The Impact of Maximum Markup Regulation on Prices[1]

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Abstract

Markup regulation is a common yet understudied type of regulation. We analyze the repeal of *maximum* wholesale and retail markup regulation in an oligopolistic and vertically nonintegrated market. By comparing the prices of products affected by regulation before and after the policy change and using unregulated products as a control group, we find that abolishing regulation led to a significant *decrease* in both retail and wholesale prices. The results provide indirect but consistent evidence that markup ceilings provided a focal point for collusion among wholesalers.

JEL: L0, L1, L4, L5

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1. Introduction

State imposed markups are common across markets. According to the World Health Organization, around 60% of low- and middle-income countries regulate wholesale or retail maximum markups in the pharmaceutical industry (Ball 2011, World Health Organization 2013). In high-income countries, maximum markups are also commonly imposed for prescription and over-the-counter drugs.[5] Markup regulation has been used in the US market for alcoholic beverages and in the Canadian and European gasoline markets.[6] In about 12 percent of the world gas market, prices are regulated using cost plus rules[7], which often prescribe regulated markups on production or import costs.[8] Extensive markup regulations have been used in the fruit and vegetable markets in Greece and are under review in Israel.[9] Yet despite this wide application, the effects of markup regulation have never been subject to systematic empirical testing.

Governments typically justify imposing maximum markups on the grounds of protecting consumers from the effects of excessive market power. In oligopolistic markets, the main argument in favor of maximum markups is to trim the right tail of the markup distribution, hence limiting the most extreme instances of exploitation of market power, in which the price exceeds by far the marginal cost. This is expected to put downward pressure on retail prices, without affecting firms with smaller markups (e.g., a competitive fringe). If binding, markup ceilings will force some firms to reduce prices. If not binding, prices will not be affected. Hence, the average price is expected to fall.

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[5] In nearly all EU member states, pharmacists' fees or margins on the sales of drugs are regulated (see Philipsen, 2013, for an overview and Schaumans and Verboven, 2008, for a study of entry in the Belgian market for pharmacies).

[6] Different types of markup regulation (often in conjunction with other types of regulation) have been used in the US market for alcoholic beverages (Seim and Waldfogel, 2013; Miravete, et al., 2014), in the Canadian and European gasoline markets (Sen et al. 2011; Suvankulov et al. 2012; Haucap and Müller 2012) and in the liberalized European telecom sector (Peitz, 2003). Finally, the American Defense Commissary Agency supplies groceries to military personnel and veterans at regulated prices, which are determined using a markup rule (Defense Commissary Agency, 2012).

[7] International Gas Union (2014).

[8] For example, gas prices in China at different stages of the production and transportation process are set by adding regulated margins to production costs. This generates significant local price differences (Corbeau et al., 2012).

[9] Consumers and producers seem to be advocating the introduction of maximum wholesale markups in the market for fruits and vegetables. Regulations are under consideration in parliament (Israel Consumer Council, 2015).

Surprisingly, there is no evidence on the actual impact of markup regulation on prices. Moreover, existing studies on the impact of price regulation challenge this seemingly uncontroversial prediction. Knittel and Stango (2003) show that mandatory price ceilings in the credit card market had the unexpected effect of *increasing* average prices by providing a focal point for collusion to unconstrained firms (Schelling 1960).[10] In principle, maximum markup regulation may also have this perverse effect. Still, the evidence on price regulation does not imply that markup regulation will have similar effects, and the impact of markup regulation on prices remains an open issue.[11]

In this paper, we estimate the impact of maximum markup regulation on retail and wholesale prices in an oligopolistic and vertically nonintegrated market. We take advantage of the repeal of maximum markup regulation in the Greek market for fresh fruits and vegetables. First implemented right after the Second World War, markup regulation was hastily canceled in June 2011 with the objective of reducing unnecessary regulation in the Greek economy.

Regulation consisted of maximum wholesale and retail markups on virtually all fruits and vegetables, whether imported or locally produced. Nonetheless, five products - apples, lemons, mandarins, oranges, and pears - were exempted from regulation. To identify the impact of deregulation on prices, we compare prices of products affected by regulation before and after the policy change and use the unregulated products as a control group. After accounting for product and store characteristics, time trends and yearly price cycles (typical of fruit and vegetable products), deregulation provides some plausibly exogenous variation that allows us to estimate the causal impact of regulation.

Our dataset consists of three types of data. First, it includes weekly store-level retail prices for each fruit and vegetable product category both from supermarkets and street markets in Athens. Our sample

[10] Albæk, Møllgaard, and Overgaard (1997) also show that price regulation may favor collusion. In their case, firms benefited from the availability of price information rather than from the existence of a focal point. The literature on price regulation has mainly focused on other issues, such as rationing and the welfare effects of binding price regulation (Olsen, 1972; Smith and Phelps, 1978; Raymon, 1983; French and Lee, 1987; Deacon and Sonstelie, 1989; Deacon and Sonstelie, 1991; Suen, 1989; Davis and Kilian, 2011). There is no evidence on the actual impact of markup regulation on prices, product availability, or entry, while there is some recent evidence on the impact of price floors on prices and market structure (Carranza, Clark, and Houde, 2013).

[11] Section 2 compares markup and price regulation in greater detail.

covers one and a half years before and after the policy change, from 4 January 2010 to 28 December 2012. Second, we use median monthly wholesale fruit and vegetable prices from the Athens Central Wholesale Market. Third, we collected weekly store-specific retail prices for 19 non-fruit and vegetable products sold in supermarkets during the same period.

The main challenge to the empirical study of markup regulation is that one cannot distinguish between constrained and unconstrained firms by observing individual prices, which are not enough to infer markups. We overcome this problem by using a difference in difference methodology and studying the impact of a specific policy change on the conditional distribution of prices at the retail and wholesale level. We find that abolishing markup regulation led to a surprising 6 percent *drop* in average retail prices. This reduction in the average price of fruit and vegetables corresponds to about 1 percent decrease in the price of food of a typical Greek household. In aggregate, this decrease implies savings of about €256 million per year.

Wholesale prices also decreased as a consequence of deregulation by about the same amount. As expected, the retail and wholesale prices of goods in the control group were not affected by the policy change. These results are robust to a number of alternative econometric specifications and different methods of selecting the control group. As to whether regulation affected the behavior of wholesalers or retailers (or both), we find that, after accounting for wholesale prices, retail prices were not significantly affected by changes in regulation. This suggests that although regulation had a direct effect on wholesalers, it only indirectly affected retailers, who adjusted their prices to the lower wholesale prices.

Given that regulation is often instituted in order to protect consumers, it is natural to ask how deregulation might actually result in lower prices. We investigate the hypothesis that maximum markups may provide a focal point for collusion (Knittel and Stango 2003) and also explore alternative hypotheses based on incentives to reduce costs and vertical relations. A number of factors facilitating collusion seem to be present in the wholesale market. First, the market operates as a licensed market, with a small and stable group of operators. Second, wholesalers operate in close physical proximity and trade homogeneous products (within varieties), making it possible to monitor and share information (Hellenic Competition Commission, 2013; henceforth HCC).

We provide specific empirical evidence consistent with collusion. All of the supermarkets in our sample typically buy from wholesalers. In contrast, while smaller retailers in street markets also rely on wholesalers for some products, they buy others from a fragmented market of local producers. We find that average prices in street markets were less affected by deregulation than those at supermarkets: although the retail prices of items sourced from wholesalers fell as much at street markets as in supermarkets, the retail prices of locally sourced products were not significantly affected. Our results complement the existing literature by providing indirect evidence that markup regulation may also lead to collusion.[12]

Our work also relates to empirical studies of markets with vertical relations. Most of the research in this area has focused on the effects of vertical agreements (restraints) among firms, whereas our aim is to measure the impact of government regulation (Lafontaine and Slade, 2008). From a policy perspective, our work also contributes to the existing literature investigating how regulation affects efficiency and economic performance (see, for example, Djankov et al. 2002; Scarpetta and Tressel 2002; Blanchard, 2004; Katsoulacos et al. 2014). Finally, our results inform the debate on recent investigations by the European competition authorities (European Competition Network, 2012) into suspected vertical and horizontal agreements harming competition in the food market.[13]

[12] Porter and Zona (1993 and 1999) study procurement auctions by comparing the bids of firms that were likely to be part in a collusive agreement and those that were not. Porter (1983), Ellison (1994), and Baldwin et al. (1997), instead, use a statistical model to identify collusive behavior from the data. Knittel and Stango (2003) build on this approach to distinguish the probability of collusion at the price ceiling from the probability of being constrained by the price ceiling. In our setting, it is not possible to observe which sellers are charging the maximum markups. Hence, our focus is entirely on policy evaluation. We do not aim at identifying the exact mechanism that links regulation to higher prices. Similarly, we do not aim at providing a general methodology to identify collusion in the absence of an exogenous policy change.

