The consequences of shocks to product safety, evidence from baby formula *

Limor Hatsor† and Ity Shurtz‡

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Abstract

We study the consequences of shocks to product safety using a plausibly natural experiment in the baby formula market that occurred in Israel in 2003, the distribution of an impaired formula by a firm called 'Remedia' (the Remedia event). We conduct our analysis in two steps. First, we examine the market-level effects on prices and quantities using four sources of data from Israel's central bureau of statistics and the Israeli antitrust authority: store level data, aggregate sales data, the Israeli household expenditures survey (IHES), and data on imports of baby formula and other commodities. Second, we study the economy-wide implications on the labor supply of mothers with young infants using two datasets. The IHES allows us to estimate the likelihood to consume baby formula by households with infants as a proxy for breastfeeding, and to further identify mothers and use questions on their labor supply. We also use administrative data on all maternity leaves in the period 2000-2007 from the National Insurance Institute of Israel to examine whether the Remedia Event led to longer maternity leaves. (In process). We find that short after the Remedia Event, baby formula prices decreased by roughly 5% and the overall quantity sold in the market decreased by about 14%, whereas sales of the two other companies rose by roughly 50%. Our study indicates that in a concentrated market, a realization of a safety hazard may increase market shares and sales of the remaining firms in the market despite causing a negative shock to demand. This paper is also the first, to the best of our knowledge, to examine the general equilibrium consequences of a shock to product safety perception through its interaction with the labor market. We observe a decrease of 10% in the likelihood to consume baby formula indicating that the Remedia Event caused an increase in the tendency to breastfeed, and in turn a reduction of roughly 5% in the labor supply (or the likelihood to work) of mothers with infants. Our results indicate that the welfare loss that a shock to safety perception causes may be larger than the direct welfare loss in the affected market. This should be taken to consideration in shaping the policy, from government control of production to liability rules of companies.

Keywords: experience goods, recalls, product quality, labor supply

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†Department of Economics, Bar Ilan University, Ramat-Gan 5290002, Israel. Email: limor.hatsor@gmail.com.

‡Department of Economics, The Hebrew University, Jerusalem 91905, Israel. Phone: 972-2-5883240. Fax: 972-2-5816071. Email: ity.shurtz@huji.ac.il (corresponding author).

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1 Introduction

Consumers often rely on their perception of product safety to make consumption decisions in a wide array of domains including vaccinations, therapeutic drugs, food, baby products and cars, just to name a few. It is unsurprising that product safety information has attracted considerable attention from both policy makers and academics in recent decades.[1] Despite the growing literature on this issue, however, the consequences of realizations to product safety hazard, often caused by the negligence of a single firm in a market, are not well understood. In this study we aim to contribute to fill this gap.

In the year 2003, Remedia, an Israeli company that distributed baby formula that was manufactured by the German company Humana, started to distribute a new soy based formula. A few months later, in October 2003, several infants were hospitalized with symptoms of apathy and convulsions. The common cause of their illnesses, to be discovered only a month later, was consuming the product. Apparently, the new formula did not contain sufficient quantity of Vitamin B1, an essential Vitamin for newborns, causing the death of four infants and various long-term motorial, neurological and cognitive damages to more than sixty others. We use this realization of a product safety hazard in the baby formula market in Israel in the end of 2003 (Hereinafter: The Remedia Event), as a plausibly natural experiment to analyze the consequences of a realization of a safety hazard.

We conduct our investigation in two steps. In the first step, we study the market-level effects–that are driven by two competing forces. On the one hand, the remaining firms may gain advantage over the failed one, reflected in higher market shares and higher prices than would be otherwise. The magnitude of this effect would depend on market concentration - in markets with fewer firms with large market shares this effect would be presumably stronger (The "Supply side effect"). On the other hand, a realization of a safety hazard in a single firm may cause a (negative) shock to product safety perception harming the remaining firms in the industry, even though they were not involved in it. This effect may arise regardless of the market structure (The "Demand side effect"). We examine the effects of the Remedia Event on prices and quantities in the baby formula market, in light of these two competing forces.

In the second step, we use the Remedia Event to study the economy-wide implications of a realization of a product safety hazard through its general equilibrium interactions. In general, quantifying the economy-wide effects is a challenging task because it requires the analysis of numerous markets that potentially interact with the market of the commodity that suffered the shock. The baby formula market, however, provides a unique opportunity

[1] see for example Dranove and Jin (2010) who review the literature on quality disclosure and certification

to investigate this issue. During the baby's first months of life, breastfeeding is the only substitute for baby formula. A negative shock to the perception of safety of baby formula may lead to an increase in the tendency to breastfeed. In turn, mothers of infants may reduce their labor supply (e.g. by extending their maternity leave). Therefore, the interaction between the baby formula market and the labor market in this context can serve as a plausible approximation to the magnitude of the general equilibrium effect (See Goulder and Williams III (2003) for a similar approach in the context of normative analysis of commodity taxation.)

From a normative standpoint, one may assume that a shock to product safety perception causes a temporary, exaggerated perception of risk. Namely, misperception of risk acts as a "tax" on baby formula in the sense that it distorts the relative price between baby formula and breastfeeding, making breastfeeding cheaper relative to baby formula than it would be otherwise. Under this premise, quantifying the effects of the shock is an important step towards quantifying the shock's welfare implications.[2]

To execute our market-level analysis, we first quantify the effects of the Remedia Event on baby formula prices. We use store level data on baby formula prices from Israel's central bureau of statistics (Hereinafter "CBS"). We merge these data with various commodity price indices. We find that immediately after the Remedia Event, baby formula prices decreased by roughly 5%. This decline persisted for at least two years after the Remedia Event.

Next, we examine the impact of the Remedia Event on sales of baby formula, using three sources of data. The first is aggregate sales data of the two other companies in the baby formula market.[3] The second source of data is the Israeli household expenditures survey, and the third is data on imports of baby formula and other commodities. We find that short after the Remedia Event, sales of the two other companies in the baby formula market rose by roughly 50% whereas the overall quantity sold in the market decreased by about 14%.

The combination of a decline in prices and, at the same time, an increase in sales of the other two firms in the market, illustrates the two competing forces at stake. The Remedia Event had a negative effect on demand, i.e., a negative shock to product safety perception. Yet, in a concentrated market, like the baby formula market we analyze, the net effect of a realization of a safety hazard may be profitable from the point of view of the other firms in the market because of the increase in their market shares.

[2]See Becker and Rubinstein (2011) on the distortive effect of fear on subjective beliefs

[3]These data were collected by the Israeli antitrust authority as part of a merger examination between Similac and Osem, an Israeli food manufacturer and distributer

We then study the effect of the Remedia Event on labor supply of young mothers by taking two empirical strategies. First, we use the fact that the Israeli household expenditure survey includes, in addition to information on consumption, questions on labor supply. Ideally, we would like to examine whether the Remedia Event led to an increase in the tendency to breastfeed, however, data on breastfeeding for the relevant period is unavailable.[4] Nonetheless, for young infants, the main substitute to breastfeeding is baby formula, therefore we use the likelihood to consume baby formula by households with infants as a proxy for breastfeeding. We observe a decrease of 10% in the likelihood to consume baby formula indicating that the Remedia Event caused an increase in breastfeeding. We then run a differences-in-differences (or "DD") analysis with mothers of infants as the treatment group and mothers whose youngest child is 2-4 years old as a comparison group. Using this approach we find that following the Remedia Event labor supply of mothers of infants decreased by roughly 5%.

This approach, however, has a basic limitation. Arguably, the comparison group that we use may be inadequate, because for the treatment group, a key factor in the labor supply immediately after childbirth is the length of maternity leave. On the other hand, the labor supply of mothers of older children is affected by other factors. In order to address this problem, we take another empirical approach. We use administrative data on all maternity leaves in the period 2000-2007 from the National Insurance Institute of Israel (Hereinafter: NIII).[5] Using these data we examine whether the Remedia Event led to longer maternity leaves. (In process)

This study is related to the empirical literature on the implications of product recalls. Early work on this issue has focused on measuring potential losses to firm owners beyond the direct costs associated with destroying or repairing the defective goods (see Jarrell and Peltzman (1985); Hoffer et al. (1988)). More recently, Liu and Shankar (2015) find that in the car industry, product recalls affect brand preferences. In the context of the toy industry, Freedman and Lederman (2012) find a thirty percent industry-wide reduction in sales following a series of recalls. Collins and Tennyson (2013) study Vioxx's drug withdrawal, and find mixed effects on own-class drugs (COX-2s) and an increase in the usage of competitor classes (substitutes) such as NSAIDS.

Several recent studies have examined the effects of food and health "scares". Anderberg et al. (2011) analyze the implications of an article in the British Medical Journal that mentioned possible serious side effects of a certain children's vaccination (MMR). They find that vaccination rates dropped by 10 percent, and did not fully recover even after the article was proven false-alarm. Schlenker and Villas-Boas (2009) and Adda (2007) report

[4]We are aware of one exception - two surveys of the Israeli Ministry of Health, in 1999 and in 2009. They provide some suggestive evidence for an increase in breastfeeding between 1999 and 2009.

[5]Israel's Social security.

a drop in the demand for meat after the mad cow crisis in the United States in the year 2003, and Chambers and Melkonyan (2013), find similar results in the UK. Studying the "mad-cow" crisis in France in 2000, Ferrer et al. (2016) develop a full demand model for the affected commodity and its substitutes and use it to recover consumers' preferences.

This study is also related to the literature that investigates the causal relationship between breastfeeding initiation and duration and mothers' employment, reflected in delaying the return to work after childbirth or working in part-time jobs. Albanesi and Olivetti (2016), for instance, show that the diffusion of infant formula played a role in women's labor force participation between 1920 and 1960. [6] While Albanesi and Olivetti (2016)'s study rely on the decline over time of baby formula prices, the Remedia Event can be viewed as causing an exogenous shock in the opposite direction, namely, **an increase** in the tendency to breastfeed.

One of the main contributions this paper makes is that it helps to reconcile some of the mixed evidence about the market-level effects of a realization of safety hazards (or recalls). While some studies show an overall decline in sales, others find mixed evidence on this issue. Our study indicates that the net effect of a realization of a safety hazard on sales depends upon the industry's market structure. Specifically, in a concentrated market, a realization of a safety hazard may increase market shares and sales via the Supply side effect, despite causing a negative shock to demand.

Another contribution of this paper to the foregoing literature is that, it is the first, to the best of our knowledge, to examine the general equilibrium consequences of a shock to product safety perception through its interaction with the labor market. Our study shows that interactions with other markets, particularly the labor market, are a significant part of the overall effect of the shock to product safety perception. Under the assumption that the shock causes a temporary, exaggerated perception of risks, our results indicate that the welfare loss that a shock to safety perception causes through its effect on the labor market may be larger than the direct welfare loss in the affected market. In turn, this should be taken to consideration in shaping the policy, from government control of production (e.g. policies concerning quality disclosure, standards, certifications and so on) to liability rules of companies and their accountability for the damage caused by their negligence.

