contaminated product-firm pairs) and those products and firms for which no contamination was ever detected.<sup>3</sup> We merge the official inspection lists with Chinese Customs data at the firm-product level and Manufacturing Survey data at the firm level to examine the direct effects of the scandal both on contaminated product-firm pairs and on other products within the firms with contamination (within-firm spillovers) as well as the effects on firms with no contamination and on uninspected firms (cross-firm spillovers).

We begin by showing that the scandal had a large impact on the overall export performance of the entire dairy sector in China, thus providing an ideal setting for studying within-sector spillovers. Using a difference-in-differences (DD) framework, we find that the average value of dairy exports plummeted by 68% following the scandal and failed

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<sup>1</sup>A list of food contamination incidents can be found at [https://en.wikipedia.org/wiki/List\\_of\\_food\\_contamination\\_incidents#2001\\_to\\_present](https://en.wikipedia.org/wiki/List_of_food_contamination_incidents#2001_to_present). Recent prominent cases include the Chinese dairy scandal of 2008 and the Brazilian meat scandal of June 2017 (see an *Economist* article on the latter incident: <https://www.economist.com/news/business/21719416-chile-china-and-eu-have-banned-some-or-all-countrys-meat-meat-scandal-brazil>).

<sup>2</sup>The survey was administered by the Jinan Institute for Economic and Social Research (IESR) and the Guangzhou General Administration of Quality Supervision, Inspection and Quarantine (GAQSIQ). We thank IESR for sharing the survey instruments and the data.

<sup>3</sup>We conducted an extensive news search through LexisNexis to cross-validate the official inspection reports. See section IIIC for more details.

to recover even after five years. This estimate captures both the direct impact on firms with contaminated products and the spillovers to other firms and products. Decomposing the direct versus indirect impacts, we estimate an aggregate spillover effect of 57%, about four-fifths of the total effect size. Our estimates are robust to various empirical specifications that relax the classical DD assumption. To the extent that products by different dairy firms are imperfect substitutes, the estimates provide a lower bound on the collective reputation effect.

Next, we investigate how the spillover effects are distributed across different firms and products. We leverage our detailed micro data on export activities and inspection outcomes at the firm-product level. Our results suggest that contaminated firms saw a drop of 84% in export revenue after the scandal relative to the national industrial trend. These firms were also 14.2% less likely to export following the scandal. Furthermore, we find that both firms verified to be free of contamination and uninspected firms experienced an equally significant decline in export revenue of about 64% of the decline suffered by directly affected firms. Moreover, firms that successfully passed government inspections did not fare any better than uninspected firms. Altogether, these findings point to large reputation spillovers and highlight the potential challenges of government actions to help firms signal quality and restore trust.

Finally, we investigate potential mechanisms that may underlie the observed spillover effects. Since a firm's reputation is essentially constituted by buyers' beliefs and perceptions, how consumers gather information and learn matters crucially for reputation externalities. Specifically, we examine the role of (1) information accuracy in global media reports, (2) firms' location and the traceability of suppliers affected by contamination episodes, and (3) firms' export experience, which proxies for the strength of individual reputation.

First, to study the role of information accuracy in global media, we construct a measure of consumers' knowledge of the scandal across different countries, using Google Trends Search indices for phrases that reflect a more or less accurate depiction of the event. We find that the spillover effects are smaller in countries where people appear to have better information about the parties directly involved in the scandal, reflected in more targeted internet search behavior. In particular, the cross-firm spillover effects are primarily driven by exports to destinations with low information accuracy.

Second, we use the Chinese Customs data to identify the sourcing locations of each exporting firm prior to the scandal to examine the impact on firms that passed inspections and uninspected firms of sourcing from the same locations as firms affected by the contamination. Interestingly, we find that the spillover effects appear to be generalized rather than contained within specific areas. This is consistent with international buyers having coarse information about contamination sources due to low traceability of the contaminated inputs.

Third, to examine the interaction between collective and individual reputation, we exploit baseline variation in firms' export experience, as measured by the number of years a firm has been exporting and the share of exports in total sales at baseline. We find that young firms and firms with a smaller baseline share of exports in total sales are more vulnerable to the collective reputation shock. The results suggest that having a more established individual reputation can (partially) shield firms from the collective damage, whereas newcomers suffer more from the "original sin" of the predecessors (Tirole, 1996).

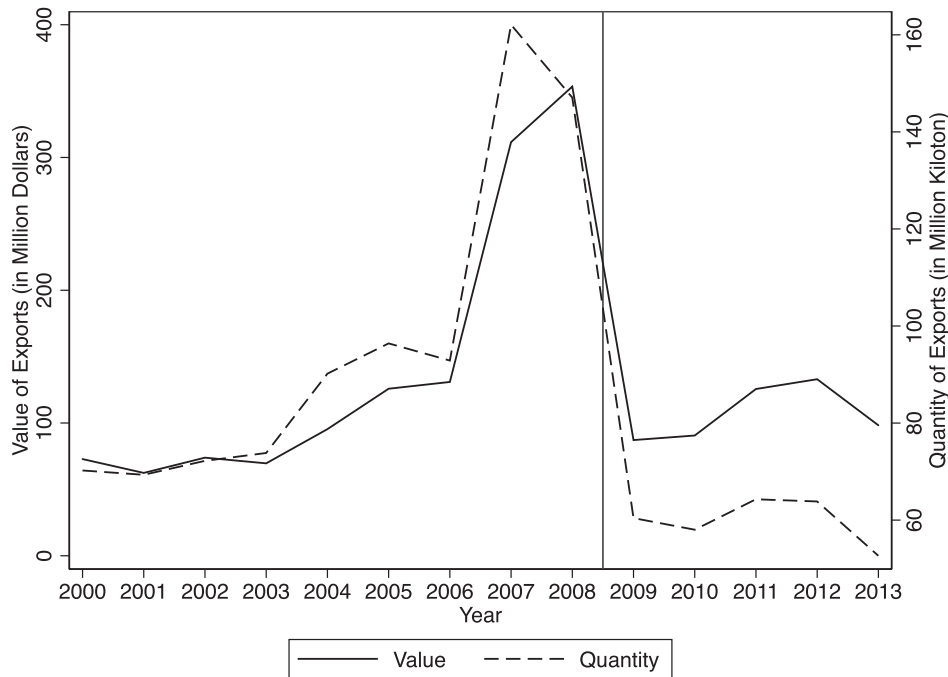
A growing empirical literature studies firm reputation and quality provision in markets with information frictions (Banerjee & Duflo, 2000; Jin & Leslie, 2009; Macchiavello, 2010; Cabral & Hortacsu, 2010; Björkman-Nyqvist, Svensson, & Yanagizawa-Drott, 2013; Bardhan, Mookherjee, & Tsumagari, 2013). While information frictions appear to play an important role in international trade (Allen, 2014; Macchiavello & Morjaria, 2015; Startz, 2017), these frictions remain understudied (Atkin & Khandelwal, 2020). We build upon these two bodies of research by examining the role of group reputation in trade. Our results demonstrate that collective reputation forces can have important implications for a country's trade patterns, contributing to a country's comparative advantage.

Despite earlier works on the theory of collective reputation (Tirole, 1996; Winfree & McCluskey, 2005; Fleckinger, 2007; Levin, 2009; Fishman et al., 2010), empirical studies on the subject remain scarce (Bai, 2018; Zhao, 2018). Exploiting a natural experiment, our results explicitly identify this important source of externalities and illustrate how its effects are mediated by various informational and market forces. Two other papers exploit similar natural experiments to study collective reputation spillovers. Freedman, Kearney, and Lederman (2012) examine toy recalls in the US and document sizable industry-wide spillover effects independent of origin country.<sup>4</sup> Bachmann et al. (2019) find large spillover effects a year after the Volkswagen scandal on US sales of other German cars. To the best of our knowledge, our study is the first one with a long enough post period to examine the persistence of collective reputation damage. More work is needed to compare developing and developed countries as well as different market settings.<sup>5</sup>

<sup>4</sup>Our paper also speaks broadly to the literature on quality scandals and product recalls. Most previous studies in this literature have either relied on laboratory experiments to examine consumer reactions to hypothetical product scandals (e.g., Ahluwalia, Burnkrant, & Unnava, 2000) or focused primarily on stock market outcomes using an event-study approach (e.g., Davidson & Worrell, 1992). Furthermore, with the exception of Freedman et al. (2012), most studies focus on losses in firms' own sales and stock market price (Van Heerde, Helsen, & Dekimpe, 2007; Jovanovic, 2021) rather than cross-firm spillovers.

<sup>5</sup>There is also a literature in agricultural and resource economics that studies collective reputation in the food and beverage industries in relation to products and labels such as Bordeaux wine and regional appellations. Most studies use hedonic price regressions to examine the role of group reputation (e.g., Castriota & Delmastro, 2014; Marchini et al., 2014; Gergaud et al.,

FIGURE 1.—EVENT STUDY GRAPH: CHINA'S DAIRY EXPORTS



This figure plots Chinese dairy export values and quantities from 2000 to 2013.

Finally, our study relates to the broad literature on firm performance and quality upgrading in development and trade (De Loecker & Goldberg, 2014). Previous studies have examined (1) supply-side constraints, including credit access, lack of quality inputs, and managerial constraints (e.g., De Mel, McKenzie, & Woodruff, 2008; Kugler & Verhoogen, 2012; Banerjee, 2013; Bloom et al., 2013), and (2) demand side factors, including access to high-income markets (e.g., Verhoogen, 2008; Park et al., 2010; Manova & Zhang, 2012; Atkin, Khandelwal, & Osman, 2017). Atkin & Khandelwal (2020) highlight that information frictions may significantly inhibit trading opportunities for firms in developing countries. Our paper is one of the first to document how a poor collective reputation deriving from information frictions affects firms' export performance in developing countries.