[13] A large literature relates to minimum markups, sales-below-cost laws, and predatory pricing (see Motta 2004 for a review and Biscourp, Boutin, and Vergè, 2013, for a recent policy evaluation). Although similar in their implementation (a constraint on markups), the economic rationale for these laws is different from that of maximum markup regulation studied in this paper.

2. Markup Regulation and Price Regulation

Imposing a maximum markup $(p-c)/c < a$ implicitly constrains the price p that a firm can charge, given its marginal cost of production c, $p < c(1+a)$. This mechanism is analogous to the way in which price ceilings constrain firms with higher prices. However, markup regulation differs from price regulation in a number of ways. First, it constrains firms (or products) with higher markups, which are not necessarily those with higher prices. Hence, the impact of markup regulation on the distribution of prices will generally differ from that of price ceilings. Second, markup regulation limits the benefits from cost reductions, while price regulation provides strong incentives to increase efficiency.[14] Third, markup regulation is used in markets (for example, fruits and vegetables) in which price regulation would be impossible to implement due to high seasonality or uncertainty in production costs. Fourth, the enforcement of markup regulations is generally more difficult and costly as firms may misreport or distort their cost structure in response to regulation.

In a repeated game framework, collusion on prices can be sustained in equilibrium by the threat of future punishments (e.g., a price war), triggered by deviations from the collusive pricing strategy (Knittel and Stango 2003; Green and Porter 1984; Rotemberg and Saloner 1986; Abreu et al. 1990; Haltiwanger and Harrington 1991). A similar mechanism may lead to collusion on markups, but this requires that firms infer the markups of competitors from available data on costs and prices. This makes collusion on markups more difficult to sustain in equilibrium than collusion on prices. Hence, the observation that price regulation may facilitate collusion does not imply that markup regulation will have the same effect. Still, our results complement those of Knittel and Stango (2003) and Albæk, Møllgaard, and Overgaard (1997) by providing evidence of a situation in which regulation had the perverse effect of favoring collusion.

[14] From this point of view, markup regulation is a relatively low-powered regulation and resembles cost of service regulation (Viscusi et al. 2005). The principal-agent problems induced by regulation have been the focus of a large literature (Laffont and Tirole 1993).

3. The Greek Market for Fruits and Vegetables

The market for fruits and vegetables in Greece consists of three layers. At the production level, the market is very fragmented.[15] The wholesale market is significantly more concentrated, with the Athens Central Wholesale market operating as a closed market in which only licensed sellers can operate. Wholesalers mainly sell to retailers (with supermarkets as their largest customers), but also to street market sellers, grocery stores, and restaurants. Finally, at the retail level, consumers buy either from street markets (58 percent market share in year 2011 but steadily declining), supermarkets (32 percent market share and steadily increasing), and - to a lesser extent - from grocery stores or other corner shops (10 percent). In street markets, approximately half of the sellers are also producers themselves (HCC, 2013).

The maximum markup regulation for fruits and vegetables was introduced after World War II as part of a broader set of regulations that covered various aspects of retail and wholesale trade, including licensing, opening hours and pricing. The regulation initially covered all fruits and vegetables. By 1977, however, five products (apples, lemons, mandarins, oranges, and pears) had been exempted from the application of maximum markup regulations. No change in the list of excluded products has occurred since. The reasoning behind making these exclusions is not clear and the available legal documents and other ministerial reports contain no clues. The production, trade, and consumption of these products is widespread throughout the country and they are not the output of any specific region or any identifiable set of producers. They are statistically indistinguishable from products subject to regulation in terms of mean cultivation area, production quantity, and yield.[16]

The law provided for product-specific maximum markups ranging between 8 and 12 percent for the wholesale market, 20 and 35 percent for supermarkets, and 17 and 32 percent for street markets and

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[15] The agricultural sector accounts for 3.1 percent of the Greek GDP and employs 9.2 percent of the total work force, which is twice the EU 27 average (4.7 percent). However, the average producer cultivates just 47,000 m^2 (11.6 ac) vs. the EU average of 126,000 m^2 (31.1 ac) Moreover, around 50 percent of the Greek producers own less than 20,000 m^2 (4.9 ac) plots.

[16] See Table A2 in the Appendix, which uses annual data at the product level from EUROSTAT for 2011. Differences remain insignificant if we use other years before 2011 or the average values for the 2006-2011 period.

grocery stores (see Table A1 in the Appendix for details).[17] The repeal of the maximum markup regulation was the outcome of mounting international pressure to liberalize the Greek economy in an attempt to limit red tape and government intervention in various markets.[18] The policy change was highly visible and prominently featured in national newspapers, and the process leading to deregulation was quick. The policy was implemented on 23 June 2011, about three weeks after the government first announced it.[19]

4. Data

We matched three different data sources for our analysis. First, we obtained weekly store-level retail prices for fruits and vegetables in Athens.[20] The data was collected through a regular survey run by the Greek Ministry for Development and Competitiveness. Prices in supermarkets and street markets were recorded on a weekly basis. We obtained store-level data for 36 products, further subdivided into 72 varieties, from 20 supermarkets and 24 street markets in Athens from 4 January 2010 to 28 December 2012.[21] Second, using a survey administered by the Greek Ministry for Development and Competitiveness, we collected information on the retail prices of 19 grocery products other than fruits and vegetables sold in the same supermarkets (all product categories and varieties are reported in Table A3 in the Appendix). None of these products was affected by the markup regulation. Third, we also obtained monthly wholesale median prices of the same fruit and vegetable varieties from the administration of Athens Central Wholesale Market during the same period. The wholesale data covers all 36 products and 59 of the 72 product varieties in the sample of retail prices.

[17] By law, maximum markups are computed over the sum of the purchase price and the transportation cost, before adding VAT.
[18] However, this was not formally part of any agreement between Greece and its creditors (IMF, ECB, EU).
[19] Ministerial decision A2-1045 (Gazette B' 1502/22-6-2011). The only other policy that potentially affected both regulated and unregulated products during that period were three increases in VAT: from 9% to 10% on 15/3/2010, from 10% to 11% on 1/7/2010 and from 11% to 13% on 1/1/2011.
[20] We focus on Athens, as it is by far the biggest market in Greece, is well-documented in our supermarket sample, and provides reliable information on wholesale prices.
[21] Sellers in street markets were sampled by employees of the Ministry for Development and Competitiveness and mean prices in each market were then computed for the same fruit and vegetable varieties as for supermarkets. Our sample does not cover grocery stores or other small independent retailers (corner or convenience stores).

Figure 1A plots the time series of the weekly average log price of fruit and vegetable products. The dashed black line shows products affected by markup regulation; the dashed grey line shows the five products not affected by regulation. The average price of products not affected by regulation (the solid grey line) is very similar in the period preceding and following the policy change (the vertical red line). On the contrary, the average price of products affected by regulation (the solid black line) shows a large drop, suggesting a significant reduction in the price of these goods.

Figure 1A also indicates that fruit and vegetable prices follow a yearly cycle, which is typical of agricultural products. To account for products' yearly cycle, we separately estimate a regression of log price on monthly indicator variables for products affected and not affected by regulation. Figure 1B plots the weekly average residuals for the two groups of products and compares the period before and after the reform.[22] In line with the previous figure, there is little change in the average residual for products not affected by regulation. However, the average residual for products affected by regulation shows a significant drop. In the next sections, we build on these descriptive results and provide a more systematic analysis of the possible impact of deregulation.