Another contribution this paper makes is to provide additional support to the evidence on the causal relationship between baby formula availability and mothers' labor supply.

[6] More generally, Albanesi and Olivetti (2016)'s study belongs to a strand of the literature suggesting a positive causal link between the declining child-bearing and child-rearing cost and the enormous rise in women's labor force participation in the course of the 20^{th} century (through e.g., the invention and diffusion of the birth control pill, the infant formula and labor-saving household technologies, and advances in medical knowledge and obstetric practices, all alleviating the difficulties of reconciling work and motherhood)

Thus our results substantiate the existing evidence by showing that an increased tendency to breastfeed causes a decrease in the labor supply of mothers.

The remainder of the paper is structured as follows. Section 2 provides some background surrounding the circumstances of the Remedia Event. In section 3 we provide the analysis of the impact of the Remedia Event on the baby formula market. In section 4 we present the evidence on the impact of the Remedia Event on the behavior of mothers of infants, and section 5 concludes.

2 Background

2.1 The baby formula market in Israel before the Remedia Event

The baby formula market in Israel is quite concentrated. Until 1999, Materna, a baby formula company that manufactures in Israel, held more than 50% of the baby formula market in Israel. Consequently Materna was declared a monopoly by the government and the government supervised the prices of baby formula. In that period there were two other main players in the baby formula market, Similac, a subsidiary of the international brand, Promedico, and Remedia, an Israeli company, partly owned by Heinz, that distributed an imported baby formula which was manufactured by the German company Humana. By 1999, the market share of the two smaller companies has increased at the expense of Materna's market share. As a result, the price control was gradually removed until in was dropped completely in the beginning of 2001. In 2003, Materna held 37% of the market, Remedia held 37% and Similac held 26%.[7]

2.2 The Remedia Event and the baby formula market afterwards

In the Beginning of 2003, Humana, the German manufacturer of Remedia's products, developed a new soy based baby formula to be distributed by Remedia in Israel.[8] In the

[7]Information on annual market shares comes from the rating report summary of Maabarot products Ltd (2004), Materna's mother company which is a public company.

[8]Soy based formula represents roughly 15% of the baby formula market in ages 0-1 and it is typically used for babies with allergies or babies with vegan nutrition. In Israel, this market segment was about 17,400 babies aged 0-1 (of the 145,000 babies born in 2003, roughly 20% were exclusively breastfed). 2,000-4,000 infants were exposed to the impaired formula to some extent (based on Remedia market share of 37%, and about 4-7 months

beginning of November 2003, of the infants that consumed the product, three infants died, and about forty others suffered from various long-term motorial, neurological and cognitive damages that include retardation, deafness, heart damage, hypothermia and epilepsy. [9] It was only discovered later that due to a sequence of errors, the new formula did not contain sufficient quantity of Vitamin B1, an essential Vitamin that helps the body convert food into energy, and aids in the function of the heart, the brain and the nervous system. The Remedia event received a lot of media coverage and public attention and resulted in civil and criminal proceedings of involved parties.[10] Figure 1 shows the stock price of Maabarot Ltd., Materna's mother company, around the Remedia Event. The figure shows that the value of the Maabarot stock increased by over 150% immediately after the Remedia Event. This figure illustrates that the Remedia Event was a very visible and dramatic event in the baby formula market. Indeed, in December 2003, a month after the Remedia Event unraveled, Remedia's share in the market for baby formula fell drastically from 37% to 5-7%, and effectively declined to zero by the end of 2005.

3 The effects of the Remedia Event on the baby formula market

In this section we study the effect of the Remedia Event on the baby formula market. The market outcome is shaped by the Supply and Demand side effects. In a concentrated market, like the market for baby formula is Israel in 2003, one may expect a dominant supply side effect, namely, after the Remedia Event, Remedia's competitors would have larger market shares and would be able to charge higher prices. On the other hand, a dominant supply side would imply that a change in the perception of the risks associated with baby food would create a shift towards substitute products, causing a shift downwards in demand and lower prices and quantities in the baby formula market. To summarize, both the supply and demand effect cause a decrease in sales. A dominant supply effect implies a price increase and, by contrast, a dominant demand effect implies a price decrease. Therefore, an overall price decrease would support the view that the Remedia Event caused a shock to the perception of the risks associated with baby formula.

the impaired formula was in the market). As infants are typically introduced to solid foods in the age of about 6 months, roughly 1,000-2,000 infants were exclusively fed by the impaired formula, at least 3-6% of them were damaged (more than 60 infants) (which is at least 0.04% of the babies born in 2003).

[9] Over the years, more victims with less severe symptoms, including ADHD and limb pain, were diagnosed, and one more victim died.

[10] In the criminal process Remedia chief technology officer was convicted of wrongful death and was sentenced to jail. In the civil process, the company and the victims' families reached a financial settlement. Officials in the Israeli Health Ministry were sentenced to public service. Humana officials were fined and the company was fined in Germany.

Below, we study the effects of the Remedia Event on the baby formula market, first on prices and then on sales. The goal of this analysis is to assess which of the two effects we describe is dominant, and whether the Remedia Event created a shock to the perception of risk associated with baby formula.

3.1 The impact of the Remedia Event on baby formula prices

In order to assess the effect of the Remedia Event on prices, we obtained, from the CBS, monthly store-level baby formula prices from a representative sample of 61 stores across the country.[11]

Figure 2 depicts the monthly average of (nominal) baby formula prices in the period 2000-2007, in natural log terms. Using a second vertical axis, we juxtapose the log price index of milk products in the country in the same period to provide a counterfactual. In 2000-2001, the period of the gradual removal of the government price supervision in the baby formula market, prices of baby formula have increased steadily relative to the milk products price index. Prices rose from about 32 NIS per unit in 2000 to roughly 34 NIS in the first months of of 2002. During 2002 and the first 10 months of 2003, prices stabilized and their level has moved parallel to the milk products price index. At the end of 2003, just after the Remedia Event, there was an apparent sharp drop in baby formula prices. In the months subsequent to the Remedia Event prices appear to remain at a low level relative to the milk products price index. Only towards the middle of 2006 price levels of baby formula return to their original levels prior to the Remedia Event.

Overall, the figure clearly indicates that immediately after the Remedia Event there was a sharp decline in prices that seem to persist until 2006. In order to formally assess the significance of this visual impression, we analyze the behavior of baby formula prices relative to the behavior of the milk products price index in 2000-2007, by estimating the following regression model:

$$(1) \quad ln(p_{it}) - ln(index_t) = \alpha + \beta_1 \cdot Q1Y2000 + ... + \beta_{14} \cdot Q2Y2003 + \beta_{15} \cdot Q4Y2003 + ... + \beta_{31} \cdot Q4Y2007 + \gamma \cdot Store_i + \epsilon_{it}$$

[11] CBS collects these data for internal use including the preparation of price indices. CBS employees typically visit the same stores across the country and record prices of various products, including baby formula on a monthly basis.

This regression captures the difference between the prices of baby formula in store i in month t and the milk products price index in month t around the Remedia Event. Particularly, the estimates of $\beta_1 - \beta_{31}$ are the main objects of interest. Since the omitted category is $Q3Y2003$, the estimates of $\beta_1 - \beta_{31}$ capture the average difference between the prices of baby formula and the price index, in each quarter, relative to the third quarter of 2003, the last period before the Remedia Event. Figure A.1 displays the estimates of $\beta_1 - \beta_{31}$ as well as the corresponding 95% confidence intervals. As the figure shows, reassuringly, the estimates in the six quarters before the Remedia Event are insignificant, supporting the view that in that period baby formula prices stabilized relative to the milk products price index. After the Remedia Event, prices decreased by about 7%. This decline in prices persisted for about 2 years. By the end of 2006, baby formula prices returned to their level before the Remedia Event. Interestingly, the estimates of baby formula prices in the periods that precede 2002 are significantly negative. This result indicates that following the ending of the baby formula price supervision by the government, there was a period in which baby formula prices rose relative to those of milk products. [12] Overall, the results in this section provide a clear indication that following the Remedia Event prices in the baby formula market declined and that this decline persisted for roughly three years. These results are consistent with a dominant demand side effect.

3.2 The impact of the Remedia Event on baby formula sales

In this section we aim to study the effect of the Remedia Event on sales and consumption of baby formula by analyzing three sources of data. The first is aggregate monthly sales data on units sold and revenues of Remedia's two competitors, the second is the consumer expenditure survey and the third is data on imports.

Aggregate sales data. To provide a first look on the effect of the Remedia Event on the quantities that were sold in the baby formula market, we use data on actual monthly sales and revenues, by baby formula product,[13] of Remedia's two competitors in the baby formula market, Materna and Similac, in the period 2003-2007. These data were obtained from Israel's antitrust authority[14] Hence they reflect very accurately the sales in the baby formula market. It is worth noting that the baby formula market tends to be relatively very stable, affected predominantly by the number of newborns. Therefore, in this particular case, the "time-series" evidence we provide here, despite its obvious

[12] In Table XX in the appendix we examine the robustness of these results using alternative price indices as a counterfactual.

[13] There are 12 products in the sample, e.g. Materna for months 0-6, dairy.

[14] The data were collected by Israel's antitrust authority as part of the examination of a request for a merger between Materna and Osem, a large Israeli food distributer–a partner of the International food company, Nestle. Unfortunately data on sales in earlier periods is unavailable.

limitations, is quite revealing. Figure 4, displays the average quarterly quantities of baby formula units that were sold in the period 2003-2007 by Materna and Similac. The vertical solid line indicates the timing of the Remedia Event. The grey shaded area indicates the 95% confidence interval around the average sales. As the figure illustrates, in the first 3 quarters of of 2003 average quantities sold by the two companies hover around 40,000 units per product. In that period, Remedia was still an important player in the market holding about 37% of the market. Immediately after the Remedia Event sales appear to spike at 60,000 units. Notice however that this spike is only slightly higher than sales in the last quarter of 2005, 2006 and 2007. Therefore it is likely reflecting for the most part seasonality. Additionally, one should bare in mind that in the short run families that were Remedia consumers with infants aged less than six months had, in fact, no substitute outside the baby formula market and were forced to switch to another company's products. In the longer run, in 2004-2005 quantities sold by Materna and Similac increased to a level of about 50,000 units relative to the pre-Remedia Event period. However, in the following years quantities appear to decrease (notwithstanding seasonal spikes at the end of the year) almost reaching their level in 2003 of about 40,000 units by 2007.

Overall, the figure shows that after the Remedia Event, sales of the two companies increased in 2004-2005, by roughly 25%, consistent with the supply side effect. In subsequent years this increase appeared to weaken, yet sales remained somewhat higher than in the pre-Remedia Event period.