The remainder of the paper is organized as follows. Section II provides background information on the 2008 scandal, and section III describes the data. Section IV presents evidence on the overall impact of the scandal on the dairy industry. Section V analyzes reputation spillovers across firms and products. Section VI examines mechanisms. Section VII concludes.

## II. Background on the 2008 Chinese Dairy Scandal

The Chinese dairy industry exhibited fast growth during the early 2000s in terms of both domestic production and exports. Prior to 2008, the industry grew at an average annual

rate of almost 24%. Figure 1 shows that the industry's annual export value increased more than threefold from 2000 to 2007. The number of exporting firms increased from 150 in 2000 to 335 in 2007.<sup>6</sup> Nonetheless, in 2007, dairy exports still constituted a relatively small share of all dairy production in China and accounted for only \$300 million of the country's \$1.2 trillion export revenue. Like many other industries in developing countries, the Chinese dairy industry was dominated by a large number of small and nonestablished players.

Over the past decade, an increasing number of quality and safety issues have affected Chinese food products. One of the most widely known incidents is the distribution of contaminated baby formula in September 2008, hereinafter referred to as "the scandal." Infant formula had been illegally adulterated with the industrial chemical melamine to mimic a higher protein content. Melamine, commonly used in the manufacture of plastics, has been linked to an increased risk of kidney stones (Hau, Kwan, & Li, 2009). The incident led to 4 infant deaths, 51,900 hospitalizations of children, and the nationwide recall of 700 tons of milk powder.

Following the outbreak, the Chinese government quickly shut down the supplier of the contaminated milk powder, Sanlu Group, one of the largest dairy firms in China. However,

<sup>6</sup>Figure 1 shows a spike in export growth between 2006 and 2007, when the total value of exports increased by about 138%. This spike was mainly driven by new firms entering the export market. Specifically, 30 firms contributed more than 80% of the growth spike; over 50% of the spike was driven by a single product—milk powder; finally, over 50% of the spike was driven by exports to 6 destinations, namely, Thailand, Germany, Bangladesh, Taiwan, UAE, and Hong Kong.

2017). We take advantage of a natural experiment that allows us to relax the identification assumptions.

further investigations revealed that the adulteration stemmed from malpractices of some upstream milk producers, raising the suspicion that more downstream dairy firms could have been affected.<sup>7</sup> This discovery led to three rounds of government inspections: the first round targeted firms producing infant formula—109 firms were inspected, and 22 were found to have traces of melamine in their products. The next two rounds targeted producers of milk powder and liquid milk, respectively, and covered most dairy producers in China. During the second round, the government inspected 154 randomly sampled milk powder producers (together making up over 70% of the market share) out of 290 producers nationwide and found 20 to be contaminated. During the third round, the government targeted another 466 established dairy brands with large market shares and found that 9 plants of 3 major brands were contaminated. That said, large firms appear to have been disproportionately targeted in the second inspection round as well: in section IIID, we find that inspected firms are significantly larger in terms of baseline sales and employment. Our identification strategy accounts for this imbalance by including a rich set of baseline controls interacted with time to allow for differential growth trajectories between large and small firms.<sup>8</sup>

These inspections uncovered contamination in several dairy and dairy-related products, including yogurt, milk, cheese, baby food, and cake. Product recalls were immediately issued. By the end of 2008, the Chinese government had issued an official statement that the incident had been fully addressed and that proper measures had been put in place to ensure the safety of the dairy products on the market.<sup>9</sup> Corroborating the Chinese government's statement, data from the EU's Rapid Alert System for Food and Feed (RASFF), which publishes safety notifications and recalls for imported food products, show that notifications related to melamine contamination in dairy products imported from China surged in the fall of 2008 but quickly subsided a few months after the initial outbreak (first figure in appendix A).

Despite the official statement, the scandal triggered widespread fears over food safety in China. Thousands of Chinese dairy-related products were pulled from supermarket shelves across the world. Some countries stepped up inspections for Chinese imports, while others issued explicit import bans for products containing dairy ingredients from China. For instance, EU authorities imposed tests on Chinese imports containing more than 15% of milk powder and announced a ban on all Chinese products containing milk for children; the U.S. Food and Drug Administration restricted

imports of all Chinese food products containing milk; India imposed an import ban on milk and all milk-related products from China that was extended until 2019. Our news search identified 43 destinations (out of 157) that imposed explicit regulatory bans on certain Chinese dairy imports (first table in appendix B).

The scandal had a long-lasting impact on the dairy industry in China. The GAQSIQ stopped issuing national exemption status to domestic food producers<sup>10</sup> and tightened inspections on domestically produced food products. Dairy firms also tightened their standards for purchased raw milk, and some started their own upstream milk farms to better control quality. However, figure 1 shows that despite these actions, dairy exports sharply declined after 2008 and had not recovered by the end of 2013, the end of our sample period. At the same time, dairy imports in China rose rapidly after the scandal (second figure in appendix A), suggesting that domestic consumers also switched to foreign dairy products in response to safety concerns about domestic producers.

### III. Data

We merge three microlevel data sets: the Chinese Customs Database, the Chinese Manufacturing Survey, and the list of inspections conducted by the Chinese government.

#### A. Chinese Customs Database (2000–2013)

The Chinese Customs Database provides information on trade flows for the universe of China's exports and imports. We focus on exports for this study. We observe the exporting firm's name, location, export value, and export quantity, the HS eight-digit product code, the city in China from which the product is sourced, and the final export destination. We compute unit prices for exported products by dividing the value of export by the quantity. For our industry-level analysis in section IV, we aggregate the data to the HS two-digit industry-year level; for our spillover analysis in sections V and VI, we aggregate the data to the firm-product-year level.<sup>11</sup> Third figure in appendix A shows that China's overall exports grew rapidly in the early 2000s following China's entry into the World Trade Organization (WTO).

We define the dairy industry using the HS eight-digit product classification. Most dairy products fall under the HS two-digit code 04, while infant dairy products fall under 19 and milk protein products extracted from raw milk fall under 35. Second table in appendix B provides the full list of the HS eight-digit codes and descriptions for dairy products.

<sup>7</sup>According to the investigation reports, these malpractices were “open secrets” in the industry. See <https://www.wsj.com/articles/SB122567367498791713>.

<sup>8</sup>In addition to the three big rounds of inspections targeting downstream dairy firms, the Chinese government conducted checks at upstream facilities and shut down a number of milk stations. We do not have systematic data on these upstream inspections, partly because many of the suppliers were very small and informal.

<sup>9</sup><http://www.telegraph.co.uk/news/worldnews/3079146/China-claims-tainted-milk-scandal-is-over.html>

<sup>10</sup>This policy was previously known as the “inspection-free” program, which gave exemption status to qualified food producers and waived various quality inspections for these firms.

<sup>11</sup>For observations from years prior to 2006, the data include exact the export date. For years after 2007, only monthly data are available. We collapse the data to the year level to account for monthly seasonality in exports.

### B. Chinese Manufacturing Survey (2005–2009, 2011–2013)

The Chinese Manufacturing Survey data are compiled from annual surveys conducted by the National Bureau of Statistics (NBS) and include all state-owned and non-state-owned industrial firms with sales revenue above 5 million RMB. Even though a large number of small to medium-size industrial firms (80%) are excluded from the sample, they account for only a small fraction of the total economic and export activities in China. In particular, the excluded firms employ 28.8% of the industrial workforce but produce only 9.3% of the total output and generate 2.5% of the export revenue (Brandt, Van Biesebroeck, & Zhang, 2012). Our spillover analysis in sections VB and VIC focuses on dairy firms within the manufacturing sector. For each firm-year, we observe production and financial information, including firms' four-digit industry code, years of operation, total sales, employment, and export revenue. When export revenue is missing, we complement the observation using the Customs data: we follow the standard procedure for matching firms across the Manufacturing Survey and the Customs data using name and address information.<sup>12</sup>

### C. Government Inspection Lists

Section II describes the three rounds of inspections implemented by the Chinese government after the scandal. For each round, the government released the list of products inspected at each firm and the inspection results. We obtained the inspection lists (at the firm-product level) from the GAQSIQ website. To cross-validate the information in the official reports, we conducted an extensive news search through LexisNexis: all the media-reported cases of contamination that we found appeared in the official inspection lists.

We merge the firm-product-level inspection lists with the Customs data using firm names and product information and with the Manufacturing Survey data using firm names (since the latter data do not include product information). We classify merged firms into one of three categories: contaminated, innocent, and uninspected. Contaminated firms have at least one product found to be contaminated during one or more rounds of inspections. Innocent firms passed the tests for all of their inspected products. Uninspected firms were never inspected. We analogously classify products into the following categories: contaminated products are those found to be contaminated in at least one of the inspected firms, and innocent products are those that cleared inspection in all firms inspected.

<sup>12</sup>This matching is not 100% accurate, as documented in the literature (e.g., Kee & Tang, 2016). Of the 335 dairy firms appearing in the Customs data in 2007, we can identify 151 in the Manufacturing Survey. The lack of matches for the remaining 184 firms could be due to mismatches in firm names or the fact that the Manufacturing Survey includes only above-scale firms.