5. Identification and Empirical Methodology

Identification of the impact of the policy change is obtained within a difference in difference framework.[23] Denote by P_{ijt} the retail price of product variety *i*, in store *j*, in week *t*. The basic empirical specification is of the form:

$$\ln(P_{ijt}) = b_0 + b_1 Post_t + b_2 Treat_i + b_3 Post_t \text{ x } Treat_i + X_{ijt} d + e_{ijt} \qquad (1)$$

where $Post_t$ is an indicator variable equal to one after deregulation, $Treat_i$ is an indicator variable for products affected by the regulation (treatment group), $Post_t \text{ x } Treat_i$ denotes their interaction; X_{ijt} is a

[22] The average residual of both series before the reform is normalized to zero.
[23] Early applications of this approach are found in Ashenfelter and Card (1985), Card (1992), and Card and Krueger (1994, 2000).

matrix of control variables and e_{ijt} is a random shock with $E(e_{ijt}|Post_t, Treat_i, X_{ijt}) = 0$. b_3 is the crucial parameter capturing the impact of the policy change.

The key identifying assumption is that price trends would be the same (conditional on covariates X_{ijt}) in the treatment and control groups in the absence of treatment. This assumption becomes increasingly credible as we progressively add appropriate controls in X_{ijt}. First, we control for changes in the VAT rates. Second, we include in X_{ijt} eleven month indicator variables, 53 store indicator variables, and 109 product variety-specific indicator variables. We then add the interaction of month and product fixed effects, capturing the yearly price cycle of each product (we assume that varieties of the same product follow the same cycle). Finally, we include a quadratic trend (measured in months).[24] This captures the overall changes in the average price of fruit and vegetable products during the sample period (due, for example, to the economic recession).

The analysis of wholesale prices from the Athens Central Wholesale Market uses the same empirical specification with the caveat that only median wholesale prices at a monthly (rather than weekly) frequency are available for each product variety.

6. Empirical Results

Table 1 reports a simple before-after comparison of the retail price of products covered by regulation (treatment group). The average price decreases by 7.7 percent after deregulation (column 1). This difference is not much affected when controlling for month (column 2), store, and variety-specific fixed effects (column 3). It is also robust to controls for product-specific yearly cycles (column 4). Additionally controlling for a linear and a quadratic trend (column 5) leads to slightly smaller estimated difference in prices (5.6 percent).

[24] We also estimate the model using flexible period-specific indicator variables (153 week-specific indicator variables) instead of a time trend, as in Jin and Leslie (2003). None of our results change in any fundamental way.

Table 2 reports our main results. The simple difference in difference estimator, with no additional controls, shows that the average price of the treatment group significantly fell by 10 percent (column 1). In contrast, prices for the control group were not significantly affected. In columns 2 and 3, the negative impact of deregulation survives the inclusion of month, store, and variety-specific fixed effects. After controlling for product-specific yearly cycles (column 4) and quadratic trend (column 5), the estimated causal impact of deregulation is -6.4 percent.[25]

The economic magnitude of the results is significant. A 6 percent decrease in the average price of fruit and vegetables corresponds to a 1 percent decrease in the price of food of a typical Greek household, and a 0.16 percent decrease in the consumer price index. This, in turn, corresponds to a decrease of €23 in expenditure per capita per year, amounting to €256 million per year in aggregate expenditure (about 0.12 percent of GDP).

Table 3 reports the results when analyzing the wholesale data alone. A simple before-after comparison of the wholesale prices of regulated products indicates that prices fell by 9.9 percent after deregulation (column 1). Without additional control variables, the difference in difference estimate of the impact of the policy change is higher in column 2. Including month and variety-specific fixed effects, product-specific yearly cycles, and the quadratic trend leads to a smaller but statistically significant estimated impact of deregulation of -9.5 percent.[26]

Selection of the Control Group and Placebo Test

The difference in difference approach assumes that the policy change does not affect the control group (no spillover effects). However, given that both our control and treatment groups consist of fresh fruits and vegetables, the policy change could potentially have an indirect impact on the demand for, and hence

[25] The results are not affected if we replace the time trend with week-specific indicator variables.
[26] Standard errors are larger than in Table 2 but the estimated coefficients are not significantly different from the corresponding estimates in Table 2.

the prices of, some products in the control group. This could happen if some cross price elasticities between products in the two groups were sufficiently high (positive or negative).

In the absence of a formal randomization into treatment status, the choice of the control group entails a tradeoff. Similar products are more likely to meet the equal trends assumption, but they are also more likely to be related (substitutes or complements). If this is the case, our estimator will not capture the impact of the policy but only the differential impact of the policy on the two groups. Note that both Figure 1, where the average prices of the control group are very similar before and after the policy change, and the insignificant $Post_t$ coefficient in Table 2 seem to refute this idea.

Nevertheless, we investigate this possible bias by using a different control group, comprised of 19 non-fruit and vegetable packaged goods such as rice, spaghetti, flour, and milk (the full list is reported in Table A3, column 3). These products are stocked in all supermarkets in our sample and are very unlikely to be strong substitutes or complements of the fruit and vegetables in our treatment group. Table 4 presents the results using the same additional control variables as in Table 2. The impact of deregulation ranges between 9 and 12 percent. In the specification with the richest set of controls (column 5), the impact of deregulation is about 8.8 percent, slightly larger than in Table 2 but within conventional confidence intervals of our previous estimates. As before, there is no systematic impact of deregulation on the price of the products in the control group. Overall, the choice of the control group seems not to significantly affect our results.

Since most of the products in the original control group are fruits, in Table 5, column 1, we also separately estimate the impact of the policy change for fruits and vegetables. The estimated impact of the policy is very similar in magnitude and not statistically different for the two groups. We also test the robustness of the common trend assumption in (1) using the period before the change in regulation to estimate the impact of a placebo treatment. In Table 5, column 2, we drop the period after 22 April 2011, which is two months before the actual policy change, to avoid any possible anticipation effects (which will be discussed in Section 6.2). We then choose the midpoint of the remaining period (22 September

2010) as the date of a fictitious reform. The results show that the fictitious policy has no impact on the treatment or the control group.[27]

6.1. Interpretation of the Estimated Impact of Deregulation: Markup Regulation and Collusion

Our results are not consistent with the view that the only effect of regulation is that of constraining firms with high markups, hence leading to a decrease in average prices. Unexpectedly, we find that average prices decreased with deregulation. Although some firms might have been constrained by the markup regulation, another effect must have played a major role. The main candidate explanation is that regulation facilitated collusive behavior (we will discuss alternative explanations in Section 6.3). The economic intuition underlying this idea is that (unconstrained) firms used the maximum markups as focal points for coordination, leading to increases in average prices (Knittel and Stango, 2003). Repeal of the law might have destroyed these focal points and led to significant price decreases.

If collusion is driving the results in Tables 1-5, we will expect to see a larger impact of the policy in markets in which collusion is easier to maintain. As discussed earlier, the wholesale market for fruit and vegetable products is more concentrated than the retail market, and less affected by entry and exit. Firms (in terms of sale volume) are also larger and more likely to be incorporated (HCC, 2013). Moreover, wholesalers are physically closer to each other and interact daily. Finally, products (within varieties) are homogenous in the wholesale market, while at the retail level there is differentiation due to location, availability, and complementary services offered to customers. Hence, collusion is expected to be more likely in the wholesale market.

We test this hypothesis in three ways. First, we investigate the impact of the policy change on retail prices holding wholesale prices constant. We merged the retail with the wholesale price data, excluding the varieties not included in the wholesale data set. Table 5, column 3 reports the results from our benchmark specification controlling for store, variety-specific fixed effects, product specific yearly cycles

[27] There is no change in the list of available products or varieties before or after deregulation in the retail or wholesale dataset. Deregulation did not seem to have any effect on product availability or product variety.

and quadratic trend on this slightly modified dataset. Not surprisingly, the impact of the policy (-5.5 percent) is very similar to what we found in Table 2, column 5 (-6.4 percent). In Table 5, column 4 we additionally control for wholesale prices, and the effect of the policy change becomes statistically insignificant. Deregulation affected retail prices indirectly through wholesale prices, but there is no evidence of a *direct* effect of deregulation on retail prices.[28]

Second, we estimate the differential effect of the change in regulation in supermarkets and street markets. This is because supermarkets typically buy all of their grocery products from wholesalers (HCC, 2013). Street vendors, on the other hand, have access to a variety of small producers or are producers themselves. Hence, collusion at the wholesale level is likely to impact prices in supermarkets more than in street markets. In Table 5, column 5 we find that the policy change indeed had a large and significant impact (-10 percent) on supermarkets, whereas street markets were relatively unaffected.