From the market-wide perspective, it is important to bear in mind that before the Remedia Event, sales of the two companies accounted for less than 70% of the market. After the Remedia event, as Remedia's market share dropped sharply, the two companies' sales accounted for a larger share of the market, over 90% in 2004-2005 and closer to a 100% in 2006-2007. Thus, the figure suggests that the number of units sold in the baby formula market decreased after the Remedia Event,[15] a point we explore in the next section.

Household expenditures survey. In order to further examine the market-wide effects of the Remedia Event we use data from Israel's household expenditure survey in the period 2000-2007. In order to examine baby formula consumption, we use the households' "diary" data. As part of the survey, households are requested to collect, during a two-weeks period, all the receipts from their purchases. Based on the receipts households fill a diary, recording all their expenditures sorted by products, or categories of products; for example, how much a household spent on "baby food" or "milk" or "cheese delicacies" during the two-weeks sampling period. Thus, these data contain a detailed record of the household-level expenditures in a two-weeks period by product. We use these data to create product-by-year cells of average household expenditures. The analysis uses

[15]Using revenues instead of units sold as the outcome in this figure provides very similar results.

a differences-in-differences approach. We examine the change in mean expenditures on baby food, the treatment group, relative to the change in expenditures on various other products, the "comparison" groups. Hence, the key identifying assumption here is that there are no unobserved factors that are correlated with the Remedia Event and that lead to differential time trends in expenditure on baby formula and other selected products. In the basic specification we estimate the following model:

$$y_{it} = \alpha + \beta_1 Post + \beta_2 Treat + \beta_3 PostXtreat + \epsilon_{it} \quad (2)$$

where y_{it} is the average amount that was spent on a given product i in year t, in natural log terms. $Treat$ is a dummy variable that equals 1 if the product is baby food and 0 otherwise. $Post$ is a dummy variable for observations in period after the Remedia Event, namely $Post$ equals 1 if the consumption took place in the year 2004 or afterwards and 0 otherwise. The estimates of β_3, the coefficient of $PostXtreat$, capture the effect of the Remedia Event on the outcome variable in the treatment group relative to the comparison group. Specifically, the coefficient β_3 captures the change in average expenditures on baby formula relative to other products.

We first provide graphical illustrations for the DD analysis. Figure 5 depicts the total spending on baby formula against several selected basic products. Panels (a)-(d) plot baby food against milk, salted cheese, eggs and butter. The figure illustrates that relative to these four basic products, there appears to be a decline in the expenditures of households on baby food.

Turning to the general DD results, we analyze three sets of regressions, each with a different comparison group of products. We report the results of this analysis in Table 1. Column (1) of the table reports the baseline specification using cheeses as the comparison group.[16] The results show a decrease of about 14% in the expenditures on baby food. In column (2) we add year and product fixed effects and the results remain unchanged. Columns (3) and (4) report the results for the second comparison group - basic products.[17] The estimates are somewhat larger, showing a 17% decrease in expenditures. In columns (5)-(6) we use a third comparison group, bread and cereal,[18] and the results are smaller– about 10% decrease, and statistically insignificant.

Overall, our results show a decline in the average expenditures of households on baby food in the order of 15% irrespective of the comparison group we apply. It is important to note that, as we have shown above, baby food prices declined after the Remedia Event and therefore the decline in expenditure may arise from both the decline in quantities and from the price decrease. In section 4.1 we examine this issue further by taking an "extensive

[16]This group includes the products: cream, hard cheese, processed cheese, soft white cheese and salted cheese
[17]This group includes: white flour, eggs, milk, sugar, other flour, yogurt
[18]This group includes: standard bread, various cereals, rice, cookies and biscuits and cornflakes and crispies

margin" approach, analyzing the likelihood to purchase baby formula in a discrete choice framework using household level data, rather than using expenditures.

Imports data. Finally, the third source of data we use is imports data. Because some of the baby formula sellers import the product we can trace the amounts of imported formula using data on imports of baby formula. Figure 6 depicts the value of imports of baby formula against selected products in log terms. Overall, imports of baby formula appear to drop sharply in 2004. By contrast imports of all the selected products in panels (a)-(e) exhibit an upward slope in that period. Panel (f) depicts the value of all imports to the country. Overall, after 2004 imports show an upward trend. Table 2 provides a DD analysis similar to the household expenditure survey analysis we performed above (in Eq.2), taking imports as the dependent variable. As the table shows, in all three comparison groups, imports of baby formula exhibit a decline of more than a 100%. Since international prices of baby formula were quite stable in the period 2000-2007, this result indicates a decrease in the amounts of baby formula that were imported into Israel after the Remedia Event. This result reflects the fact that the sales of Remedia–who imported its product–shrunk drastically short after the Remedia Event. The results also indicate that imports by Similac, who also imports its product to Israel, did not offset this decline in imports.

In order to further examine the implications of these results for the total size of the baby formula market, we use information about annual market shares of Materna, the only company in the baby formula market that produces its products in Israel.[19] Combining market shares with the import data we impute annual size of the baby formula market. We report the imputed annual baby formula market size and imports of baby food in Figure 7. According to Figure 7, the size of the baby formula market has declined after the Remedia event, consistent with the results we report above. It is not surprising that the decline in the size of the baby formula market seems somewhat smaller than the decline in the imports of baby formula, considering that Remedia imported its baby formula. While the imputed market size we derive should be taken with a grain of salt, we believe it is quite an appealing exercise because it provides us with an additional "independent" source of information to investigate the evolvement of the baby formula market size.

[19]Information on annual market shares of Materna was hand-collected by the authors from publicly available sources such as newspaper articles and company reports to the stock market.

4 The effect of the Remedia Event on mothers of infants

In this part we explore the general equilibrium effects of the Remedia Event. Specifically, we focus attention to a segment of the baby formula market consumers, mothers of young infants. This is a particulary interesting group of consumers because for this group, the main substitute for baby formula is breastfeeding, whereas older babies also consume solid food. We study the interaction between the Remedia Event and labor supply of mothers of infants via the channel of substitution between breastfeeding and labor supply. The analysis has two steps. The first step ideally would evaluate the effect of the Remedia Event on breastfeeding. However, in practice, data on breastfeeding is unavailable. Nonetheless, for young infants, the main substitute for breastfeeding is baby formula, therefore we use the likelihood to consume baby formula by households with infants as a proxy for breastfeeding; a decrease in the likelihood to consume baby formula indicates an increase in breastfeeding.[20] The second step evaluates the effect of the Remedia Event on labor supply of mothers of infants.

4.1 Consumption of baby formula by households with infants

We return to the Household expenditure survey. The analysis implements a similar standard DD approach. We study the impact of the Remedia Event on the consumption of baby food. Our sample includes households with infants in ages 0-1. We examine the change in utilization of baby food, the treatment group, relative to the change in consumption of various other products, the "comparison" groups.[21]

In the basic specification we estimate a simple linear probability model of the form

$$y_{ijt} = \alpha + \beta_1 Post + \beta_2 Treat + \beta_3 PostXtreat + \epsilon_{ijt} \quad (3)$$

where y_{ijt} is a measure of consumption of product i by household j in year t, specifically we use an indicator for purchasing a positive amount of a product. $Treat$ is a dummy variable that equals 1 if the product i is baby food and 0 otherwise. $Post$ is defined as before. The estimates of β_3, the coefficient of $PostXtreat$, capture the effect of the Remedia event on the outcome variable in the treatment group relative to the comparison

[20] A limitation of our analysis is that the age group we analyze is measured in whole years. In the case of infants, our notion of exclusive substitutability between breastfeeding and baby formula is true only for young infants.

[21] Descriptive statistics of our sample repeated cross section of households are provided in Appendix A

group.

Specifically, the coefficient β_3 captures the change in the share of households with infants who buy baby food relative to other products. Other specifications include year fixed effects and product fixed effects. Moreover, we include household characteristics. The household characteristics capture whether the mother attended higher education (more than 12 years of schooling), whether the infant is an only child (in the age 0-18), and control for two specific populations who may have different characteristics than the rest of the Israeli population: non-Jews and Ultra-Orthodox Jews.[22]

Similar to our approach in the sections above, the identification assumption of our empirical approach is that, absent the Remedia Event, differences in the likelihood to buy various products in the period of 2000-2007 are adequately captured by the year fixed effects and the product fixed effects, as well as the household characteristics. Or, put differently, the key identifying assumption of our model is that there are no unobserved factors that are correlated with the Remedia Event and that lead to differential time trends across baby formula and other selected products.

We first provide graphical illustrations for the DD analysis. Figure 8 depicts the annual shares of households who purchase baby food against several selected basic consumption products. Panels (a)-(d) plot baby food against sugar, salted cheese, eggs and yogurt. The figure illustrates that relative to these four examples, there appears to be a decline in the share of households who purchase baby food.

We now turn to report the general DD results. We analyze three sets of regressions each with a different comparison group of goods. We report the results of this analysis in Table 3. As column (1) indicates, the results of the DD analysis with dairy products as the comparison group reflect a 12 percentage point decrease in the likelihood to buy baby formula. The results are robust to inclusion of year and product fixed effects (column (2)) as well as household characteristics (column (3)). In columns (4)-(6) we repeat the analysis using basic products as the comparison group and the results are similar, showing a 10 percentage point decrease in the likelihood to buy baby formula. With bread and cereal as the comparison group, the effect is a 13 percentage point decrease in the likelihood to buy baby formula as columns (7)-(9) of the table show. Therefore, given that baby formula was consumed by about 70% of the households in the period before the Remedia Event, the results in Table 3 indicate a decline of around 15% in the likelihood of buying baby food among households with young infants.

In order to further validate these results we take an alternative approach. Following

[22]We define Ultra-Orthodox Jews as those who attended religious post-secondary school: Kolel, Yeshiva, or Rabbis school.

Abadie et al. (2010) we run a synthetic control analysis. We collapse the Household expenditure survey data into product by year cells. Equivalent to the DD analysis, our outcome variable is the the share of households who buy baby formula.

Figure 9 depicts the annual share of households who buy baby formula and the synthetic baby formula As the figure shows, the real and synthetic baby formula were consumed by about 70% of the households in the before period and they appeared to be very similar. After the Remedia Event the two lines diverge. The real baby formula share declines relative to the synthetic baby formula opening a gap of about 10 percentage points between the two groups.

We next turn to assess the significance of these results following Abadie et al. (2010). To do so, we run a placebo analysis. We run the same synthetic control analysis on every product in the sample. The results of this exercise are reported in panel (a) of Figure 10. As the figure illustrates the results we obtain appear to be uncommon among other food products, indicating that they reflect the effect of the Remedia Event on the consumption of baby formula. In order to more formally evaluate the implications of this test we depict the MSPE of baby formula and the other products in panel (b) of Figure 10. The dashed red line in the figure represents the 95th percentile of MSPE ratio and the solid vertical red line marks the MSPE ratio of baby formula . As the previous figure suggested, the result appears to be significant.