### D. Summary Statistics

Our spillover analysis in section V uses two samples. First, we use our linked Customs-Inspections sample to study the scandal's spillover effects on the export performance of dairy firms at the firm-product level. This sample includes 1,868 firm products across 1,464 firms and 25 products. Of these, we identify 149 contaminated firm-product pairs in 67 contaminated firms and 413 innocent firm-product pairs in 95 innocent firms. Second, we use our linked Manufacturing Survey-Inspections sample to study the scandal's spillover effects on the domestic performance of the dairy firms. This sample includes 1,687 firms, 73 of which were contaminated and 352 innocent. Restricting the sample to firms that appear in the Manufacturing Survey both before and after the scandal reduces the sample to 238 firms: 19 contaminated and 103 innocent.

Table 1 presents firm-level baseline (2000–2007) summary statistics for export performance measures in the linked Customs-Inspections sample (panel A) and for employment and total sales in the Manufacturing Survey-Inspections sample (panel B). It compares contaminated (columns 1 and 2), innocent (columns 3 and 4), and uninspected firms (columns 5 and 6). Column 7 calculates the difference in means between contaminated and uninspected firms (columns 2 and 6), and column 8 reports the *p* value of this difference. On average, contaminated firms have larger export revenue and are more experienced than innocent firms; however, they are not systematically different from uninspected firms (panel A). Contaminated firms are larger in terms of both employment and sales revenue than both innocent firms and uninspected firms (panel B). This pattern is consistent with the Chinese government targeting larger firms in the third round of inspections.<sup>13</sup> Even for the second round of inspections, which were claimed to be random, inspected firms appear to differ from uninspected firms on several observable characteristics, including the value of exports in 2007 (second table in appendix A). Section V discusses how our empirical framework addresses selection into inspection.

Table 2 presents product-level baseline summary statistics for the same export performance measures in the Customs-Inspections sample for dairy (panel A) and nondairy (panel B) products. On average, contaminated products are exported in larger quantities and for longer export periods than innocent and uninspected products. Contaminated products also appear to be less likely to be exported to countries in the Organisation for Economic Cooperation and Development (OECD) although the difference is not significant.

Fourth figure in appendix A plots the number of export products and destinations for contaminated, innocent, and uninspected firms before and after the scandal. Many firms exported a single product to a single destination. In

<sup>13</sup>First table in appendix A shows similar patterns for firms producing nondairy food products.

TABLE 1.—BASELINE SUMMARY STATISTICS: DAIRY FIRMS

	Contaminated		Innocent		Uninspected		Contaminated vs. Uninspected	
	Number (1)	Mean (2)	Number (3)	Mean (4)	Number (5)	Mean (6)	Difference (7)	<i>p</i> value (8)
Panel A. Customs database								
Avg. yearly export revenue (in million dollars)	15	3.32 (6.16)	23	.49 (.91)	960	1.85 (6.62)	1.47 (1.55)	.34 —
Years of exporting	15	4.6 (2.92)	23	3.39 (2.37)	960	4.22 (2.43)	.38 (.73)	.61 —
% exports to OECD countries (conditioning on exporting)	15	.51 (.44)	23	.39 (.42)	960	.6 (.39)	−.09 (.11)	.41 —
Panel B. Manufacturing survey								
Employment	41	1087 (1979)	244	300 (554)	808	185 (292)	902 (306)	.003 —
Log (employment)	41	5.79 (1.57)	244	5.06 (1.01)	808	4.63 (1.01)	1.16 (.25)	0 —
Sales revenue (in million RMB)	41	1038 (2193)	243	113 (222)	780	87 (184)	951 (339)	.005 —
Log (sales revenue)	41	5.17 (2.02)	243	3.76 (1.26)	780	3.38 (1.33)	1.80 (.32)	0 —

For each firm, the sample includes only dairy products. Panel A uses the baseline (2000–2007) Customs database linked with the inspection list to identify contaminated, innocent and uninspected firms. Panel B uses the baseline (2005–2007) Manufacturing Survey data, also linked with the inspection list. The unit of observation is collapsed to the firm level. Columns 1, 3, and 5 show the number of firms in each category. Columns 2, 4, and 6 show the mean of selected variables in each subsample. For these variables, column 7 calculates the difference between contaminated firms (column 2) and uninspected firms (column 6), obtained by regressing the outcome variable on a contaminated group dummy. Column 8 presents the *p* value of the difference. Standard deviations are in parentheses for columns 2, 4 and 6. For column 7, robust standard errors are in parentheses.

TABLE 2.—BASELINE SUMMARY STATISTICS: DAIRY AND DAIRY-RELATED PRODUCTS

	Contaminated		Innocent+Uninspected		Difference (5)	<i>p</i> value (6)
	Number (1)	Mean (2)	Number (3)	Mean (4)		
Panel A. Dairy products						
Avg. yearly export revenue (in million dollars)	11	6.36 (11.12)	12	3.99 (6.41)	2.37 (3.83)	.542 —
Number of exporting years	11	7.64 (1.21)	12	6.42 (1.98)	1.22 (.68)	.086 —
% to OECD countries	11	.55 (.25)	12	.65 (.33)	−.10 (.12)	.437 —
Panel B. Nondairy food products						
Avg. yearly export revenue (in million dollars)	16	38.53 (51.01)	944	21.23 (67.02)	17.30 (12.55)	.168 —
Number of exporting years	16	7.88 (.50)	944	6.09 (2.51)	1.79 (.15)	0 —
% to OECD countries	16	.80 (.13)	944	.76 (.26)	.04 (.03)	.204 —

The sample is obtained from the baseline (2000–2007) Customs database linked with the inspection list to identify contaminated, innocent and uninspected products. Panel A only includes dairy products, while panel B includes nondairy food products. The unit of observation is collapsed to the product (HS eight-digit) level. Columns 1 and 3 show the number of products (HS eight-digit) in each category. Columns 2 and 4 show the mean of selected variables in each subsample. Column 5 calculates the difference between contaminated products (column 2) and innocent plus uninspected products (column 4), obtained by regressing the outcome variable on a contaminated group dummy. Column 6 presents the *p* value of the difference. Standard deviations are in parentheses for columns 2 and 4. For column 5, robust standard errors are in parentheses.

section V, we discuss how these patterns generate the variation that we exploit for the firm-product-level analysis.

#### IV. Impact of the Scandal: Industry-Level Analysis

This section estimates the overall impact of the scandal on the export performance of the Chinese dairy sector. Section IVA discusses our preferred empirical specification, a difference-in-differences (DD) specification, as well as threats to the validity of the DD assumptions and additional tests we perform that relax these assumptions. Section IVB presents our DD estimates. Our finding that the scandal

decreased the total value of dairy exports by 68% over the course of five years motivates us to further explore within-sector spillovers across firms and products in section V.

##### A. Empirical Specification

Equation (1) presents our baseline DD specification, which compares the value of exports of the dairy industry (the treated industry) to the value of exports of other two-digit-level industries before and after 2008, the year of the scandal.

$$Y_{jt} = \beta_{\text{dairy}} \text{Dairy}_j \times \text{Post}_t + \gamma_j + \delta_t + \pi X_{jt} + \epsilon_{jt}. \quad (1)$$

TABLE 3.—IMPACT OF THE SCANDAL ON EXPORTS: INDUSTRY-LEVEL ANALYSIS

Dep Var: Log (export value)	(1)	(2)	(3)	(4)
Panel A. All dairy exports				
DairyXPost	-1.065*** (0.080)	-0.892*** (0.114)	-0.685*** (0.238)	-1.140*** (0.086)
FoodXPost		-0.174 (0.139)		
R-squared	0.964	0.963	0.970	0.980
Observations	1120	1386	1107	1120
Panel B. Innocent+uninspected firm products only				
DairyXPost	-0.915*** (0.080)	-0.741*** (0.114)	-0.554** (0.233)	-0.848*** (0.086)
FoodXPost		-0.174 (0.139)		
R-squared	0.964	0.963	0.970	0.980
Observations	1120	1386	1107	1120
Year, Industry FEs	YES	YES	YES	YES
YearXValue Share to different continents	NO	NO	YES	NO
Industry time trends	NO	NO	NO	YES
Excluding the food sector	YES	NO	YES	YES

This table shows the regression results for equation (1). Panel A contains all exporters, collapsed to the industry-year level. Panel B excludes contaminated firm products to quantify the aggregate spillover effect. We create a balanced panel at the industry (HS two-digit) and year level. The dependent variable is log annual export value for each industry. The baseline specification in column 1 includes only year and industry fixed effects. Columns 3 and 4 build on this specification by adding time-varying controls, including the value share exported to different continents at baseline (2000–2007) interacted with year indicators and industry-specific linear time trends. Columns 1, 3, and 4 exclude nondairy food industries; column 2 includes all HS two-digit industries. Standard errors clustered at the product (HS two-digit) level. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% level, respectively.

$Y_{jt}$  is the natural logarithm of the value of exports for industry  $j$  in year  $t$ ; Dairy $_j$  is an indicator for the dairy industry; and  $X_{jt}$  includes time-varying controls at the industry level, such as the value share exported to different continents at baseline (2000–2007) interacted with year indicators. These covariates control for differential trends in destination countries that may affect different industries differently. In our preferred specification, we include 79 non-food control industries. Nondairy food exports may also be affected by the scandal if foreign consumers update their perceptions about the quality of Chinese food products in general. We cluster standard errors at the industry level, allowing for arbitrary correlation in error terms across time for a given industry.