Our third approach focuses on the differential impact of the policy on specific products sold at street markets, since even street vendors have to rely on wholesalers for their supply of some specific products. Unfortunately, the classification of products along this dimension is very difficult. Still, the HCC report (2013) shows that street vendors almost never buy lettuce from wholesalers, while they rely on them heavily for peaches. Hence, we can test if the policy had a different impact on the price of these two products in street markets.

Table 6, column 1 reports the results of our benchmark specification using the same control group as before but including only lettuce (classified as "low") and peaches ("high") in the treatment group. The impact of the policy is very similar, although standard errors are larger, due to the smaller sample. Column 2 confirms our previous findings on the differential effect in supermarkets and street markets. Column 3 shows that in street markets, deregulation had no significant impact on the price of lettuce ($\text{Low}_i \times \text{Street market}_j$) but had a negative impact on the price of peaches ($\text{High}_i \times \text{Street market}_j$). By

[28] The coefficient of the wholesale price in this regression is expected to be positive, since increases in wholesale price lead to increases in marginal cost for the retailers.

contrast, in supermarkets, both lettuces and peaches were affected by the policy. These new results are consistent with markup regulation affecting wholesale prices first, and only indirectly affecting retail prices.

The interpretation of the results based on collusion requires that wholesalers could monitor the strategies of their competitors. It is difficult to evaluate what wholesalers knew about their competitors' costs and prices, although monitoring seems to have been possible for three main reasons. First, the identity of (large) customers supplied by each wholesaler could easily be observed because of the physical arrangement of the Athens Central Wholesale Market. Second, wholesale transactions were far from confidential, although they were subject to negotiation between wholesalers and (large) buyers.[29] Finally, information on retail prices in supermarkets was widely available to competitors.

The Impact of the Level of Regulated Markups

According to the collusion hypothesis, collusion should be more difficult to maintain as the gains from deviating from collusive behavior increase. Knittel and Stango (2003) show that cheating may become more attractive when the focal point is higher, since profits from cheating rise faster than profits from cooperation. They also provide evidence that higher price ceilings in the credit card market made collusion more difficult to sustain.

We categorize products into two groups based on the level of the maximum wholesale markup (low maximum markup, including products with maximum markup at 8 and 10 percent, and high maximum markups, including products with 12 percent maximum markup, see Table A1). In Table 7, column 1 we report the estimated impact of deregulation on the wholesale price obtained interacting $Post_t$ x $Treat_i$ with an indicator variable for each group. We find that the effect of deregulation was stronger for products with low maximum markups than for products with high maximum markups. These results are

[29] Each wholesaler had to report wholesale prices to the market authorities (for each transaction). Given the physical proximity of wholesalers, this information could easily be shared with other wholesalers. There is no evidence of systematic use of rebates that would generate a difference between the reported wholesale price and the price actually paid by retailers.

consistent with the collusion hypothesis and the existing literature. Still, they should be interpreted with caution, since we estimate the differential impact of deregulation on average prices, not directly on the probability of collusion.

Maximum markups are correlated across markets. The correlation coefficient between the maximum markups for wholesalers and supermarkets is 0.33, between those for supermarkets and street markets is 0.99. In column 2, we replicate column 1 for retail prices in supermarkets, splitting products into two categories based on their maximum markups in the retail market. We find no significant difference between the two groups in the impact of the policy change. Interestingly, when we classify products according to the level of the maximum markup in the *wholesale* market (column 3), we find that retail prices fell more for products with low maximum markups. Only differences in maximum markups at the wholesale level generate differences across products in the impact of the policy change. These results are consistent with previous evidence suggesting that collusion was taking place in the wholesale market and not in the retail market.

The Impact on the Distribution of Prices and Quantile Regressions

While the previous sections focused on the impact of deregulation on the mean, we now investigate how deregulation affected the entire price distribution. Figure 2 plots the distribution of the logarithm of prices for products in the treatment group for one year before and after deregulation. After deregulation, the distribution shifts to the left and becomes more dispersed. In particular, the mean and the median decrease, together with the 1^{st} and 5^{th} percentiles, whereas the 95^{th} and 99^{th} percentiles slightly increase.

A similar pattern emerges from the distribution of residuals from a regression of retail prices on product, store, product-month interactions, and a quadratic time trend (see Figure A1 in the Appendix). In Table 8, we use quantile regressions to measure the impact of markup regulation on the distribution of residuals. Deregulation affected the left more than the right tail of the distribution. Overall, the magnitude of the impact of deregulation is consistent with the impact on the mean measured in Table 2, column 5.

The effect of deregulation on the distribution of prices is consistent with the collusion hypothesis. However, this hypothesis implies that regulation leads to a more concentrated markup distribution, but does not necessarily imply a more concentrated price distribution, as marginal costs (purchase price plus transportation costs) vary across firms. Only if there is a positive correlation between the level of prices and markups will markup regulation lead to less price dispersion. While a positive correlation between prices and markups seems plausible at the product level, we cannot directly test this with our data.[30]

Dynamic effects

Finally, we estimate a dynamic model interacting $Treat_i$ with indicator variables for 10 two-week periods before and after the policy change,

$$\ln(P_{ijt}) = b_0 + b_1 Post_t + b_2 Treat_i + b_{3,T-10}[Treat_i \text{ x } D^{T-10}] + b_{3,T-9}[Treat_i \text{ x } D^{T-9}] + \cdots + b_{3,T+9}[Treat_i \text{ x } D^{T+9}] + b_{3,T+10}[Treat_i \text{ x } D^{T+10}] + X_{ijt}d + e_{ijt} \quad (2)$$

where $D^{T-i} = 1$ in the i^{th} period before deregulation.[31] The last period (T+10) includes all the observations 20 or more weeks after the policy change.[32]

Figure A2 in the Appendix plots the regression coefficients together with their 95% confidence interval.[33] Deregulation has no effect on prices until four weeks before the actual implementation.[34] There seems to be some anticipation effect about four weeks before the policy change, as indicated by the drop in the estimated coefficient in T-2. This corresponds to government announcement concerning the impending change in regulation. Point estimates are negative and stable from that point on, and their magnitude is in

[30] There is a growing empirical literature on the impact of collusion and cartels on price variability (see, for example, Abrantes-Metz, et al., 2006, and Botolova, et al., 2008).
[31] The results are robust with respect to the choice of the window around the policy change.
[32] The omitted indicator variable covers the period 20 or more weeks before deregulation. See, Autor (2003) or Laporte and Windmeijer (2005) for a discussion of this approach.
[33] Estimated coefficients are reported in Table A4 of the Appendix.
[34] The null hypothesis that all coefficients for periods before the deregulation are equal to zero is not rejected at conventional levels (p-value = 0.939).

line with our previous estimates of the impact of deregulation (Figure A2 also reports the estimated treatment effect from Table 2, column 4).[35]

6.2. Alternative Hypotheses and Interpretations of the Results

Markup Regulation and Cost Inflation

A binding markup regulation limits the benefits from cost reductions, as investments that reduce marginal cost result in a reduction in the maximum price that a firm can charge. For example, a retailer may not benefit from exerting effort in trying to buy at the lowest price, or in minimizing transportation costs, since lower costs are reflected in a lower maximum price. Hence, in principle, firms may distort their cost structure in response to regulation.

Leaving aside the possibility of collusion, the introduction of a binding markup regulation has, in theory, two effects. First, it directly reduces prices for a given marginal cost. Second, it may lead to inefficiencies and higher marginal costs, which results in higher prices. However, the incentives to inflate costs only partially offset the direct impact of regulation.[36] Hence, markup regulation is expected to lead to lower prices, which clearly contradicts the empirical evidence.