Overall, our results suggest a decline in the share of households that consume baby formula in the order of 10 percentage points irrespective of the comparison group or the empirical method we apply. Thus the results reflect roughly a 15% decline in the share of households with young infants who buy baby formula.

4.2 The mothers' labor market

Here, we study the effect of the Remedia Event on labor supply of mothers with young infants by taking two empirical strategies. The first, we use the fact that the Israeli household expenditure survey includes, in addition to information on consumption, questions on labor supply. We run a DD analysis with mothers with young infants, aged 0-1, as the treatment group and mothers whose youngest child is 2-4 years old (referred to also as mothers with older children) as a comparison group.

This approach, however, has a basic limitation. The comparison group may be inadequate because for the treatment group, a key factor in the labor supply immediately after

birth is the length of the maternity leave.[23] On the other hand, the labor supply of mothers of older children may be affected by other factors. We therefore take another empirical approach. We use administrative data on all maternity leaves in the period 2000-2007 from the National Insurance Institute of Israel. We examine whether the Remedia Event caused extended maternity leaves. (In process)

4.2.1 The household expenditure survey data

We return to the household expenditure survey and use the questions about labor supply. The analysis implements a standard DD approach to study the impact of the Remedia Event on the labor supply of mothers with young infants. [24] We examine the change in labor supply of mothers with young infants in ages 0-1, the treatment group, relative to the change in labor supply of mothers whose youngest child is 2-4 years old, the comparison group.[25]

In the basic specification we estimate a simple linear probability model of the form

$$y_{it} = \alpha + \beta_1 Post + \beta_2 Treat + \beta_3 PostXtreat + \epsilon_{it} \quad (4)$$

where y_{it} is a measure of labor supply of mothers in household i in year t. We use two common measures to the labor supply of mothers. In the first specification, y_{it} is an indicator that assumes the value 1 if a mother reported that she had *not* worked in the three months before she participated in the survey. In the second specification, y_{it} assumes the value 1 if a mother works full-time (at least 4 weeks a month). Treat is a dummy variable that equals 1 if mother i has an infant in ages 0-1 and 0 otherwise. Post

[23] In Israel, most working mothers are eligible to a compulsory paid maternity leave of 3 months, after which about 60% of them returned to work in 2002. About 26% took an additional unpaid maternity leave in the following year. The compulsory paid maternity leave was 3 months for women who worked at least 10 from 14 or 15 from the 22 months preceding birth or 6 weeks for women who worked at least 6 months from 14 months preceding birth. Working continuously for 2 years provides the right for an additional unpaid job-protected maternity leave of a quarter of the working period and a maximum of a year.

[24] In our sample, we identify mothers as females in the ages 18-45 who are the head of the household or the spouse.

[25] We exclude mothers whose youngest child is 1-2 years old from the comparison group because some of these mothers may belong to the treatment group. While these mothers may have just finished their maternity leave (a maximum of a year) their return to work may be delayed for several reasons. First, they may still search for a job. Second, their return to work may depend on the time schedule of their employers or on the the pre-school year (for example, if the maternity leave ends close to the summer holiday, some parents may postpone their return to work and enroll their children in the beginning of the school year or right after the subsequent Jewish holidays). Note that including this group does not change our results, though the DD estimates are typically smaller.

is defined as in the previous sections. The estimates of β_3, the coefficient of $PostXtreat$, capture the effect of the Remedia Event on the labor supply of mothers with young infants relative to mothers with older children. Other specifications include year fixed effects and child age fixed effects. Moreover, we include household characteristics defined as before. The key identifying assumption of our model is that there are no unobserved factors that are correlated with the Remedia Event and that lead to differential time trends across labor supply of mothers with young infants and mothers with older children.

Sample creation. Our sample is designed to deal with two potential limitations. First, a limitation of our data is that the age group is measured in whole years. This raises a concern that many infants reported to be in ages 0-1 in the last months of 2003 and in the first six months of 2004 (close after the Remedia event) may have been born before the Remedia event. Therefore, to increase the preciseness of our analysis, we exclude these observations from our sample. Second, two regulatory policies took place during the period 2000-2007 potentially affecting the labor supply of mothers: the reduction of government allowance for families with three or more children in 2003, and the gradual implementation of the Preschool law starting in 1999, providing free preschool education for all children aged 3 and 4, affecting mostly non-Jewish families. To isolate the effect of the Remedia event from these policies our sample includes Jews with one or two children (younger than 18 years old). [26]

Results. We first provide graphical illustrations for the DD analysis. Figure 11 depicts the labor supply of mothers with young infants in ages 0-1 against mothers whose youngest child is 2-4 years old (or mothers with older children) in log terms. Pannel (a) depicts their annual likelihood not to work in the three months before they were sampled, and pannel (b) describes their annual likelihood to work full-time (at least 4 weeks a month).

According to pannel (a), the likelihood not to work seems to decline by roughly 20 percent during 2002-2003 for both mothers with young infants as well as mothers with older children. In 2004-2005, after the Remedia event, the decline continues for mothers with older children (about 20 percent), whereas at the same time, the likelihood of mothers with young infants not to work increases by 10 percent. In the following years the gap widens until in 2007 there is a difference of about 70 percent between the two groups of mothers relative to 2003. Pannel (b) shows a similar result. The likelihood to work full-time seems to increase in the two groups of mothers by 20 percent at most during 2002-2003. After the Remedia event, this trend continues for mothers with older children (about 20 percent increase), whereas mothers with young infants reduce their likelihood to work full-time by 10 percent until 2007, a total divergence of 30 percent between the

[26] In Appendix A we provide the descriptive statistics of this sample. We also report there the DD estimates of the full sample, smaller in value as expected.

two groups of mothers relative to 2003.

Bearing in mind the limitations of our comparison group, or specifically the assumption that without the Remedia event the treatment and comparison groups would have had a common trend, we should interpret these results carefully. Overall, the figure provides suggestive evidence that in contrast to a gradual increase in the labor supply of mothers with older children in 2000-2007, after the Remedia event there appears to be a counter-trend decline in the labor supply of mothers with young infants.

We now turn to report the DD results. We report the results of this analysis in Table 4. As column (1) indicates, the results of the DD analysis with the likelihood not to work as the dependent variable reflect a 5 percent increase in the likelihood not to work for mothers with young infants. The results are robust to inclusion of year and child age fixed effects (column (2)) as well as household characteristics (column (3)). In columns (4)-(6) we repeat the analysis using the likelihood to work full-time as the dependent variable and the results are similar, showing a 5 percent decrease in the likelihood to work full-time for mothers with young infants.

While the estimates in Table 4 are insignificant (the t statistics are in the range of 1.3-1.5), the results are consistent with a reduction in the labor supply of mothers with young infants.[27]

4.2.2 Maternity leave administrative data

(In process)

5 Conclusion

This study uses the Remedia Event, a realization of a product safety hazard in the baby formula market in Israel in 2003, as a plausibly natural experiment to analyze the consequences of a (negative) shock to product safety perception that was caused by a single firm in the market.

We find that following the Remedia Event prices in the baby formula market declined by about 5% and sales decreased by about 14%. This study is the first, to the best of our knowledge, to study the general equilibrium effects of a shock to product safety

[27] Using other labor supply variables, such as the likelihood to work less than 10 hours a week and the likelihood to be salaried, provide similar results.

perception. The analysis indicates that the Remedia Event caused a persistent decrease in labor supply of mothers of infants.

By showing that interactions with other markets, particularly the labor market, can be a significant part of the overall effect of a shock to product safety perception, our study provides useful guidance to policymaking in this context.