The internal validity of the DD design rests on the assumption that the treated and control industries would be on parallel trends absent the scandal. This parallel trends assumption may not hold in our context for two reasons. First, as discussed in section II, prior to the scandal, dairy exports grew rapidly, a growth episode that might not be paralleled in other industries. Second, the global financial crisis in 2008 could have affected different industries differently. If so, we may erroneously attribute to the scandal an export decline in dairy products that was in fact due to the crisis. While perfectly overcoming these concerns is challenging in the current context, we perform a series of robustness checks, detailed in appendix C. Our estimates of the impact of the scandal are robust to several specifications that relax the parallel trends assumption, such as including a vector of industry-specific linear time trends. Moreover, an interactive fixed effect model (Gobillon & Magnac, 2016) and a synthetic control model produce qualitatively and quantitatively similar estimates to those produced by the DD design, despite relying on different identification assumptions.

### B. Results: Difference-in-Differences

Table 3 presents estimates of equation (1). We focus first on panel A. The baseline specification in column 1 includes only year and industry fixed effects and estimates a decline of 65.5% in the value of dairy exports following the scandal.<sup>14</sup> Columns 3 and 4 build on this specification by adding time-varying controls and industry-specific linear trends. Our preferred specification in column 4 estimates that the value of dairy exports plummeted by 68% following the scandal. Column 2 expands our sample to include nondairy food industries. The coefficient on the interaction between the food-industry indicator and the post-scandal indicator suggests that the scandal did not affect the nondairy food industry in an economically and statistically significant way.

Panel A estimates the overall impact of the scandal on the dairy industry, capturing both the direct impact on contaminated firm products and the spillovers to innocent and uninspected firms and products. Panel B disentangles the aggregate spillover effect by excluding contaminated firm products from the treated (dairy) industry. We estimate a 57% decrease in exports for innocent and uninspected firm products, about four-fifths of the total effect of the scandal.<sup>15</sup> The difference between the spillover and the total effect is only statistically significant in our preferred specification in column 4.

<sup>14</sup>Because most of the coefficients that we estimate are large in magnitude, we compute elasticities using the following formula: Elasticity =  $(e^{\text{Coeff}} - 1) \times 100$ , where Coeff is the estimated coefficient reported in the tables.

<sup>15</sup>An analogous analysis shows that dairy imports significantly increased relative to imports in other sectors after 2008 (third table in appendix A) as domestic consumers switched to foreign brands following the crisis.

## V. Reputation Spillover: Firm-Product-Level Analysis

Motivated by the findings in the previous section, we examine how the impact of the scandal spilled over across firms and products within the dairy sector. We study both the direct impact on contaminated firm products and the spillover effects *within* and *across* firms in the industry. To do so, we use our Customs-Inspection sample described in section III to exploit *within-industry* variation in involvement in the scandal. Our main regression specification is as follows:

$$\begin{aligned}
 Y_{fpt} = & \beta_{\text{direct}} \text{CFirm-Product}_{fp} \times \text{Post}_t \\
 & + \beta_{\text{within-firm}} \text{CFirm}_f \times \text{Post}_t \\
 & + \beta_{\text{across-firm}} \text{CProduct}_p \times \text{Post}_t \\
 & + \lambda_1 \text{IFirm-Product}_{fp} \times \text{Post}_t \\
 & + \lambda_2 \text{IFirm}_f \times \text{Post}_t \\
 & + \gamma_{fp} + \delta_t + \epsilon_{fpt}. \quad (2)
 \end{aligned}$$

We restrict the analysis to the dairy industry. The dependent variable  $Y_{fpt}$  is an outcome for firm  $f$ 's product  $p$  in year  $t$ , including the inverse hyperbolic sine (IHS) transformation of export revenue and export quantity, the natural logarithm of export price, and an indicator for exporting.<sup>16</sup> Except for the price outcome, we first create a balanced panel at the firm-product and year levels to capture extensive-margin responses (i.e., entry and exit into export).  $\text{CFirm-Product}_{fp}$  is an indicator for contaminated firm-product pairs directly involved in the scandal: the indicator equals 1 if a given product of a firm was inspected and failed the quality test.  $\text{CFirm}_f$  is an indicator for contaminated firms: the indicator equals 1 if a firm was inspected and *at least one* of its products failed the test.  $\text{CProduct}_p$  is an indicator for contaminated products: the indicator equals 1 if at least one of the inspected firms failed the quality test for the given product.  $\text{IFirm-Product}_{fp}$  and  $\text{IFirm}_f$  are defined similarly:  $\text{IFirm-Product}_{fp}$  is an indicator for innocent firm-product pairs that were inspected and passed the quality test.  $\text{IFirm}_f$  is an indicator for innocent firms that passed the quality test for *all* of their inspected products.

Identification relies on the assumption that unobserved firm-product-year-specific shocks that affect the outcomes are uncorrelated with the initial inspection status. In other words, absent the scandal, all firm products would have seen the same growth in export performance over time. However, the Chinese government did not choose which firms to inspect randomly. As discussed in section IIID, inspected firms are on average larger than uninspected firms.

To assuage concerns of omitted variable or selection bias, our preferred specification includes (1) firm-product ( $\gamma_{fp}$ ) and (2) year ( $\delta_t$ ) fixed effects as well as (3) an interaction of

baseline firm-product export volume with the post-scandal indicator. First, this specification partials out time-invariant firm-product unobservable characteristics, such as quality. Second, it controls for common nationwide dairy industry time trends, such as global demand shocks. Third, differential trends for firms of different sizes account for potentially different growth trajectories during the dairy boom prior to the scandal. Thus our analysis captures differential changes in performance across firm products over time. To examine the sensitivity of our results, we also estimate an alternative specification including firm, product and year fixed effects separately (fourth table in appendix A). We cluster standard errors two ways at the product-year and firm level, allowing for arbitrary correlation in error terms over time for a given firm and across firms for a given product-year. This two-way clustering allows for persistent shocks within a firm over time as well as for cross-sectional yearly shocks affecting all firms producing the same products.

The omitted category in equation (2) includes innocent products and uninspected products from uninspected firms. Therefore,  $\beta_{\text{across-firm}}$  identifies the impact of the scandal on uninspected firms selling one of the products found to be contaminated in other firms (i.e., *cross-firm* spillovers).  $\beta_{\text{within-firm}}$  identifies the overall impact on the contaminated firms (i.e., *within-firm* spillovers), whereas  $\beta_{\text{direct}}$  captures the additional impact on their directly involved products. Similarly,  $\lambda_1$  and  $\lambda_2$  capture the impact on innocent firms and innocent firm products relative to the omitted group. Given that the regression is done at the firm-product-year level, fifth table in appendix A presents an overview of the variation in the data by counting the number of observations falling under different cells, namely, contaminated versus noncontaminated firms and products before and after the scandal.

We present our baseline estimation results in section VA and discuss their interpretation in section VB as well as alternative explanations and robustness checks in section VC.

### A. Results: Direct and Spillover Effects on Exports

Table 4 reports the main estimates from equation (2). Column 1 examines the impact of the scandal on the IHS of export revenue and shows large within-firm and cross-firm spillovers. Specifically, we estimate  $\hat{\beta}_{\text{within-firm}} = -1.8$ , which is significant at the 1% level; that is, contaminated firms experienced a drop of 84.1% in export revenue after the scandal relative to the national trend and the firms' average performance. Within contaminated firms, directly involved products were affected more—the estimated coefficient  $\beta_{\text{direct}}$  is meaningful ( $-0.489$ , or  $-38.7\%$ ) but imprecisely estimated, suggesting that there may be heterogeneous impacts among directly contaminated firm products. Another possibility is that since most products within the contaminated firms were affected, the coefficient is only picking up any *differential* impact of contaminated versus innocent and uninspected products within those firms.

<sup>16</sup>We use the IHS transformation for export revenues and quantity to obviate the fact that we have missing firm-product-year cells when exports are zero (Burbidge, Magee, & Robb, 1988).



TABLE 4.—IMPACT OF THE SCANDAL ON EXPORTS: FIRM-PRODUCT-LEVEL ANALYSIS

	IHS (Value) (1)	IHS (Quantity) (2)	Log (Price) (3)	Exporting (dummy) (4)
CFirm-ProductXPost	-0.489 (1.180)	-0.345 (1.157)	-0.122 (0.091)	-0.019 (0.078)
CFirmXPost	-1.838*** (0.437)	-1.811*** (0.456)	0.209*** (0.051)	-0.153*** (0.031)
CProductXPost	-0.773*** (0.281)	-0.757*** (0.257)	-0.157* (0.087)	-0.064*** (0.023)
IFirm-ProductXPost	1.083 (0.978)	0.981 (0.929)	-0.211** (0.083)	0.081 (0.071)
IFirmXPost	-0.944 (0.768)	-0.847 (0.708)	0.219** (0.097)	-0.081 (0.063)
R-squared	0.285	0.299	0.903	0.211
Observations	13775	13775	1519	13775
Firm-product FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
BaselineSizeXPost	YES	YES	YES	YES

This table shows the regression results for equation (2). The unit of observation is at the firm-product-year level. The sample contains all dairy exporters (excluding intermediaries) in the Chinese Customs data (2000–2013). We rectangularize the data to create a balanced panel at the firm-product (HS eight-digit) and year level for the outcomes in columns 1, 2, and 4. Columns 1 and 2 present results for the inverse hyperbolic sine (IHS) transformation of the outcome variables of interest, export value and export quantity. Column 3 presents results for the natural logarithm of unit price, while column 4 uses an indicator for positive exports as the outcome variable. The interaction terms are the products of the post-scandal dummy (2009–2013) with the following five group indicators: (C)ontaminatedFirm-Product, (C)ontaminatedFirm, (C)ontaminatedProduct, (I)nnocentFirm-Product, and (I)nnocentFirm. The omitted category includes innocent and uninspected products from uninspected firms. All regressions include firm-product and year fixed effects. Baseline size measures a firm's baseline (2000–2007) total export volume. Standard errors are two-way clustered at the firm and product-year level. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% level, respectively.