Moreover, the cost inflation hypothesis implies that constrained firms drive the higher average prices during the regulation period. If there is a positive correlation between the level of prices and markups, then the impact of regulation will be concentrated in the right tail of the price distribution. However, Figure 2 and the results on the quantile regressions suggest a larger impact of the policy in the left tail of the price distribution, where unconstrained firms are more likely to operate.

[35] The coefficients are imprecisely estimated, as fruit and vegetable prices show considerable weekly variability in addition to their yearly cycle. The estimates of the dynamic impact of the reform on wholesale prices are also very noisy. Figure A3 and Table A5 in the Appendix describe the regression coefficients. The null hypothesis that all coefficients for periods before the deregulation are equal to zero is not rejected at conventional levels (p-value = 0.454).

[36] Consider the introduction of a binding maximum markup regulation. Regulation makes profit proportional to revenues, but a price that maximizes revenues is strictly lower than the profit maximizing price (for any positive marginal costs). Hence, even if the firm can manipulate its marginal cost, the second effect of markup regulation will never fully offset the first. The argument is described in detail in Appendix B.

Markup Regulation and Vertical Relations

The introduction of a binding markup regulation at the retail level can affect the incentives of an upstream wholesaler. However, theoretical arguments suggest that the wholesaler will never charge a higher wholesale price in response to the introduction of markup regulation downstream.[37] This implies that the higher prices observed in the fruits and vegetable market before the reform are unlikely to be caused by vertical relations along the supply chain.[38]

Weak or Imperfect Law Enforcement

The specific nature of the regulation we are studying required extensive monitoring by the regulator. How could weak or imperfect law enforcement affect the interpretation of the results? Evidence from the HCC (2013) report suggests that the law was well enforced in supermarkets. We do not have direct evidence on the quality of enforcement in street and wholesale markets. In any case, our analysis does not rest on any assumption on the quality of enforcement. Lack of enforcement would imply that regulation was less effective (or perhaps even completely ineffective) in constraining prices. We would then expect no impact of deregulation, whereas we find a significant effect. However, even if not binding or poorly enforced, regulation might have provided a focal point for collusion.

7. Concluding Remarks

In this paper, we present the first systematic evidence of the impact of maximum markup regulation on retail and wholesale prices. Our results show that repeal of regulation led to significant price decreases, corresponding to an estimated €256 million yearly decrease in consumer expenditure. We also provide indirect but consistent evidence that the most likely explanation for this phenomenon was collusion at the wholesale level. First, several features (centralized physical arrangement, barriers to entry, limited

[37] In the classic vertical relations game (Spengler 1950; Tirole 1988), the introduction of a maximum markup regulation downstream cannot lead to higher wholesale prices upstream. Appendix B illustrates this result in more detail.

[38] Also this second alternative explanation is based on the idea that constrained retailers drive the increase in average price during the regulation period. Hence, one would again expect a larger impact of deregulation in the right tail of the distribution of prices, which is not observed in the data.

number of large competitors, daily interaction) of the wholesale market make it more susceptible to collusion. Second, the negative impact of deregulation on retail prices is driven by price changes at the wholesale level. Third, prices in supermarkets, which mainly buy from wholesalers, experienced the most significant changes, whereas prices in the street markets decreased significantly only for products that passed through the wholesale channel.

The existing data do not allow us to investigate the exact mechanism possibly used to sustain collusion, nor to assess whether explicit or tacit collusion is more likely to have taken place (although this distinction is clearly important for competition policy). Overall, the results of our ex-post policy evaluation highlight the unexpected consequences of a common yet understudied type of regulation. While maximum markup regulation may well serve its intended purpose in some markets, our results show that this cannot be taken for granted.

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Appendix 2

NOT FOR PUBLICATION

Markup Regulation and Cost Inflation

Consider the standard monopoly pricing problem, denoting as c>0 the marginal cost and D(p) the demand function, with $D' < 0$, $D'' \leq 0$. The monopoly price is obtained with the inverse elastic rule, $\frac{p^m - c}{p^m} = 1/\varepsilon$, where $\varepsilon = -\frac{D' p^m}{D}$. At the optimum, the absolute value of the elasticity of demand ε is larger than 1. The monopoly profits are decreasing in the marginal cost, hence the firm benefits from increases in efficiency.

Consider now the introduction of a binding markup regulation, where a is the maximum markup, so that the regulated price is $c(1+a)$. In this case, the benefits from increases in efficiency are less clear-cut, since the profit function is $\Pi = c(1+a)D\big(c(1+a)\big) - cD\big(c(1+a)\big)$, which can be rewritten as $\Pi = acD\big(c(1+a)\big)$. Increasing c increases the regulated price and the absolute profit margin for each unit, while also decreasing demand. Hence, the monopolist may in principle benefit from optimally choosing c. However, the first order condition with respect to c implies that $c^*(1+a) = -\frac{D\left(c^*(1+a)\right)}{D'\left(c^*(1+a)\right)}$. This implies that, at the optimum, the elasticity of demand ε is equal to 1. Hence, the price of a regulated monopolist cannot be higher than the standard monopoly price.

Markup Regulation and Vertical Relations

Consider the standard vertical relations model (Spengler, 1950; Tirole, 1988) in which an upstream wholesaler sells to a downstream retailer (stage 1), who then sells to final consumers (stage 2). For simplicity, the demand function is linear, $D(p) = 1 - \beta p$, where p denotes the retail price. The marginal cost of production is denoted by c and the wholesale price by p_w. The retailer maximizes $(p - p_w)D(p)$ at a price $p^*(p_w)$ that solves $p^*(p_w) = p_w - \frac{D(p)}{D'(p)}$. The wholesaler maximizes $(p_w - c)D\big(p^*(p_w)\big)$ at a wholesale price p_w^* that solves

$$p_w^* = c - \frac{D(p)}{D'(p)\frac{dp^*}{dp_w}}.$$

Substituting, the equilibrium retail price is given by

$$p^* = c - \frac{D(p)}{D'(p)}\left(1 + \frac{1}{\frac{dp^*}{dp_w}}\right), \text{ where } \frac{dp^*}{dp_w} = \frac{1}{2 - \frac{D(p)D''(p)}{[D'(p)]^2}}.$$

Using the linearity of the demand function, we can obtain simple expressions for the equilibrium prices, $p^* = \frac{c}{4} + \frac{3}{4\beta}$ and $p_w^* = \frac{c}{2} + \frac{1}{2\beta}$.

After the introduction of a binding markup regulation, the retail price is constrained by the regulation. The wholesaler maximizes $(p_w - c)D\big(p_w(1 + a)\big)$ at a wholesale price $p_{w,r}^*$ that solves

$$p_{w,r}^* = c - \frac{D\left(p_{w,r}^*(1+a)\right)}{D'\left(p_{w,r}^*(1+a)\right)(1+a)}.$$

The retail price is then $p^* = p_{w,r}^*(1 + a)$. Since demand is linear, we can solve for $p_r^* = \frac{c(1+a)}{2} + \frac{1}{2\beta}$ and $p_{w,r}^* = \frac{c}{2} + \frac{1}{2\beta(1+a)}$. In equilibrium, the wholesale price with regulation $p_{w,r}^*$ is lower than the wholesale price without regulation p_w^* for any c. Figure B1 describes the retail prices p_r^* and p^* with and without regulation; p_r^* is smaller than p^* if $c < \frac{1}{(1+2a)\beta}$. However, this condition is always met when the markup regulation is binding, since $p^* - (1 + a)p_w^* > 0$ implies that $c < \frac{1-2a}{(1+2a)\beta}$. Hence, in equilibrium, the retail price is also lower after the implementation of a binding markup regulation.

Figure B1: The equilibrium retail price with and without markup regulation.