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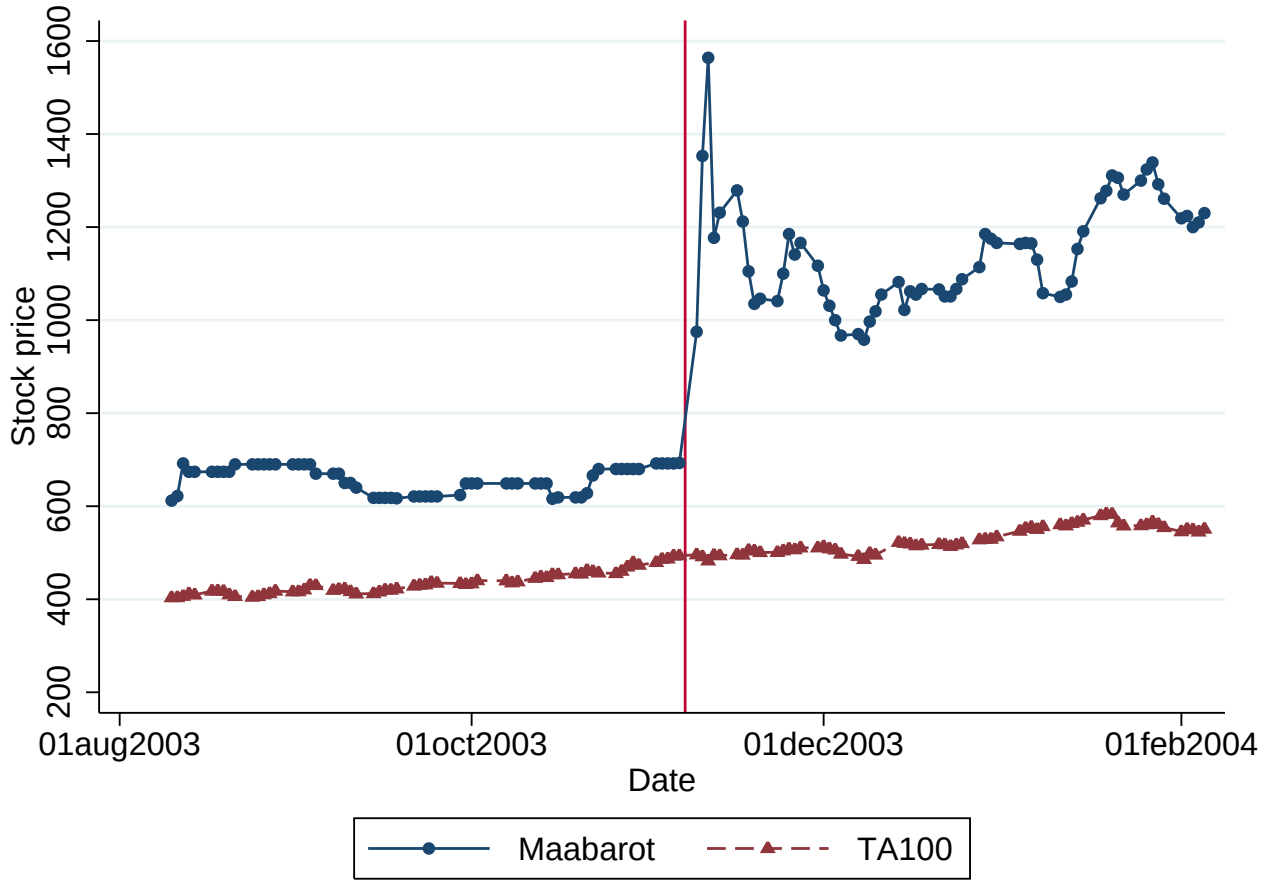
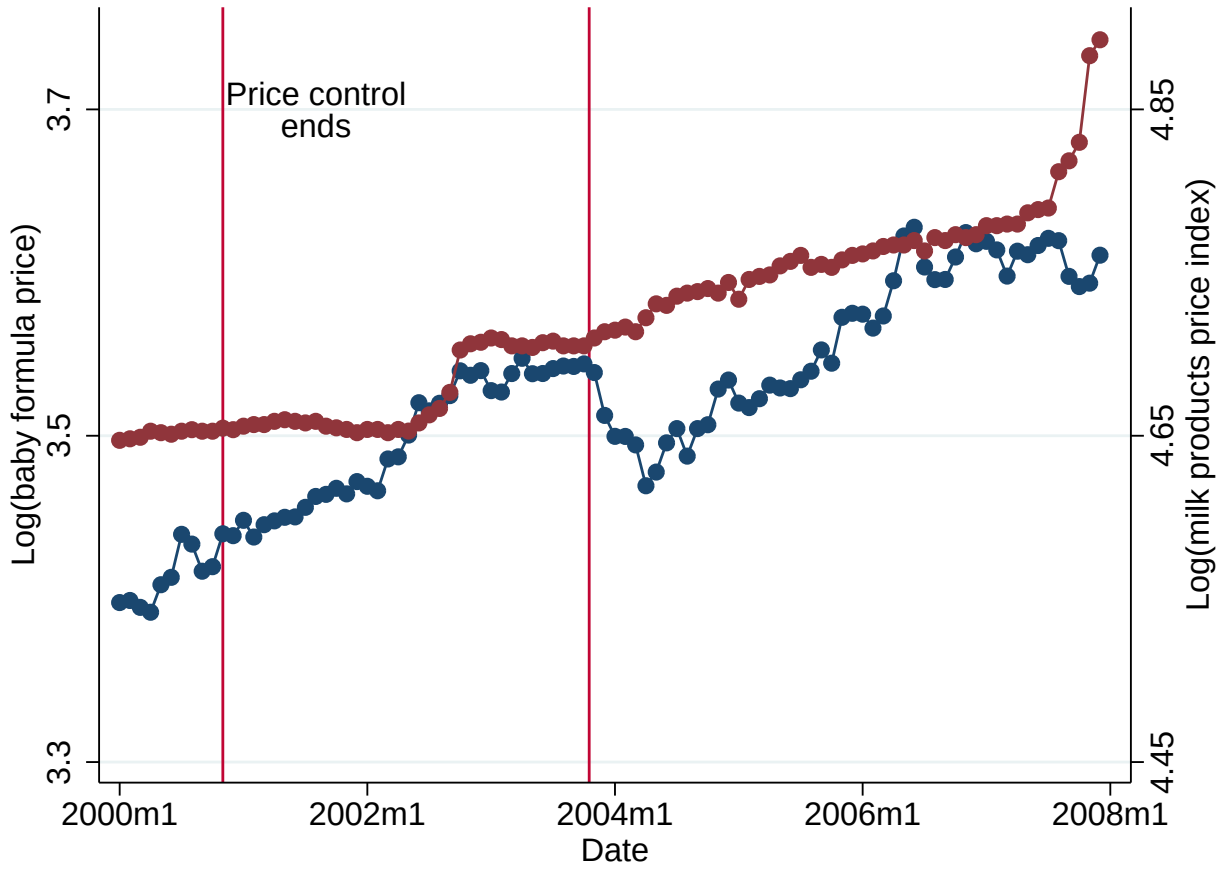
Figure 1: Market expectations around the Remedia Event



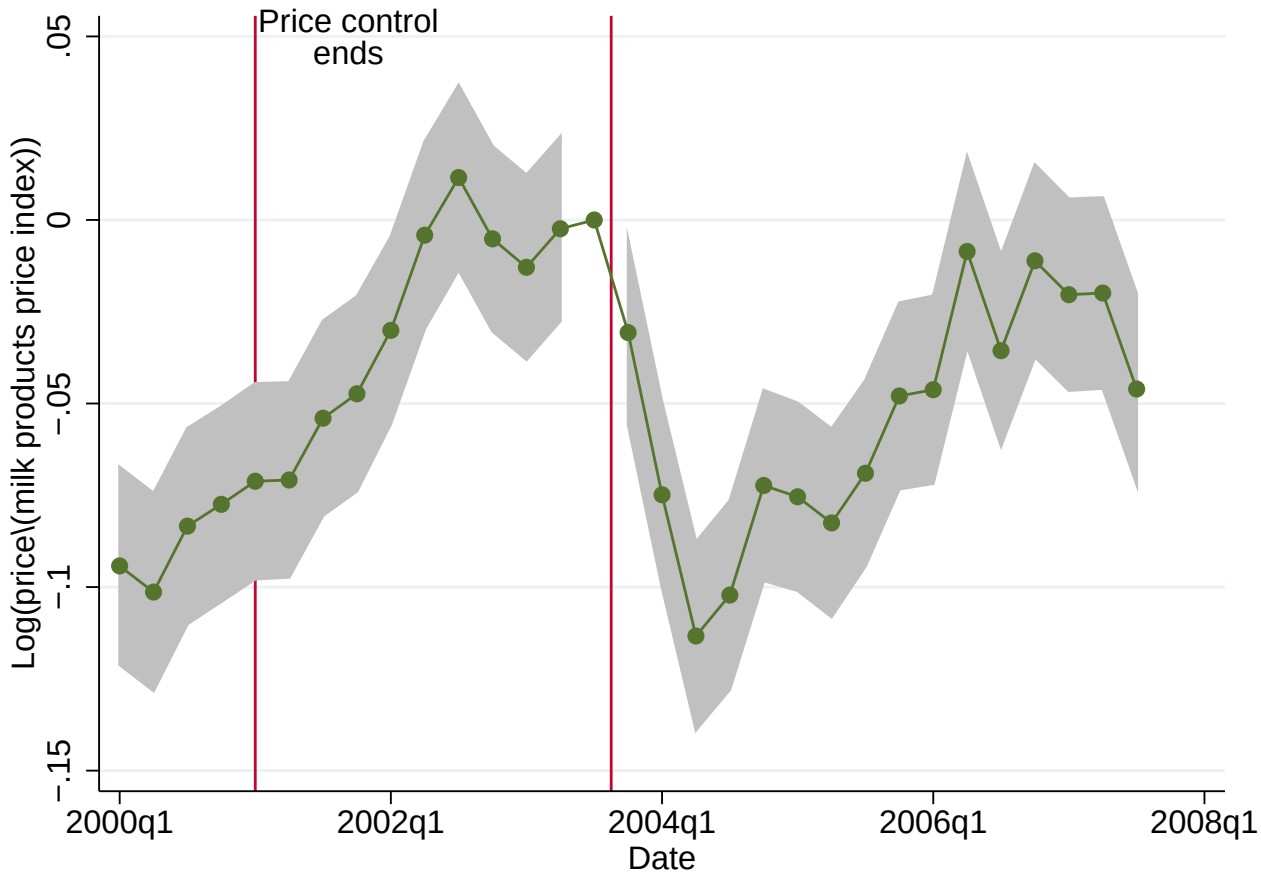
The figure plots the stock price of Maabarot Ltd., Materna's mother company, and Tel-Aviv 100 index around the Remedia Event.

Figure 2: The impact of the Remedia Event on baby formula prices



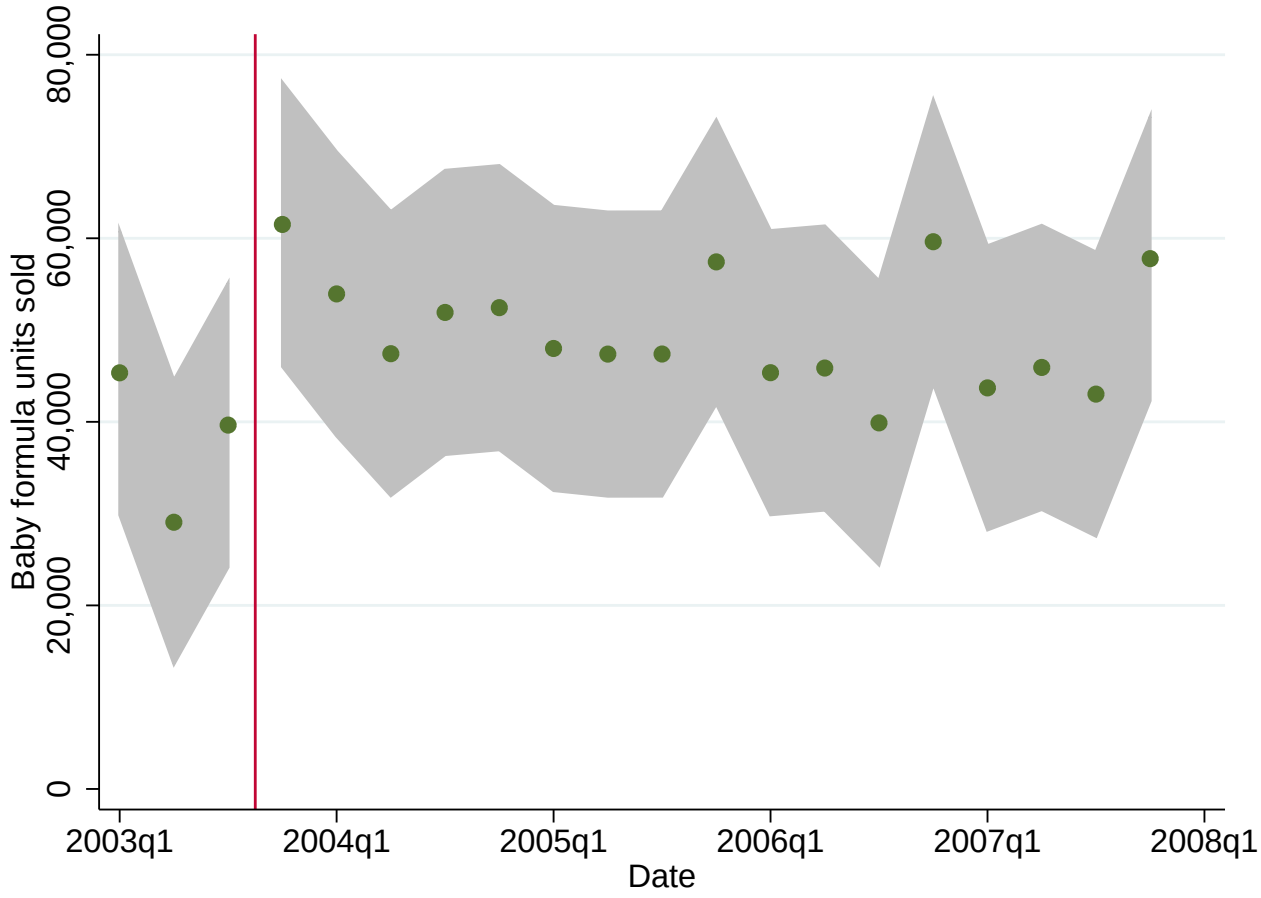
The figure plots the monthly average of (nominal) baby formula prices in the period 2000-2007, in natural log terms. The second vertical axis denotes the log price index of milk products.