In line with the industry-level analysis in section IV, we also see a large negative spillover effect on firms selling contaminated products: the estimate for  $\beta_{\text{across-firm}}$  is  $-0.773$  (or  $-53.8\%$ ) and is significant at the 1% level. Finally, the effects on innocent firms and products are mixed: while the coefficient on IFirm-Product $\times$ Post is large and positive, the overall impact on innocent firms, relative to uninspected firms, is negative. Neither of these estimates is statistically significant.

Column 2 examines the effects of the scandal on the IHS of export quantity and finds similar results. Comparing the estimates of  $\beta_{\text{across-firm}}$  in columns 1 and 2, the decrease in quantity explains 97.9% of the cross-firm spillovers, after entry and exit are taken into account.

Column 3 examines changes in unit price on the unbalanced panel of firm-product-year observations with positive export activity. The estimate of  $\beta_{\text{across-firm}}$  is  $-0.157$  ( $-14.5\%$ ) and is significant at the 10% level. The direct impact on contaminated firm products is  $-0.122$  ( $-11.5\%$ ) but is not statistically significant, whereas the within-firm spillover  $\hat{\beta}_{\text{within-firm}}$  is positive at 0.209 (18.9%) with a standard error of 0.051. One possible explanation for this positive within-firm price coefficient is that contaminated firms disproportionately raised the prices of their noncontaminated products to make up for lost revenue. Alternatively, contaminated firms may have incurred larger cost shocks (e.g., costs of recalling products or clearing government inspections) than noncontaminated firms and partially passed those costs through to final consumers. The estimated  $\beta_{\text{within-firm}}$  captures the net of these additional spillover effects in addition to potential reputation spillovers.

Column 4 examines the impact of the scandal on the extensive margin and finds that contaminated firms are 14.2% less likely to export after the scandal. The estimate for  $\beta_{\text{within-firm}}$

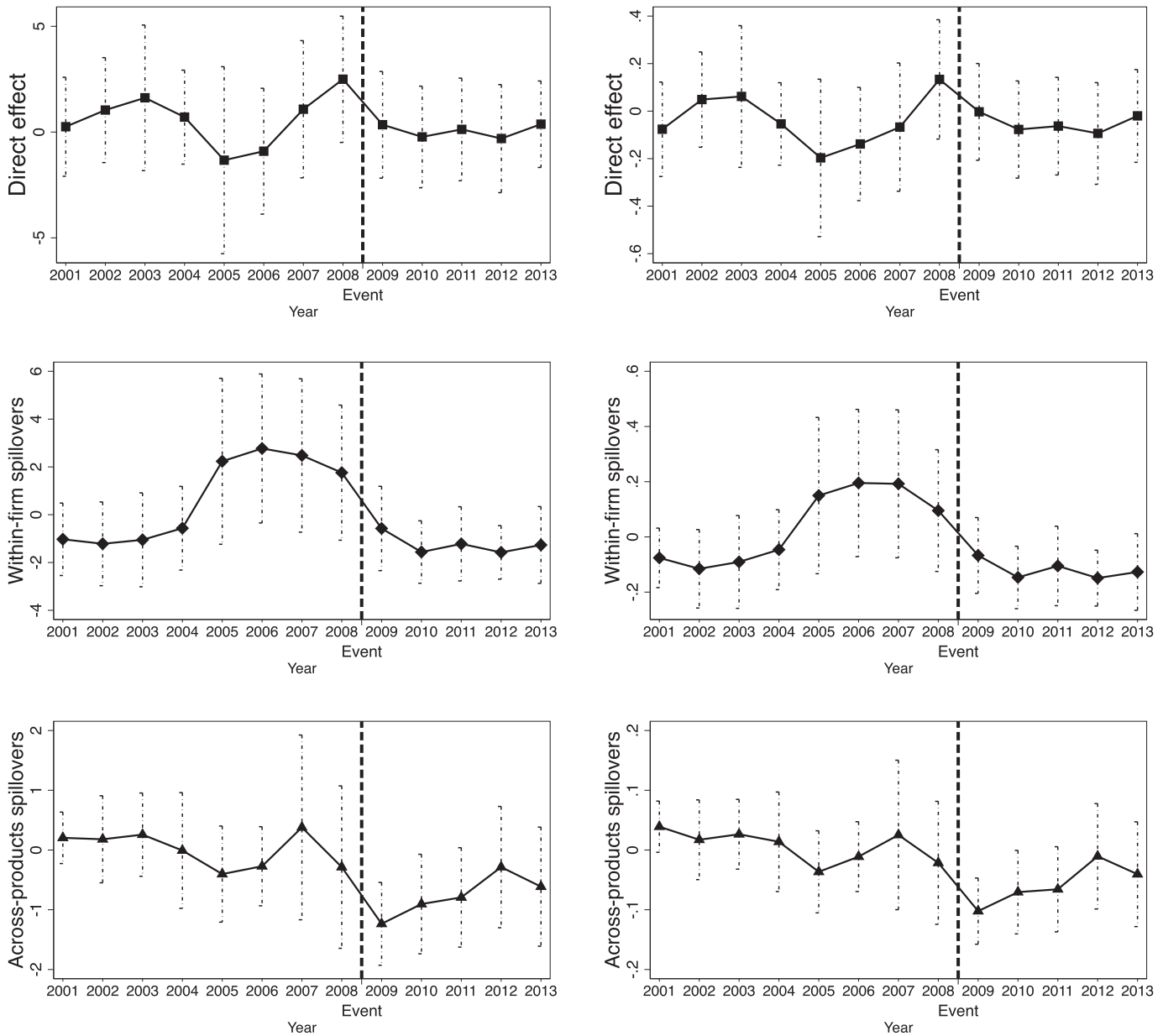
is significant at the 1% level, whereas the one for  $\beta_{\text{direct}}$  is indistinguishable from 0. All Chinese dairy firms carrying products found to have been contaminated during the scandal, regardless of whether the firms themselves are innocent, contaminated or not inspected, are 6.2% less likely to export those products, and the estimate of  $\beta_{\text{across-firm}}$  is significant at the 1% level. The results on innocent firms and products are again inconclusive.

We examine how persistent the direct and spillover effects are by fully interacting the firm-product group dummies in equation (2) with year dummies. Figure 2 plots the regression coefficients with 95% confidence intervals for two outcome variables: log value of exports and exporting indicator. Both the within-firm and cross-firm spillover effects persist more than five years after the scandal and display little sign of recovery.

Our findings contrast with estimates of reputation spillover effects in developed countries. For example, Freedman et al. (2012) and Bachmann et al. (2019) document cross-firm reputation spillover effects for US and German manufacturers, respectively, that are much smaller than what we estimate for Chinese dairy firms. This difference in magnitude suggests that information frictions may be larger in developing countries.<sup>17</sup> Mistrust of government agencies in developing countries may make it more difficult for firms to recover from damages to collective reputation. More work is needed to draw systematic comparisons across different countries and market environments.

<sup>17</sup>Specifically, Bachmann et al. (2019) finds that other German auto manufacturers experienced a 9.2 percentage point reduction in sales growth rate from 2015 to 2016 following the VW scandal. Freedman et al. (2012) finds that sales revenue during the Christmas holiday season declined by 30% for unaffected toy manufacturers in the US after a related scandal.

FIGURE 2.—EFFECTS OVER TIME: EXPORT VALUE (LEFT) AND EXPORT DUMMY (RIGHT)



This figure plots the regression coefficients of the following three group dummies interacted with year dummies: ContaminatedFirm-Product, ContaminatedFirm and ContaminatedProduct. The same regressions also include the interaction terms between year dummies and InnocentFirm-Product as well as InnocentFirm dummies; these coefficients are not plotted. The outcome variable for the left column is the inverse hyperbolic sine (IHS) transformation of export value, and the one for the right column is the export dummy. All regressions include firm-product and year fixed effects. The dotted lines plot the 95% confidence intervals, based on two-way clustered standard errors at the firm and product-year level.

### B. Interpretation: The Role of Government Inspections

We find large cross-firm spillovers in export performance, including for uninspected firms. However, we find mixed evidence of reputation spillovers to innocent firms and products. These findings highlight the potential challenges of government inspection efforts in helping firms signal quality. First, the public may perceive government inspections to be a negative signal. Being inspected may have been taken to indicate that something was not right (“bad signaling effect”), even though some inspections were allegedly targeted at random. Second, being mentioned in news reports on the scandal may

impose a stigma if customers do not pay attention to the details of the news. Ma, Wang, and Khanna (2016) discuss this “reminder (salience) effect.”