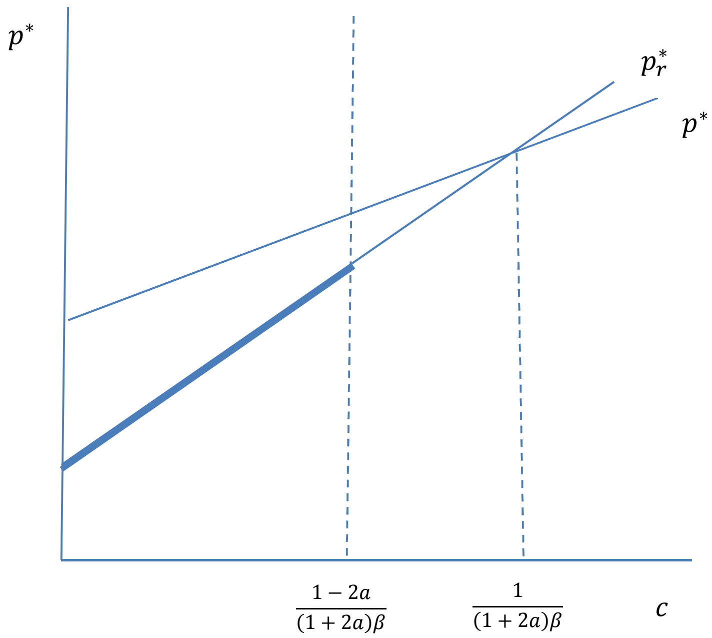
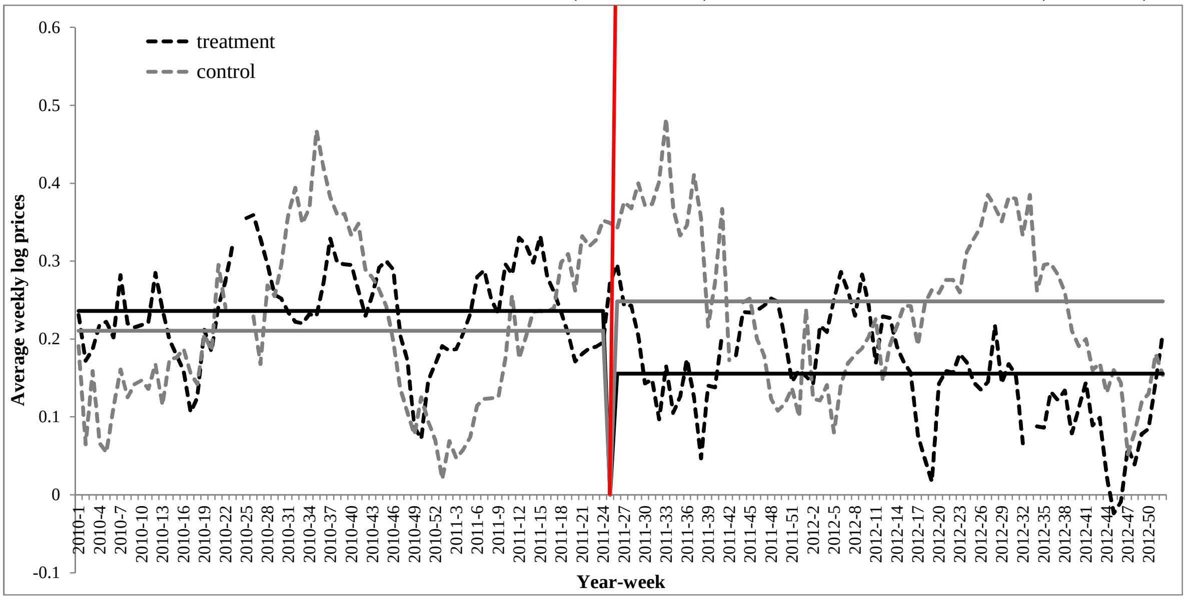
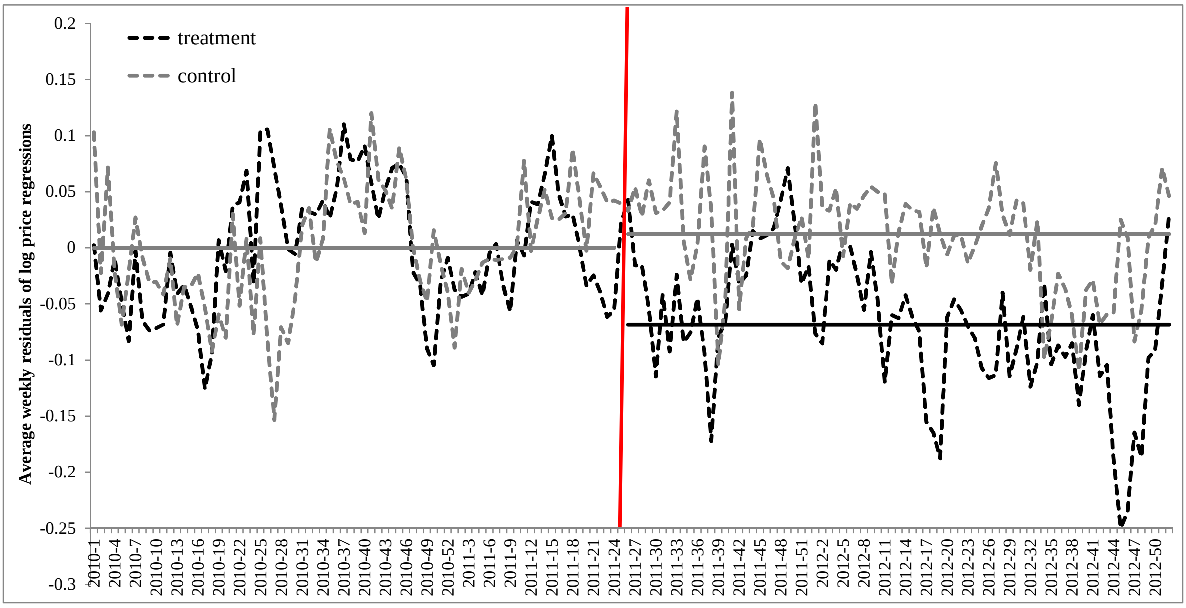


FIGURE 1A: AVERAGE RETAIL PRICES OF REGULATED (TREATMENT) AND UNREGULATED PRODUCTS (CONTROL)



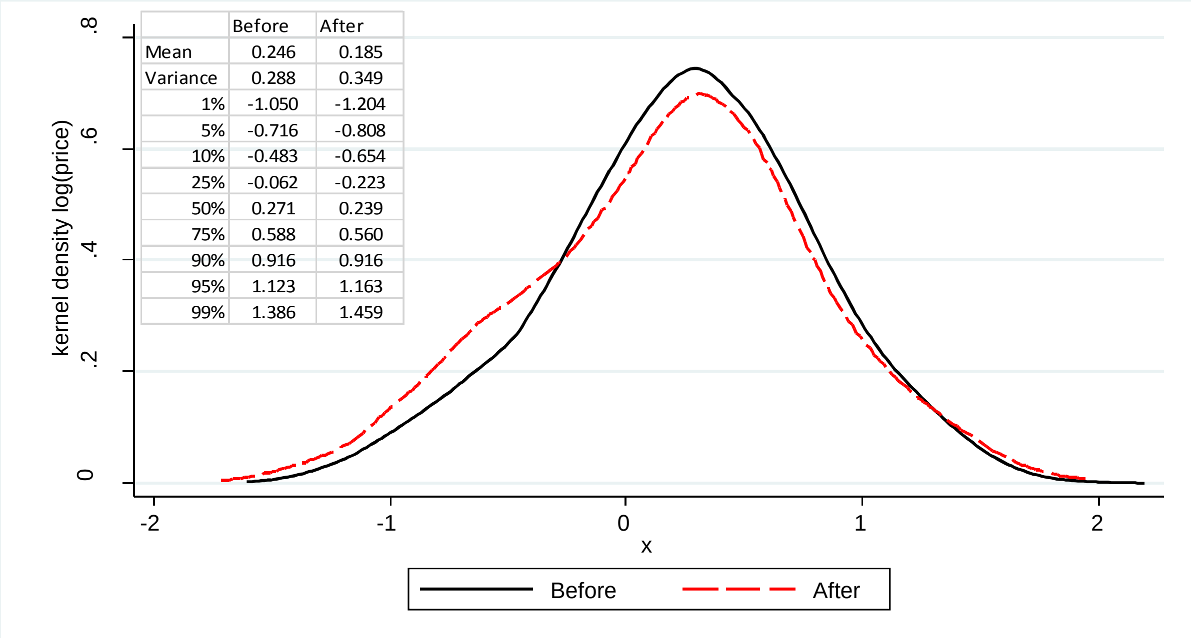
Notes: The figure reports the weekly average of the logarithm of products' prices affected by the markup regulation (treatment group, black dashed line) and not affected by regulation (control group, grey dashed line) and their averages (black solid line for the treatment group and grey solid line for the control group) before and after deregulation.
Source: Authors' calculations based on data from the Greek Ministry of Development.