Figure 3: The impact of the Remedia Event on baby formula prices, regression results



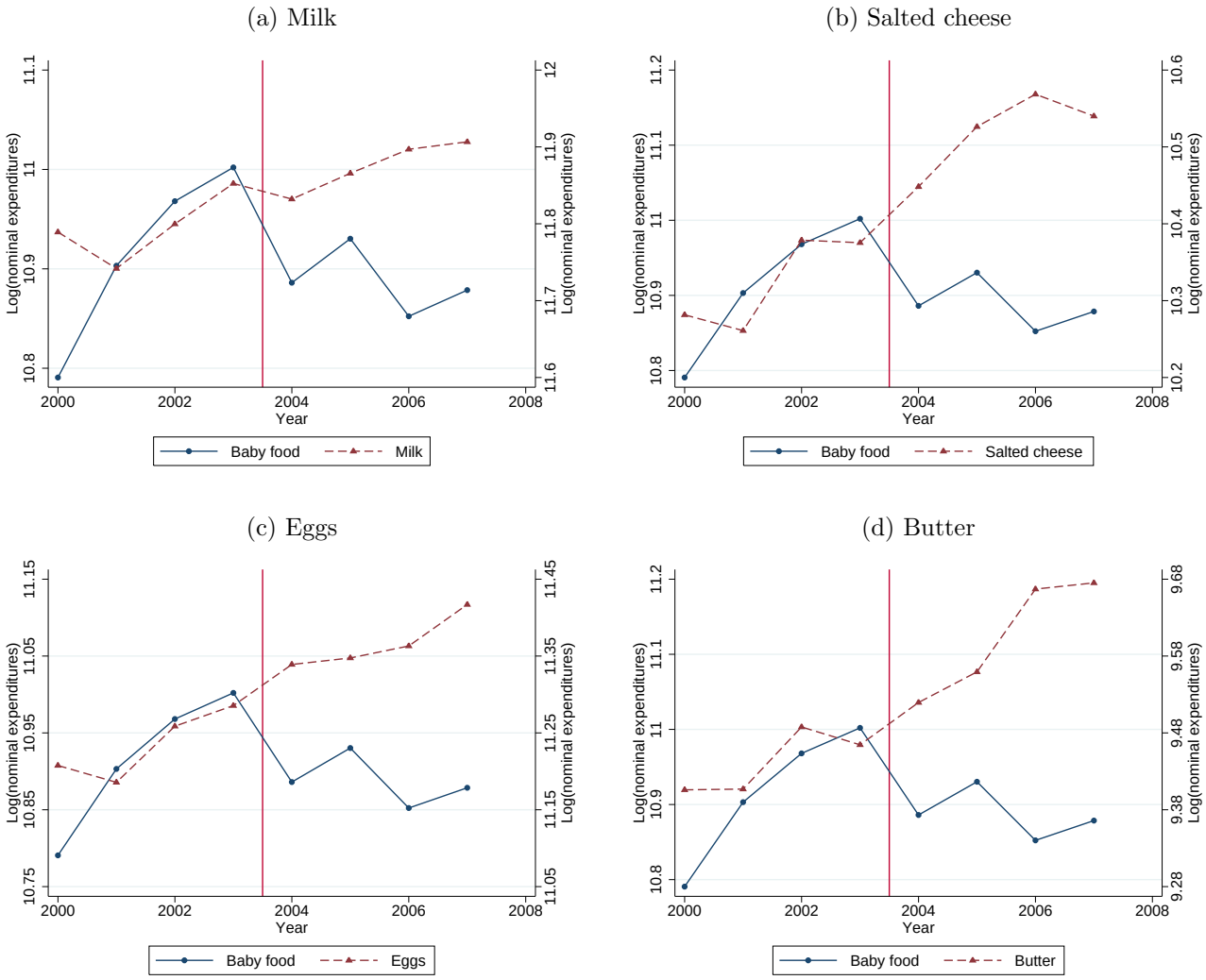
The figure plots the estimates of the average difference between the prices of baby formula and the price index of milk products in each quarter, relative to the third quarter of 2003, the last period before the Remedia Event as well as the corresponding 95% confidence intervals.

Figure 4: The impact of the Remedia Event on sales of the other companies in the baby formula market



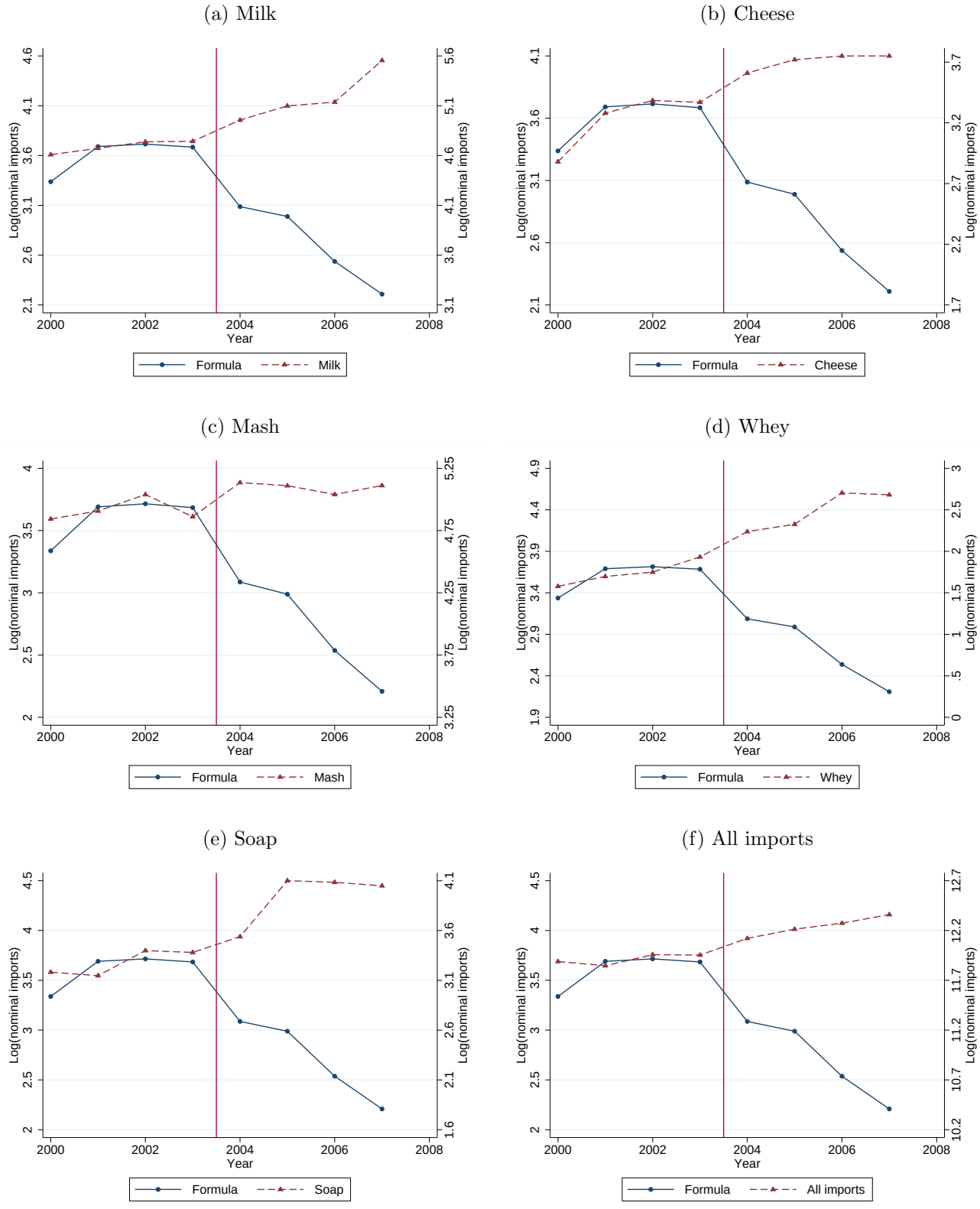
The figure displays the average quarterly quantities of baby formula units that were sold in the period 2003-2007 by Materna and Similac.

Figure 5: The impact of the Remedia Event on expenditures on baby formula



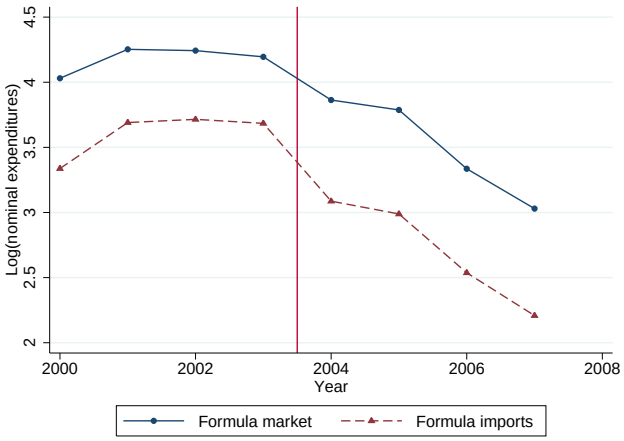
The figure plots the annual expenditures on baby food against several selected basic consumption products in the period 2000-2007 in log terms. Panels (a)-(d) plot baby food against milk, salted cheese, eggs and butter.