Both the bad signaling and reminder effects may also be present in the domestic market, potentially making government inspections ineffective. The second figure in appendix A and the third table in appendix A show that the scandal increased imports, suggesting mistrust of domestic brands. To shed light on domestic spillover effects, we turn to the Manufacturing Survey data, which are only available at the firm level. We restrict the analysis to a balanced sample of

TABLE 5.—IMPACT OF THE SCANDAL ON FIRMS' DOMESTIC PERFORMANCE

	Log (total sales revenue) (1)	Log (domestic sales revenue) (2)	Log (employment) (3)
CFirmsXPost	−0.315 (0.255)	−0.309 (0.255)	−0.181 (0.235)
IFirmsXPost	−0.036 (0.089)	−0.027 (0.091)	−0.099 (0.067)
R-squared	0.884	0.882	0.839
Observations	1664	1665	1666
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
BaselineSizeXPost	YES	YES	YES

This table shows the regression results for the effects of the scandal on firms' sales and employment. The unit of observation is at the firm-year level. The sample includes the balanced sample of dairy firms in the Manufacturing Survey data (2005–2009 and 2011–2013). We compute a firm's domestic sales by subtracting export sales from total sales; in cases where export information is missing in the Manufacturing Survey data, we merge the sample with the Customs data and fill in the missing export sales information whenever we can. The interaction terms are the post-scandal indicator (2009–2013) with the following two group indicators: (C)contaminatedFirm and (I)innocentFirm. The omitted category is uninspected firms. All regressions include firm and year fixed effects. Baseline size measures a firm's total sales revenue from 2005 to 2007. Standard errors are clustered at the firm level. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% level, respectively.

firms to account for survey composition changes.<sup>18</sup> In total, 238 dairy firms appeared in all years between 2005–2009 and 2011–2013, out of 1,687 that ever appeared during this period. These firms account for 49.8% of the total dairy production during this period.

Table 5 estimates the impact of the scandal on this sample of continuing firms. We cluster standard errors at the firm level, as product-level information is not available in this sample. The coefficients are not precisely estimated. Qualitatively, we see a negative impact of the scandal on contaminated firms, while innocent firms do not appear to perform better than uninspected ones. These findings are consistent with the bad signaling and reminder effects acting on the domestic market and highlight the challenges that governments may face in restoring trust. These results speak to the importance of understanding how consumers acquire information. We come back to this point in section VI when we discuss the mechanisms underlying the reputation spillover.

### C. Alternative Explanations and Robustness Checks

This section considers several alternative explanations aside from reputation spillovers that may contribute to the results in section VA and presents additional robustness checks.

*Differential time trends.* Different subindustries within the dairy sector may have followed different growth trajectories in the absence of the scandal, leading to biased estimates of the spillover effects. Fourth table in appendix A allows for differential time trends across subindustries at the HS two-digit level. Reassuringly, these results are qualitatively very similar to the results in table 4.

<sup>18</sup>Section IIIB explains that the Manufacturing Survey only includes firms with sales revenue exceeding 5 million RMB. Thus we cannot distinguish between true exits due to the scandal versus mere reductions in scale.

Reversion to the mean could also bias our results. If contaminated firms were growing faster prior to the scandal, our estimates may be partly driven by these fast-growing firms mechanically scaling down their production and reducing exports after the scandal. To alleviate this concern, we allow for differential time trends with respect to baseline sales in our baseline specification. In sixth table in appendix A, we further exclude firms and destination countries that account for most of the export growth spike between 2006 and 2008 (see the discussion in section II). The results are very similar.<sup>19</sup>

*Confounding supply-side factors.* Collective reputation represents a demand-side force, but supply-side forces may also have contributed to the observed spillover effects. For example, the scandal disrupted the activities of some upstream suppliers: some milk farmers and milk stations exited the market as a result. Similarly, stronger government regulations may have imposed additional costs on firms, raising their production costs. All these supply-side forces could have led to reductions in export revenue and quantity. However, a pure upward shift of the supply curve would have resulted in an unambiguous increase in price (conditional on exporting), contrary to what we estimate in table 4, column 3: the coefficient on CProductXPost, the key collective reputation spillover effect, is negative and significant at the 10% level.<sup>20</sup> This result alone implies that the demand curve must have moved downward and offset the supply curve movement. While we cannot completely rule out supply-side movements, we conclude that the demand-side force due to collective reputation effects played an important role in this context.

*Confounding foreign demand shocks.* Different firms may be subject to idiosyncratic demand shocks depending on the conditions in the destination countries that they export to. If contaminated firms were more likely to export to countries that happened to demand more or fewer imported dairy products after 2008, the estimated coefficients would be biased. To examine this possibility, we construct a measure of firm-specific demand shocks using a firm's baseline export value share for each destination country multiplied by each destination country's yearly dairy imports from the rest of the world excluding China and summed over all destinations. The fourth table in appendix A shows that our results are robust to including these firm-specific demand shocks as additional controls.

*Foreign import regulations due to protectionist motives.* Import regulations targeted at all firms from the same origin industry can result in patterns similar to those estimated in table 4. The first table in appendix B lists the 20 countries

<sup>19</sup>As discussed in section II, a few predominant firms and export destinations drove the growth spike in the pre-scandal period (2006–2007).

<sup>20</sup>We can estimate the price regression on a balanced sample of exporters (i.e., firms that exported both before and after the scandal) to account for any sample composition change; the results are robust.

plus the EU that imposed explicit import bans on Chinese dairy products after the 2008 scandal by the countries' value share in total dairy exports from China.

One way to think about such trade policies is that foreign governments react on behalf of domestic consumers in light of rising safety concerns about products imported from a particular country. Such blanket regulations represent an underlying channel for the collective reputation effect. Alternatively, these regulations may arise from protectionist motives. In other words, foreign countries could take advantage of the scandal to raise import barriers. Empirically distinguishing these two stories is challenging. The seventh table in appendix A presents estimates only for the sample of destinations without explicit import bans. These results are very similar to our main estimates, suggesting that explicit government regulations cannot fully explain the spillover effects. Market-based forces due to collective reputation do matter.

## VI. Mechanisms

In this section, we investigate three potential mechanisms that may mediate the strength of the reputation spillover effects documented in sections IV and V. Since a firm's reputation consists essentially of buyers' beliefs, how consumers gather information and learn matters crucially for reputation externalities. Thus the mechanisms that we investigate relate to what may shape consumers' information sets. Specifically, we examine the roles of (1) information accuracy in global media reports, (2) firms' location and the traceability of contaminated suppliers, and (3) firms' export experience. All of these forces can act jointly and interact with one another. Rather than trying to disentangle and quantify the impact of each, our goal is to examine whether a particular force has bite.

### A. Information Accuracy in Global Media Reports

A large literature has shown that the media influence people's perceptions, thereby affecting a wide range of social and economic outcomes (DellaVigna & Gentzkow, 2010). In the context of food scares, Adda (2007) and Luong, Shi, and Wang (2019) show that news information alters consumers' perceived risk of encountering low-quality products and thereby affects demand. Therefore, how the media report an event shapes the event's impacts. We investigate an important aspect of media reports on the scandal: informational accuracy, that is, the level of detail with which media outlets described the involvement of different firms in the scandal. The fifth figure in appendix A shows a typical Chinese media report on the scandal (left panel), which includes a full list of contaminated firms and products, and an example from the Western media, the *New York Times* (right panel), which only reported an estimated number of contaminated firms without mentioning any specific names.

Such heterogeneity in media reports across countries can generate different information sets among local consumers.

We can imagine two scenarios: one in which consumers perfectly understand the evolution of the scandal and are able to closely keep track of the inspection outcomes and another in which consumers have trouble identifying the contaminated firms and worry about Chinese dairy products in general as a result of the scandal. Collective reputation forces would be stronger in the latter scenario than in the former.

To construct a systematic measure of consumers' information accuracy across different export destinations, we leverage Google Trends data. Google Trends provides public time series indices based on Google Search data, which capture how often a search term is entered relative to the total search volume in a given geographical area. To allow comparisons of relative popularity across search terms, each data point in Google Trends indices is divided by the total searches in the corresponding geographical area and time range and scaled on a range of 0 to 100 for any given period. We collect data for 31 countries available on Google Trends and construct the relative search intensity ratio for two keywords—"Sanlu" versus "2008 Chinese milk scandal"—for each country. Figure 3 displays the relative search intensity across countries. Web users in Japan, China, Hong Kong, and New Zealand, for example, searched for "Sanlu" much more than the generic phrase, suggesting that consumers in these locations may have been more informed about the parties directly involved in the scandal. In comparison, the searched information appears to have been much less specific in countries such as Myanmar, Pakistan, Austria, and Vietnam.<sup>21</sup> We classify countries into two groups based on the relative search intensity: high indicates a higher ratio (top quartile) and thus higher information accuracy (figure 3).<sup>22</sup>