FIGURE 1B: AVERAGE RESIDUALS OF REGRESSIONS OF LOG PRICE ON MONTHLY DUMMIES FOR REGULATED (TREATMENT) AND UNREGULATED PRODUCTS (CONTROL)



Notes: The figure plots the weekly average residual of a regression of log price on monthly indicator variables run separately for products affected by the markup regulation (treatment group, black dashed line) and not affected by regulation (control group, grey dashed line) and their averages (black solid line for the treatment group and grey solid line for the control group) after the deregulation. The average residual of both series before the reform is normalized to zero.
Source: Authors' calculations based on data from the Greek Ministry of Development.

FIGURE 2: THE DISTRIBUTION OF RETAIL PRICES BEFORE AND AFTER DEREGULATION (TREATMENT GROUP)



	Before	After
Mean	0.246	0.185
Variance	0.288	0.349
1%	-1.050	-1.204
5%	-0.716	-0.808
10%	-0.483	-0.654
25%	-0.062	-0.223
50%	0.271	0.239
75%	0.588	0.560
90%	0.916	0.916
95%	1.123	1.163
99%	1.386	1.459

Notes: The figure plots the distribution of log prices of products in the treatment group one year before ("Before") and one year after ("After") the policy change. Sample statistics are reported in the top left corner.
Source: Authors' calculations based on data from the Greek Ministry of Development.

TABLE 1 - THE IMPACT OF DEREGULATION ON RETAIL PRICES (TREATMENT ONLY)

	(1)	(2)	(3)	(4)	(5)
Estimation method	OLS	FE	FE	FE	FE
Dependent variable	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$
Post$_t$	-0.077***	-0.061**	-0.067***	-0.075***	-0.056**
dummy=1 after 22 June 2011	(0.026)	(0.027)	(0.024)	(0.024)	(0.025)
Observations	44,606	44,606	44,606	44,606	44,606
Adjusted R^2	0.005	0.008	0.808	0.867	0.868
Clusters	56	56	56	56	56
Month FE		yes	yes		
Store FE			yes	yes	yes
Product variety FE			yes	yes	yes
Month × Product FE				yes	yes
Year-month trend and square					yes

Notes: The dependent variable is the logarithm of the retail price of product variety *i*, in store *j*, and week *t*. All regressions include binary indicators for the changes in VAT rates. Standard errors clustered at the product variety level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.
Source: Authors' calculations based on data from the Greek Ministry of Development.
.

TABLE 2 - THE IMPACT OF DEREGULATION ON RETAIL PRICES (CONTROL AND TREATMENT)

	(1)	(2)	(3)	(4)	(5)
Estimation method	OLS	OLS	FE	FE	FE
Dependent variable	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$
Treat$_i$ × Post$_t$	-0.101**	-0.100**	-0.096***	-0.064***	-0.064***
	(0.045)	(0.044)	(0.026)	(0.022)	(0.023)
Post$_t$	0.024	0.033	0.015	-0.015	0.005
dummy=1 after 22 June 2011	(0.036)	(0.035)	(0.025)	(0.020)	(0.021)
Treat$_i$	0.028	0.025			
	(0.117)	(0.117)			
Observations	56,523	56,523	56,523	56,523	56,523
Adjusted R^2	0.005	0.009	0.789	0.858	0.859
Clusters	72	72	72	72	72
Month FE		yes	yes		
Store FE			yes	yes	yes
Product variety FE			yes	yes	yes
Month × Product FE				yes	yes
Year-month trend and square					yes

Notes: The dependent variable is the logarithm of the retail price of product variety *i*, in store *j*, and week *t*. All regressions include binary indicators for the changes in VAT rates. Standard errors clustered at the product variety level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.
Source: Authors' calculations based on data from the Greek Ministry of Development.
.

TABLE 3 - THE IMPACT OF DEREGULATION ON WHOLESALE PRICES

	(1)	(2)	(3)	(4)	(5)	(6)
Estimation method	OLS	OLS	OLS	FE	FE	FE
Dependent variable	ln(Wholesale Price)$_{it}$	ln(Wholesale Price)$_{it}$	ln(Wholesale Price)$_{it}$	ln(Wholesale Price)$_{it}$	ln(Wholesale Price)$_{it}$	ln(Wholesale Price)$_{it}$
Sample	Treatment only	Control & Treatment	Control & Treatment	Control & Treatment	Control & Treatment	Control & Treatment
$Treat_i \times Post_t$		-0.156**	-0.156**	-0.244***	-0.093**	-0.095**
		(0.072)	(0.072)	(0.049)	(0.040)	(0.041)
$Post_t$	-0.099**	0.056	-0.022	0.052	-0.074*	-0.077
dummy=1 after 22 June 2011	(0.041)	(0.059)	(0.063)	(0.052)	(0.043)	(0.055)
$Treat_i$		-0.021	-0.026			
		(0.148)	(0.149)			
Observations	880	1,115	1,115	1,115	1,115	1,115
Adjusted R^2	0.007	0.012	0.028	0.787	0.910	0.911
Clusters	45	59	59	59	59	59
Month FE			yes	yes		
Product FE				yes	yes	yes
Month × Product FE					yes	yes
Year-month trend and square						yes

Notes: The dependent variable is the logarithm of the wholesale price of product variety *i* in month *t*. All regressions include binary indicators for the changes in VAT rates. Standard errors clustered at the product variety level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.
Source: Authors' calculations based on data from the Greek Ministry of Development.

TABLE 4 - THE IMPACT OF DEREGULATION ON RETAIL PRICES (ALTERNATIVE CONTROL GROUP)

	(1)	(2)	(3)	(4)	(5)
Estimation method	OLS	OLS	FE	FE	FE
Dependent variable	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$
$Treat_i \times Post_t$	-0.089***	-0.089**	-0.120***	-0.087***	-0.088***
	(0.037)	(0.038)	(0.020)	(0.017)	(0.017)
$Post_t$	0.012	0.010	0.041**	0.016	0.026
dummy=1 after 22 June 2011	(0.026)	(0.033)	(0.018)	(0.016)	(0.018)
$Treat_i$	-0.546**	-0.548**			
	(0.254)	(0.255)			
Observations	65,753	65,753	65,753	65,753	65,753
Adjusted R^2	0.118	0.119	0.931	0.954	0.954
Clusters	75	75	75	75	75
Month FE		yes	yes		
Store FE			yes	yes	yes
Product variety FE			yes	yes	yes
Month × Product FE				yes	yes
Year-month trend and square					yes

Notes: The dependent variable is the logarithm of the retail price of product variety *i*, in store *j*, and week *t*. The control group comprises of products sold in supermarkets and shown in column 3 of Table A3. All regressions include binary indicators for the changes in VAT rates. Standard errors clustered at the product variety level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.
Source: Authors' calculations based on data from the Greek Ministry of Development.