Figure 6: The impact of the Remedia Event on imports of baby formula



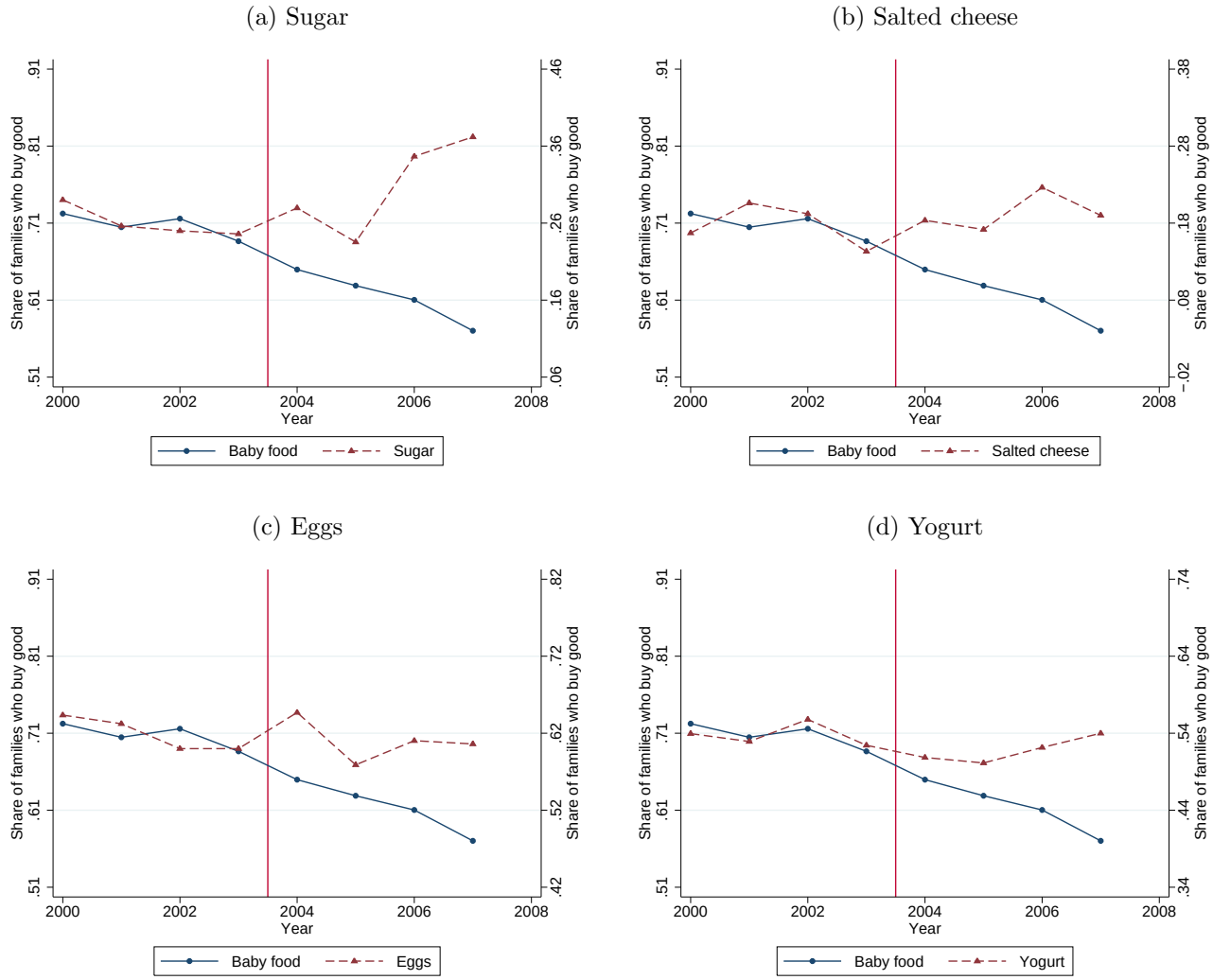
The figure plots the annual value of imports of baby food against several selected basic consumption products in the period 2000-2007 in log terms. Panels (a)-(f) plot baby food against milk, cheese, mash, whey, soap and all imports.

Figure 7: The impact of the Remedia Event on imputed expenditures on baby formula



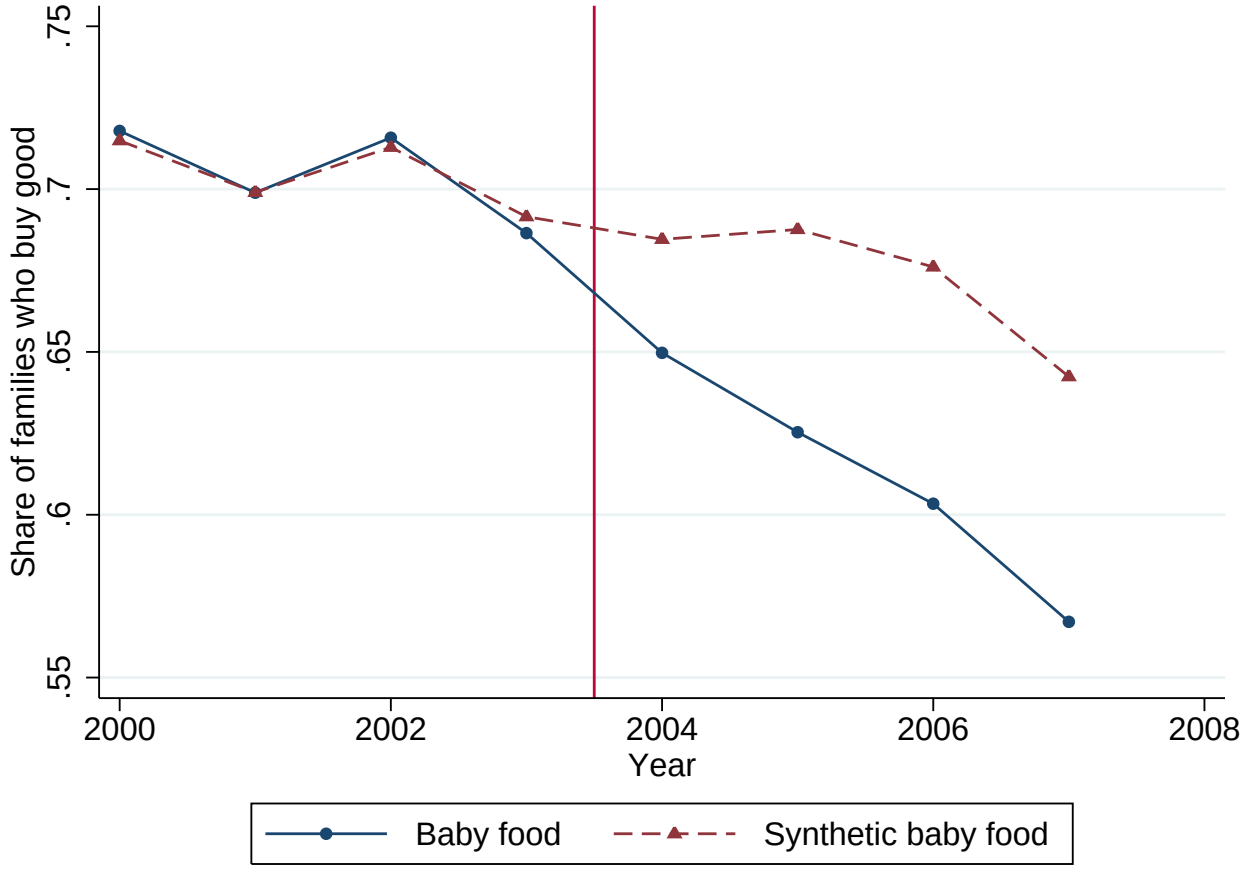
The figure plots the annual expenditures on baby food in the period 2000-2007, imputed from annual import data and market share data.

Figure 8: The impact of the Remedia Event on the likelihood of buying baby formula



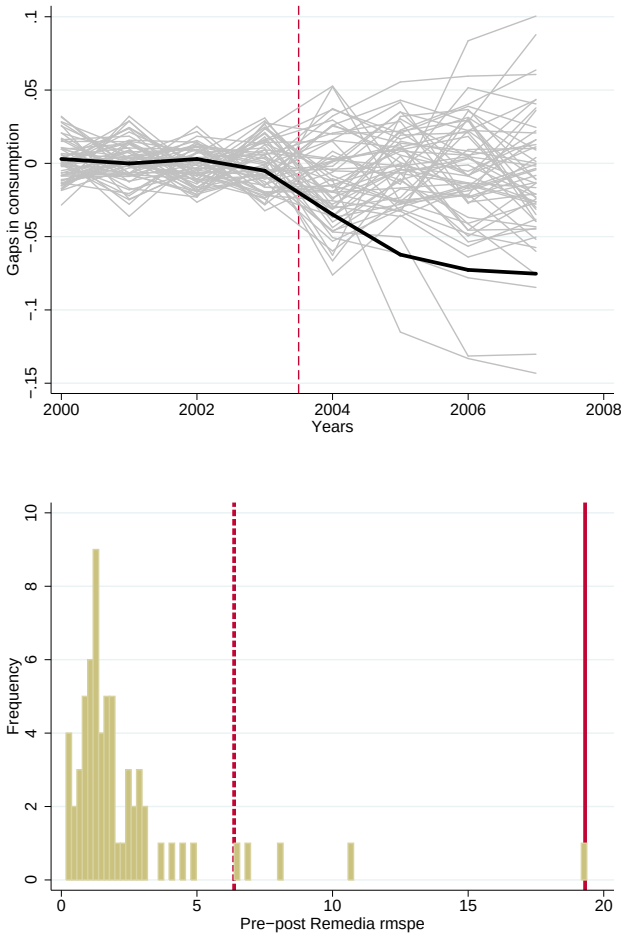
The figure plots the annual shares of households with infants (ages 0-1) who buy baby food against several selected basic consumption products in the period 2000-2007. Panels (a)-(d) plot baby food against sugar, salted cheese, eggs and yogurt.

Figure 9: The impact of the Remedia Event on the likelihood of buying baby formula, synthetic control approach



The figure depicts the annual share of households who buy baby formula and the synthetic baby formula.

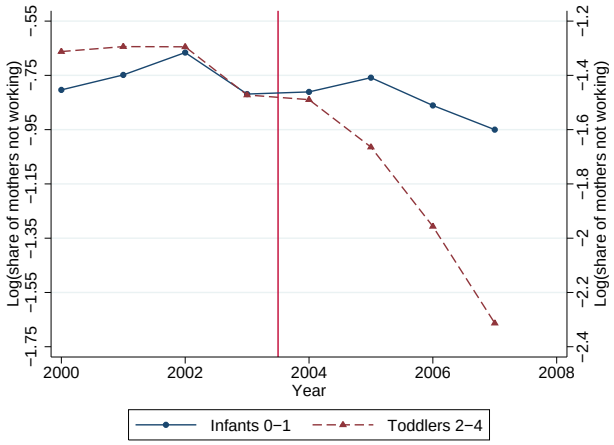
Figure 10: The impact of the Remedia Event on the likelihood of buying baby formula, placebo analysis



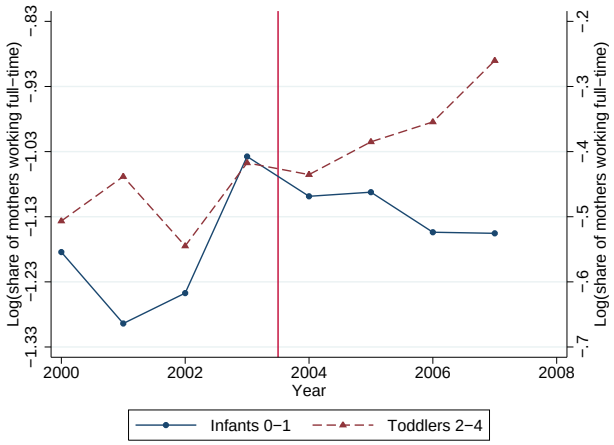
The figure reports the results of a placebo analysis. Panel (a) reports the results of a synthetic control analysis on every product in the sample. Panel (b) depicts the MSPE of baby formula and the other products.