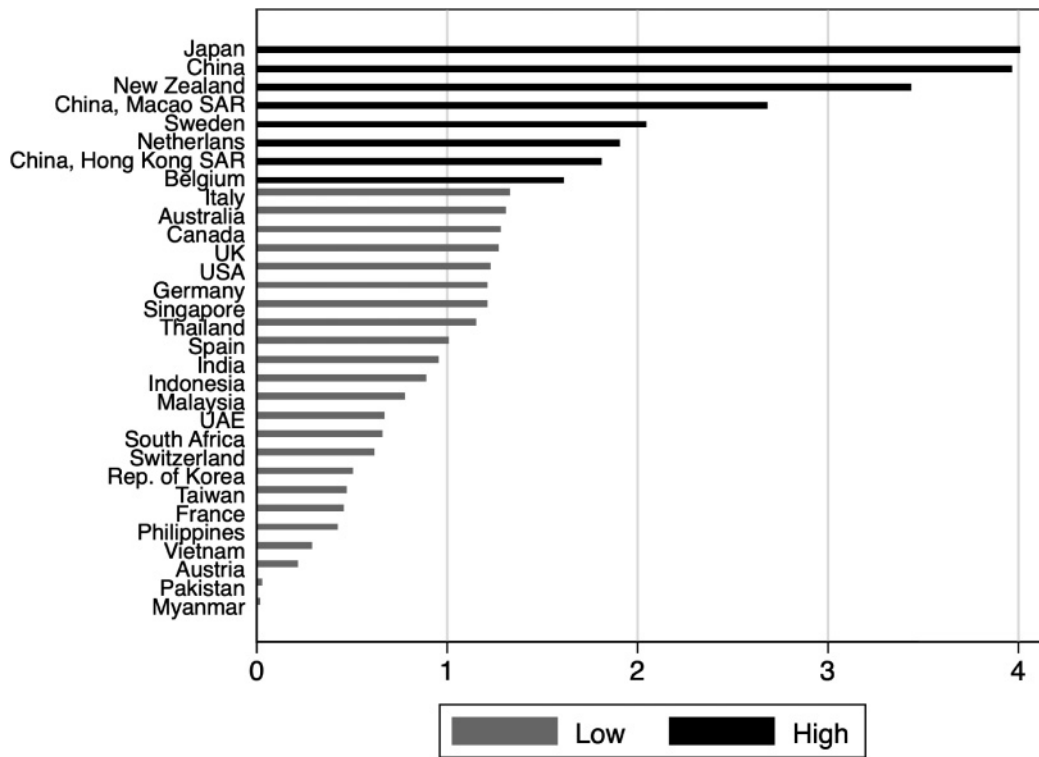
Table 6 reports the effect of the scandal on export performance to destinations with high and low search intensity ratios. Consistent with consumers in countries with low information accuracy not being able to distinguish innocent and contaminated firms, the cross-firm spillover effect ( $\hat{\beta}_{\text{across-firm}}$ ) is driven by exports to destinations with low information accuracy ( $-0.639$  compared to  $-0.025$ , with a  $p$  value for testing equality of 0.0016). In eighth table in appendix A, we further divide countries into quartiles of the information accuracy measure. We find suggestive evidence of bigger cross-firm spillover effects as information worsens.

Overall, these results show that information accuracy plays an important role in mediating the force of collective reputation. Information accuracy may be particularly relevant in the context of international trade, as media coverage of events

<sup>21</sup>The sixth figure in appendix A shows the search behavior across provinces in China. Not surprisingly, Hebei province, where the headquarters of Sanlu was located, has the highest search intensity for the keyword "Sanlu."

<sup>22</sup>This measure of information accuracy may be correlated with countries' baseline market share of Chinese dairy exports, potentially confounding the estimation results. Regressing the Google search index on countries' baseline market share yields a low R-square of 0.007 (0.005), suggesting that most variation in information accuracy cannot be explained by market share. One factor affecting information accuracy could be how the scandal was covered in the local media, which may depend on political attitudes.

FIGURE 3.—RATIO OF GOOGLE SEARCH INDEX: “SANLU” VERSUS “2008 CHINESE MILK SCANDAL”



This figure plots the ratio of the Google search index for the keyword “Sanlu” versus “2008 Chinese milk scandal” by country between 09/01/2008 and 10/31/2008. The black bars mark countries with high information accuracy (the top quartile), while the grey ones mark countries with low information accuracy.

that happen in foreign countries, where information needs to travel far, may be less precise.

### B. Firms’ Sourcing Location

Next, we investigate how firms’ location mediates the strength of reputation spillovers. In the case of the Chinese dairy scandal, contamination stemmed from wrongdoings in the upstream sector, as discussed in section II. Given that dairy firms from the same location tend to source inputs from the same local upstream farms, one may expect to see stronger spillover effects on innocent and uninspected firms located in the same areas as contaminated firms.<sup>23</sup> To examine this aspect, we take advantage of the Chinese Customs data, in which firms are required to report the sourcing location for each of their export transactions. We leverage this

<sup>23</sup>In general, the source of contamination and the public’s knowledge of this information matter for the degree of reputation spillovers. If the root cause of a quality defect is limited to a well-known individual firm, consumers may not be concerned about other firms in the same origin-industry. One example of a defect that involved a single firm only is the case of the Samsung Galaxy battery fire, the aftermath of which did not affect any other South Korean phone brands. By contrast, if the quality defect stems from upstream production processes, as was the case in the Chinese dairy scandal, all downstream firms may suffer from reputation spillover effects, especially if inputs are hard to trace. A scandal about the product quality of one firm may cause consumers to worry about the quality of other firms that source from the same upstream sources.

information to identify whether a city hosts any contaminated firms for a given product; if so, we call it a “contaminated city.” We define an indicator variable  $CSourceCity$  for firm  $i$  that equals 1 if  $i$  sourced (any product) from a contaminated city prior to the scandal. We define another indicator variable  $CSourceCity-Product$  that equals to 1 if  $i$  ever sourced contaminated product  $j$  from the same city as a contaminated firm. We interact these indicator variables with the post-Scandal indicator to study how baseline sourcing patterns affected firms’ post-scandal export performance.

Table 7 reports the impact of sourcing from a contaminated location for innocent and uninspected firms. While we estimate large overall cross-firm spillovers (the negative coefficient on  $CProductXPost$ ), the exact sourcing location of a firm does not appear to matter: the point estimates on the two additional interaction terms are very close to zero, though the standard errors are fairly large. The result suggests that the spillover effects were generalized rather than contained around contaminated sources. One potential explanation is that international buyers may have very coarse information about contamination sources due to the low traceability of the contaminated inputs; as a result, the spillover effects are not localized. This echoes our previous findings that information accuracy matters for the strength of reputation spillover effects. Moreover, to the extent that firms in one location compete for the same labor and upstream supplier inputs, innocent

TABLE 6.—HETEROGENEOUS IMPACT BASED ON THE GOOGLE SEARCH INDEX

	IHS (value)			IHS (quantity)			Exporting (dummy)		
	High (1)	Low (2)	Rest (3)	High (4)	Low (5)	Rest (6)	High (7)	Low (8)	Rest (9)
CFirm-ProductXPost	-1.101 (1.391)	-0.068 (0.963)	-0.208 (0.452)	-0.958 (1.349)	-0.026 (0.929)	-0.180 (0.420)	-0.061 (0.094)	0.005 (0.062)	-0.014 (0.033)
CFirmXPost	-0.571 (0.639)	-1.678*** (0.595)	-0.739*** (0.230)	-0.650 (0.657)	-1.585*** (0.586)	-0.690*** (0.219)	-0.055 (0.047)	-0.132*** (0.049)	-0.062*** (0.018)
CProductXPost	-0.025 (0.153)	-0.639*** (0.195)	-0.367*** (0.141)	-0.057 (0.138)	-0.591*** (0.183)	-0.341*** (0.130)	-0.001 (0.013)	-0.053*** (0.016)	-0.031*** (0.011)
IFirm-ProductXPost	0.391 (0.496)	0.713 (0.756)	0.676 (0.543)	0.363 (0.494)	0.649 (0.723)	0.621 (0.513)	0.023 (0.038)	0.047 (0.059)	0.062 (0.042)
IFirmXPost	-0.259 (0.368)	-0.452 (0.382)	-0.810 (0.637)	-0.231 (0.362)	-0.410 (0.346)	-0.725 (0.592)	-0.026 (0.037)	-0.035 (0.031)	-0.069 (0.049)
R-squared	0.418	0.294	0.255	0.440	0.296	0.254	0.341	0.242	0.224
Observations	13775	13775	13775	13775	13775	13775	13775	13775	13775
Firm-product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
BaselineSizeXPost	YES	YES	YES	YES	YES	YES	YES	YES	YES

This table shows the regression results for the heterogeneous effects of the scandal across export destinations with different information accuracy. The unit of observation is at the firm-product-year level. The sample contains all dairy exporters in the Chinese Customs data (2000–2013). We create a balanced panel at the firm-product (HS eight-digit) and year level. Columns 1–6 present results for the inverse hyperbolic sine (IHS) transformation of the outcome variables of interest, export value and export quantity. Columns 7–9 use an indicator for positive exports as the outcome variable. We categorize export destinations by high and low information accuracy, using the Google search intensity ratio. High-information-accuracy destinations display a high ratio of searches for the word “Sanlu” relative to searches for “2008 Chinese milk scandal”. We also include results for countries without a Google search index (“Rest”). The interaction terms are the products of the post-scandal dummy (2009–2013) with the following five group indicators: (C)ontaminatedFirm-Product, (C)ontaminatedFirm, (C)ontaminatedProduct, (I)nnocentFirm-Product, and (I)nnocentFirm. The omitted category is innocent and uninspected products from uninspected firms. All regressions include firm-product and year fixed effects. Baseline size measures a firm’s baseline (2000–2007) total export revenue. Standard errors are two-way clustered at the firm and product-year level. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% level, respectively.