Figure 11: Mothers labor supply

(a) The likelihood not to work



(b) The likelihood to work full time



The figure plots the labor supply of mothers with young infants in ages 0-1 against mothers whose youngest child is 2-4 years old in log terms in the period 2000-2007. Panel (a) plots the annual likelihood not to work in the three months before they were sampled and panel (b) plots annual likelihood to work full-time (at least 4 weeks a month). The sample includes Jews with one or two children.

Table 1: The impact of the Remedia event on baby food expenditures, DD Estimates

	Dairy products		Basic products		Bread and cereal	
	(1)	(2)	(3)	(4)	(5)	(6)
Remedia eventXBaby food	-0.142	-0.142**	-0.170	-0.170*	-0.098	-0.098
	(0.985)	(0.045)	(0.708)	(0.065)	(0.556)	(0.108)
Year FEs	No	Yes	No	Yes	No	Yes
Product FEs	No	Yes	No	Yes	No	Yes
Observations	48	48	56	56	48	48

NOTE: This table summarizes the DD estimates of Eq.**??**. The product categories are (1) Dairy products; (2) Basic products; (3) Bread and cereal.

** Significant at 5%.

*** Significant at 1%.

Table 2: The impact of the Remedia event on baby food imports, DD Estimates

	Dairy products		Basic products		Bread and cereal	
	(1)	(2)	(3)	(4)	(5)	(6)
Remedia eventXBaby food	-1.312	-1.312***	-1.302	-1.302***	-1.262	-1.262***
	(0.678)	(0.243)	(1.421)	(0.260)	(0.965)	(0.275)
Year FEs	No	Yes	No	Yes	No	Yes
Product FEs	No	Yes	No	Yes	No	Yes
Observations	56	56	56	56	56	56

NOTE: This table summarizes the DD estimates of Eq.2 taking imports as the dependent variable. The product categories are (1) Dairy products; (2) Basic products; (3) Bread and cereal.

** Significant at 5%.

*** Significant at 1%.

Table 3: The impact of the Remedia event on the likelihood of buying baby food, DD Estimates

	Dairy products			Basic products			Bread and cereal		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Remedia eventXBaby food	-0.119***	-0.119***	-0.119***	-0.102***	-0.102***	-0.102***	-0.132***	-0.132***	-0.132***
	(0.026)	(0.023)	(0.022)	(0.027)	(0.023)	(0.023)	(0.025)	(0.024)	(0.024)
Year FEs	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Product FEs	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
HH Characteristics	No	No	Yes	No	No	Yes	No	No	Yes
Observations	9,372	9,372	9,372	10,934	10,934	10,934	9,372	9,372	9,372

NOTE: This table summarizes the DD estimates of Eq.3. The product categories are (1) Dairy products; (2) Basic products; (3) Bread and cereal.

* Significant at 5%.

** Significant at 1%.

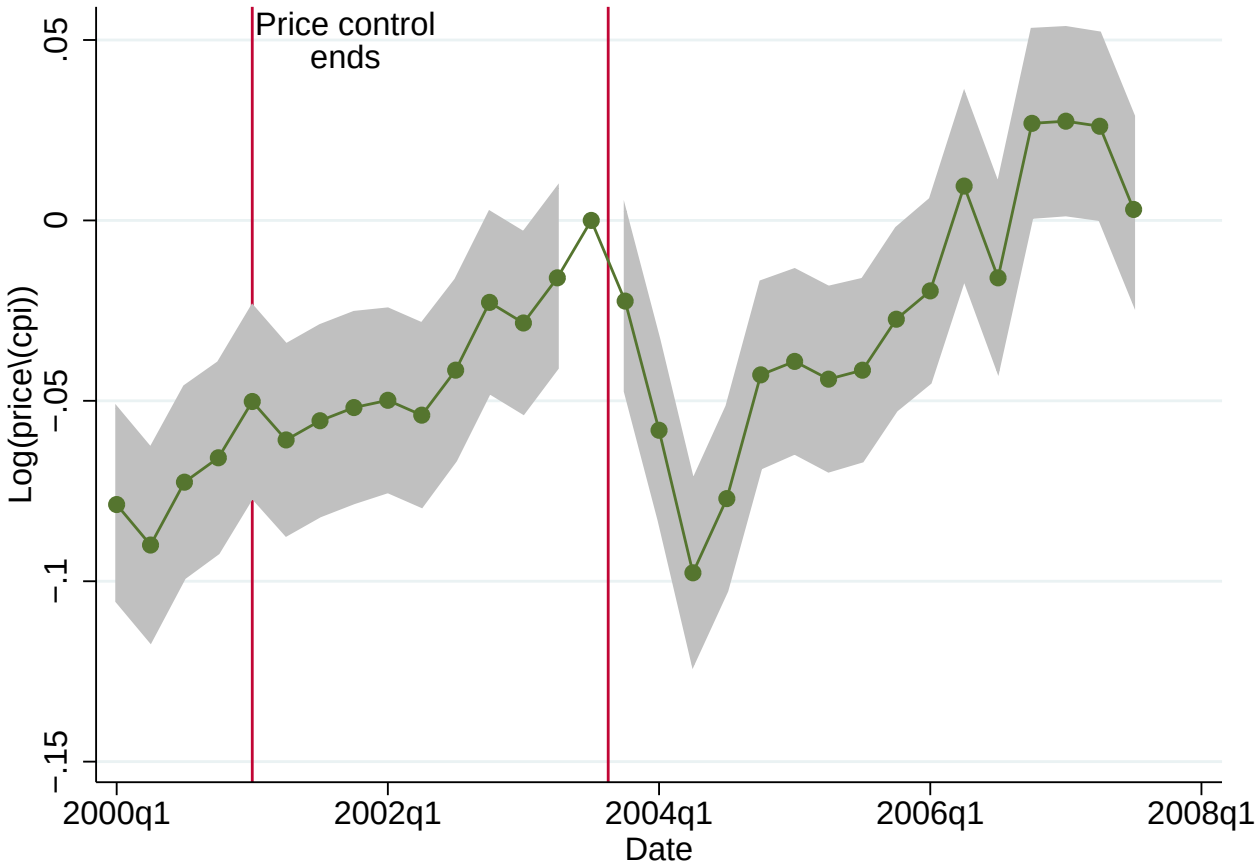
Table 4: The impact of the Remedia event on mothers labor supply, DD Estimates

	Likelihood not to work			Likelihood to work full time		
	(1)	(2)	(3)	(4)	(5)	(6)
Remedia eventXInfant0-1	0.046	0.048	0.041	-0.054	-0.055	-0.051
	(0.034)	(0.034)	(0.034)	(0.036)	(0.036)	(0.036)
Year FEs	No	Yes	Yes	No	Yes	Yes
Child age	No	Yes	Yes	No	Yes	Yes
HH Characteristics	No	No	Yes	No	No	Yes
Observations	2,878	2,878	2,878	2,878	2,878	2,878

NOTE: This table summarizes the DD estimates of Eq.4. The dependent variable, the labor supply of mothers, is measured by two variables: the likelihood not to work in the last 3 months and the second is the likelihood to work full time (at least 4 weeks a month). The sample includes Jews with one or two children.

A Appendix

Figure A.1: The impact of the Remedia Event on baby formula prices, regression results



The figure plots the estimates of the average difference between the prices of baby formula and the consumer price index in each quarter, relative to the third quarter of 2003, the last period before the Remedia Event as well as the corresponding 95% confidence intervals.

Table A.1: The impact of the Remedia event on mothers labor supply, DD Estimates, full sample

	Likelihood not to work			Likelihood to work full time		
	(1)	(2)	(3)	(4)	(5)	(6)
Remedia eventXInfant0-1	0.014	0.014	0.009	-0.016	-0.015	-0.011
	(0.025)	(0.025)	(0.022)	(0.024)	(0.024)	(0.022)
Year FEs	No	Yes	Yes	No	Yes	Yes
Child age	No	Yes	Yes	No	Yes	Yes
HH Characteristics	No	No	Yes	No	No	Yes
Observations	6,753	6,753	6,753	6,753	6,753	6,753

NOTE: This table summarizes the DD estimates of Eq.4 for the full sample. The dependent variable, the labor supply of mothers, is measured by two variables: the likelihood not to work in the last 3 months and the second is the likelihood to work full time (at least 4 weeks a month).

Table A.2: Descripitive statistics, households with infants ages 0-1

	Pre Remedia (1)	Post Remedia (2)	Diff (3)
Children under 18	2.862	2.823	0.039
			(0.069)
Mother years of schooling	13.266	13.555	-0.288
			(0.124)
Mother completed post-sec education	0.502	0.548	-0.045
			(0.019)
HH expenditure	1849.894	1814.875	35.019
			(59.157)
Share develpoment town	0.254	0.217	0.037
			(0.016)
Ultra_Orthodox Jews	0.138	0.157	-0.020
			(0.013)
Non-Jews	0.201	0.231	-0.031
			(0.015)
Baby food consumption	0.704	0.611	0.093
			(0.018)
Mother not working	0.579	0.539	0.040
			(0.019)
Mother working 4 weeks a month	0.238	0.268	-0.031
			(0.016)
Observations	1,431	1,435	

NOTE: This table provides descriptive statistics of the households in the pre- and post-Remedia period.

* Significant at 5%.

** Significant at 1%.

Table A.3: Descripitive statistics, households with infants in ages 2-4

	Pre Remedia (1)	Post Remedia (2)	Diff (3)
Children under 18	2.702	2.742	-0.040 (0.052)
Mother years of schooling	12.860	13.346	-0.486 (0.118)
Mother completed post-sec education	0.415	0.467	-0.052 (0.016)
HH expenditure	1887.434	2071.641	-184.207 (192.993)
Share develpoment town	0.249	0.248	0.002 (0.014)
Ultra_Orthodox Jews	0.051	0.070	-0.019 (0.008)
Non-Jews	0.227	0.267	-0.040 (0.014)
Baby food consumption	0.176	0.158	0.018 (0.012)
Mother not working	0.415	0.360	0.054 (0.016)
Mother working 4 weeks a month	0.491	0.544	-0.053 (0.017)
Observations	1,869	1,792	

NOTE: This table provides descriptive statistics of the households in the pre- and post-Remedia period.

* Significant at 5%.

** Significant at 1%.