TABLE 7.—HETEROGENEOUS IMPACT BY FIRMS’ SOURCING LOCATION

	IHS (value) (1)	IHS (quantity) (2)	Log (price) (3)	Exporting (dummy) (4)
CProductXPost	-0.587** (0.274)	-0.551** (0.259)	-0.164 (0.110)	-0.045** (0.021)
CSourceCity-ProductXPost	0.030 (0.554)	0.050 (0.520)	0.053 (0.096)	0.023 (0.045)
CSourceCityXPost	-0.090 (0.274)	-0.113 (0.257)	0.027 (0.083)	-0.002 (0.022)
R-squared	0.313	0.319	0.898	0.248
Observations	8768	8768	1098	8768
Firm-product FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
BaselineSizeXPost	YES	YES	YES	YES

This table shows the regression results for the heterogeneous effects of the scandal on exports across firms with different baseline sourcing locations. The unit of observation is at the firm-product-year level. The sample contains innocent and uninspected dairy exporters in the Chinese Customs data (2000–2013). We create a balanced panel at the firm-product (HS eight-digit) and year level for the outcomes in columns 1, 2, and 4. Columns 1 and 2 present results for the inverse hyperbolic sine (IHS) transformation of the outcome variables of interest, export value and export quantity. Column 3 presents results for the natural logarithm of unit price, while column 4 uses an indicator for positive exports as the outcome variable. The interaction terms are the products of the post-scandal dummy (2009–2013) with the following three group indicators: (C)ontaminatedProduct, (C)ontaminatedSourceCity-Product and (C)ontaminatedSourceCity. All regressions include firm-product and year fixed effects. Baseline size measures a firm’s baseline (2000–2007) total export revenue. Standard errors are two-way clustered at the product-year and firm level. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% level, respectively.

and uninspected firms may have benefited when their rivals were hit by the scandal. The estimated coefficients thus reflect the net of the reputation and competition effects.

### C. Firms’ Export Experience

A firm’s reputation can have both an individual component and a collective component: for example, consumers may observe a quality signal from each firm as well as a noisy signal of the industry’s average quality. In this case, a strong individual reputation may mitigate the impact of a collective reputation shock. To examine this possibility, we proxy a firm’s individual reputation in the global market by its export experience, measured by the number of years the firm had been exporting prior to the scandal and the firm’s baseline share of exports in total sales.

Table 8 shows the heterogeneous impact of the scandal based on export experience. Due to our short baseline period, we define new (young) firms as those that had just started exporting in 2008 and established firms as those that had exported for one or more years prior to 2008. Consistent with individual reputation shielding a firm from collective reputation shocks, the cross-firm spillover effect is larger for new exporters. Here, too, we allow for differential time trends with respect to firm size, which is likely to differ between new and established exporters. A test of equality of  $\hat{\beta}_{\text{across-firm}}$  in columns 1 and 2 (or columns 3 and 4) has a  $p$  value of 0.0191 (or 0.0734). The test of equality of the spillover effects on the extensive margin,  $\hat{\beta}_{\text{across-firm}}$  in columns 5 and 6 (or columns 7 and 8), has a  $p$  value of 0.0335 (or 0.1313). These findings suggest that in light of a collective reputation shock, a more established individual reputation can (partially) shield firms

TABLE 8.—HETEROGENEOUS IMPACT BY FIRMS' EXPORT EXPERIENCE

	IHS (value)				Exporting (dummy)			
	Established (1)	New (2)	Established (3)	New (4)	Established (5)	New (6)	Established (7)	New (8)
CFirm-ProductXPost	-0.678 (1.419)	-1.251*** (0.433)	-0.760 (1.423)	-0.943*** (0.332)	-0.032 (0.092)	-0.091*** (0.034)	-0.036 (0.092)	-0.068* (0.039)
CFirmXPost	-1.119** (0.502)	-2.098*** (0.712)	-1.069** (0.508)	-2.112** (0.832)	-0.084** (0.035)	-0.190*** (0.063)	-0.082** (0.035)	-0.192*** (0.073)
CProductXPost	-0.390 (0.358)	-1.520*** (0.438)	-0.214 (0.411)	-1.160*** (0.382)	-0.034 (0.028)	-0.115*** (0.034)	-0.026 (0.033)	-0.089*** (0.030)
IFirm-ProductXPost	-0.456 (0.831)	2.979* (1.764)	-0.463 (0.821)	2.787 (1.843)	-0.026 (0.061)	0.199* (0.120)	-0.026 (0.060)	0.185 (0.126)
IFirmXPost	-0.597 (0.798)	-1.714 (1.209)	-0.583 (0.794)	-1.375 (1.209)	-0.047 (0.067)	-0.147 (0.093)	-0.048 (0.067)	-0.122 (0.093)
R-squared	0.339	0.228	0.340	0.230	0.252	0.206	0.253	0.208
Observations	9830	3945	9830	3945	9830	3945	9830	3945
Firm-product FE	YES	YES	YES	YES	YES	YES	YES	YES
BaselineSizeXPost	YES	YES	YES	YES	YES	YES	YES	YES
HS2digitXYear	YES	YES	NO	NO	YES	YES	NO	NO
HS2digitXPost	NO	NO	YES	YES	NO	NO	YES	YES

This table shows the regression results for the heterogeneous effects of the scandal on exports across firms with different lengths of export experience. The unit of observation is at the firm-product-year level. The sample contains all dairy exporters in the Chinese Customs data (2000–2013). We create a balanced panel at the firm-product (HS eight-digit) and year level. Columns 1–4 present results for the inverse hyperbolic sine (IHS) transformation of the outcome variable of interest, export value. Columns 5–8 use an indicator for positive exports as the outcome variable. Columns 1, 3, 5, and 7 use the subsample of established firms, which are firms that had exported for more than 1 year before 2008. Columns 2, 4, 6, and 8 use the subsample of new firms, which are firms that had not exported before 2008. The interaction terms are the products of the post-scandal dummy (2009–2013) with the following five group indicators: (C)ontaminatedFirm-Product, (C)ontaminatedFirm, (C)ontaminatedProduct, (I)nnocentFirm-Product, and (I)nnocentFirm. The omitted category is innocent and uninspected products from uninspected firms. All regressions include firm-product and year fixed effects. Baseline size measures a firm's baseline (2000–2007) total export revenue. Standard errors are two-way clustered at the firm and product-year level. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% level, respectively.

from the collective damage, whereas newcomers are more likely to suffer from the “original sin” of their predecessors.

Ninth table in appendix A explores an alternative measure of export experience based on firms' fraction of exports in total sales in 2007. For this exercise, we merge the Chinese Customs data with the Manufacturing Survey data and use the total sales information in the latter. Of the 335 dairy firms in the Chinese Customs sample in 2007, 151 are identified in the Manufacturing Survey. The relatively low match rate could be due to the imperfect matching of firms' names and addresses across the Manufacturing Survey and the Chinese Customs data or the fact that the Manufacturing Survey only includes above-scale firms (see section IIIB). Seventh figure in appendix A plots the distribution of the fraction of exports in total sales in the baseline year. On average, conditional on exporting, exports account for 10.3% of the firms' total sales (the median is 9.8%) with a standard deviation of 0.35. We classify firms as large exporters if their fraction of exports exceeds the median and small otherwise. The results again suggest that small firms tend to suffer more from collective reputation damage.

*Summary.* This section explores three mechanisms potentially driving collective reputation spillover effects. First, information accuracy plays an important role in mediating the strength of collective reputation—the spillover effects are smaller in destinations where people appear to have had better information about the parties involved in the scandal. Second, the spillover effects appear to be generalized rather than localized to contaminated sources, consistent with international buyers having coarse information about contamination sources due to low traceability of the contaminated inputs. Finally, individual reputation can mitigate collective reputa-

tion damage, and new exporters and firms with larger baseline export shares appear to be the most vulnerable to collective reputation shocks.

## VII. Conclusion

Understanding how reputation spreads within an industry or a geographic area is key for informing trade and development policy, as the existence of collective reputation implies important externalities. We study this question in the context of Chinese dairy firms' exports following the 2008 scandal. We document strong reputation spillover effects on firms whose products were not contaminated. Surprisingly, firms that cleared formal inspections do not appear to have fared any better than uninspected firms. These findings highlight the role of collective reputation in international trade and the challenges that governments may face in signaling quality and restoring trust. Analyses of potential mechanisms highlight the role of information accuracy, supply chain traceability and firms' individual reputations in mediating the collective reputation effect.

Our study has two broad policy implications concerning (1) the role of government and third-party certifications and (2) the role of market structure. That said, the external validity of the results is an empirical question, as the exact magnitudes of spillovers vary across industries and countries and depend on whether directly affected firms are large industry leaders or small players. Our approach can be applied to other contexts.

First, collective reputation may call for government interventions, but government-led inspection efforts may generate counterproductive signals, depending on the reputation of the inspection body itself. Private third parties and international certification bodies may act as an effective

complement to or substitute for government regulations, especially in developing-country settings. However, based on our interviews with firms in the Chinese dairy industry, third-party certification has not been adopted in this sector. This could be due either to high costs or logistical hurdles in obtaining these certifications or to perceived low returns to certification. Understanding the barriers to adoption as well as the effectiveness of these programs is crucial for designing policies that could assure a high quality standard and break the low-quality-low-reputation equilibrium.

Second, this study takes a first step in investigating various mechanisms that may affect the transmission of reputation spillovers. Understanding these mechanisms can help inform policies in response to a collective reputation crisis. Following the milk scandal, many firms integrated vertically with upstream farms. One rationale for vertical integration is the ability to enforce stronger quality controls (Hansman et al., 2017); an equally important rationale is to signal quality, so that a firm is better shielded from wrongdoing by other firms' suppliers. It is expected that by 2020, over 70% of Chinese raw milk will be produced from vertically integrated milk farms.<sup>24</sup> Future work is needed to better understand how collective reputation affects firms' quality investment incentives. Acting as an important externality, collective reputation could also have rich interactions with other market forces, such as market entry and competition.

<sup>24</sup>News source accessed on 09/28/2020: [http://www.gov.cn/zhengce/content/2018-06/11/content\\_5297839.htm](http://www.gov.cn/zhengce/content/2018-06/11/content_5297839.htm).

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