TABLE 5 - THE IMPACT OF DEREGULATION ON RETAIL PRICES (ROBUSTNESS)

	(1)	(2)	(3)	(4)	(5)
Estimation method	FE	FE	FE	FE	FE
Dependent variable	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$
Sample	Control & Treatment	Placebo	Merged Retail & Wholesale data	Merged Retail & Wholesale data	Merged Retail & Wholesale data
$Treat_i \times Post_t$		0.027	-0.055**	-0.020	
		(0.024)	(0.027)	(0.013)	
$Treat_i \times Post_t \times Fruit_j$	-0.070*				
	(0.036)				
$Treat_i \times Post_t \times Vegetable_j$	-0.063***				
	(0.023)				
$Treat_i \times Post_t \times$ Street $market_j$					-0.027
					(0.026)
$Treat_i \times Post_t \times$ Super $market_j$					-0.102***
					(0.038)
ln(Wholesale Price)$_{it}$				0.526***	
				(0.024)	
$Post_t$	0.004	-0.014	-0.010	0.027*	-0.016
dummy=1 after 22 June 2011	(0.021)	(0.024)	(0.024)	(0.014)	(0.024)
Observations	56,523	23,091	43,159	43,159	43,159
Adjusted R^2	0.858	0.805	0.866	0.887	0.867
Clusters	72	71	59	59	59
Store FE	yes	yes	yes	yes	yes
Product variety FE	yes	yes	yes	yes	yes
Month × Product FE	yes	yes	yes	yes	yes
Year-month trend and square	yes	yes	yes	yes	yes

Notes: The dependent variable is the logarithm of the retail price of product variety *i*, in store *j*, and week *t*. In column 2, the sample includes only observations before 22 April 2011. In columns 3-5, the sample includes only products for which data on wholesale prices is available. All regressions include binary indicators for the changes in VAT rates. Standard errors clustered at the product variety level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.
Source: Authors' calculations based on data from the Greek Ministry of Development.

TABLE 6 - THE IMPACT OF DEREGULATION ON RETAIL PRICES (SELECTED PRODUCTS)

	(1)	(2)	(3)
Estimation method	FE	FE	FE
Dependent variable	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$
$Treat_i \times Post_t$	-0.113***		
	(0.030)		
$Treat_i \times Post_t \times$ Street $market_j$		-0.032	
		(0.042)	
$Treat_i \times Post_t \times$ Super $market_j$		-0.245***	
		(0.032)	
$Treat_i \times Post_t \times Low_i \times$ Super $market_j$			-0.250***
			(0.031)
$Treat_i \times Post_t \times High_i \times$ Super $market_j$			-0.238***
			(0.036)
$Treat_i \times Post_t \times Low_i \times$ Street $market_j$			0.006
			(0.018)
$Treat_i \times Post_t \times High_i \times$ Street $market_j$			-0.136***
			(0.021)
$Post_t$	-0.013	-0.017	-0.003
dummy=1 after 22 June 2011	(0.033)	(0.034)	(0.038)
Observations	14,075	14,075	14,075
Adjusted R^2	0.876	0.879	0.880
Clusters	19	19	19
Store FE	yes	yes	yes
Product variety FE	yes	yes	yes
Month FE	yes	yes	yes
Year-month trend and square	yes	yes	yes

Notes: The dependent variable is the logarithm of the retail price of product variety *i*, in store *j*, and week *t*. The sample includes all the products assigned to the control group (see Table A1) but only lettuces ("Low") and peaches ("High") in the tretment group. All regressions include binary indicators for the changes in VAT rates. Standard errors clustered at the product variety level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.
Source: Authors' calculations based on data from the Greek Ministry of Development.

TABLE 7 - THE IMPACT OF THE LEVEL OF REGULATED MARKUPS

	(1)	(2)	(3)
Estimation method	FE	FE	FE
Dependent variable	ln(Wholesale Price)$_{it}$	ln(Retail Price)$_{ijt}$	ln(Retail Price)$_{ijt}$
Treat$_i$ × Post$_t$ × Low markup regulation$_j$	-0.147***		-0.086**
Wholesale markup regulation ≤ 10%	(0.047)		(0.036)
Treat$_i$ × Post$_t$ × High markup regulation$_j$	-0.063		-0.044
Wholesale markup regulation > 10%	(0.043)		(0.028)
Treat$_i$ × Post$_t$ × Low markup regulation$_j$		-0.066*	
Retail markup regulation ≤ 30%		(0.034)	
Treat$_i$ × Post$_t$ × High markup regulation$_j$		-0.055*	
Retail markup regulation > 30%		(0.028)	
Observations	1,115	17,895	17,895
Adjusted R^2	0.899	0.897	0.897
Clusters	59	72	72
Store FE	yes	yes	yes
Product variety FE	yes	yes	yes
Month × Product FE	yes	yes	yes
Year-month trend and square	yes	yes	yes

Notes: The dependent variable is the logarithm of the wholesale (column 1) and retail (columns 2 and 3) price of product variety *i* and week (retail) or month (wholesale) *t*. All regressions include binary indicators for the changes in VAT rates. Standard errors clustered at the product variety level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

TABLE 8 - THE IMPACT OF DEREGULATION ON RETAIL PRICES (QUANTILE REGRESSIONS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable	residuals	residuals	residuals	residuals	residuals	residuals	residuals
	1^{th} percentile	5^{th} percentile	25^{th} percentile	50^{th} percentile	75^{th} percentile	95^{th} percentile	99^{th} percentile
Treat$_i$ × Post$_t$	-0.087*	-0.067*	-0.052**	-0.063***	-0.066***	-0.038*	-0.032
	(0.044)	(0.037)	(0.020)	(0.018)	(0.019)	(0.023)	(0.053)
Observations	56,523	56,523	56,523	56,523	56,523	56,523	56,523
Clusters	72	72	72	72	72	72	72

Notes: The dependent variable is the residuals of a regression of the logarithm of the retail price of product variety *i*, in store *j*, and week *t* on store, product variety, month × product fixed effects and a linear and quadratic trend measured in months including binary indicators for the changes in VAT rates. Standard errors clustered at the product variety level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.
Source: Authors' calculations based on data from the Greek Ministry of Development.

APPENDIX 1

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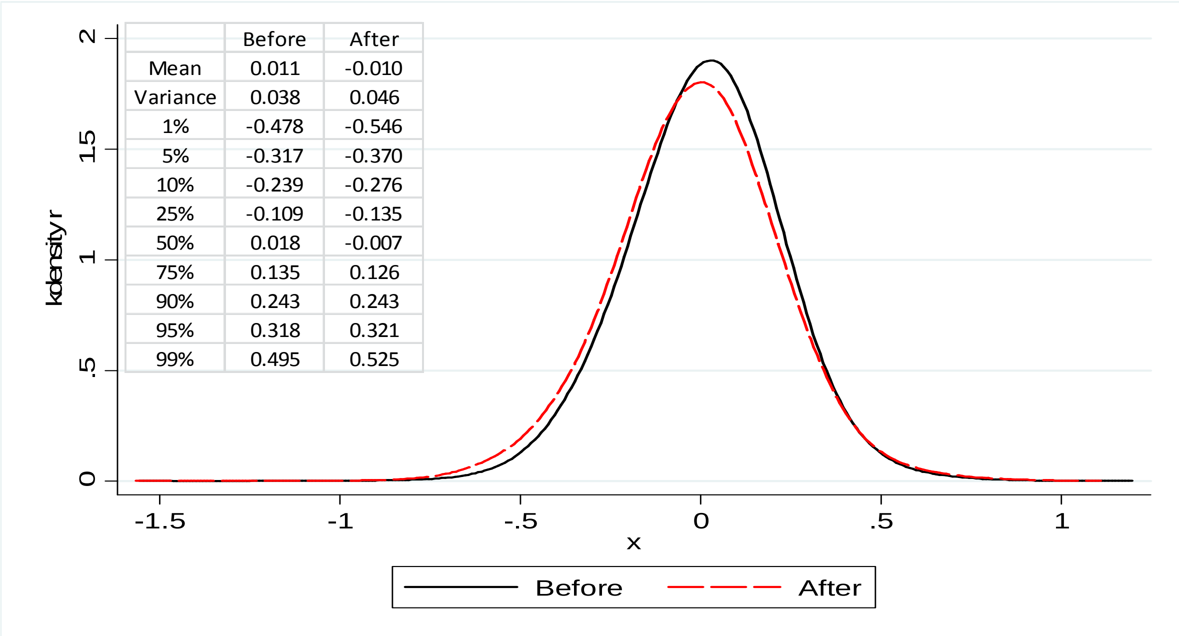
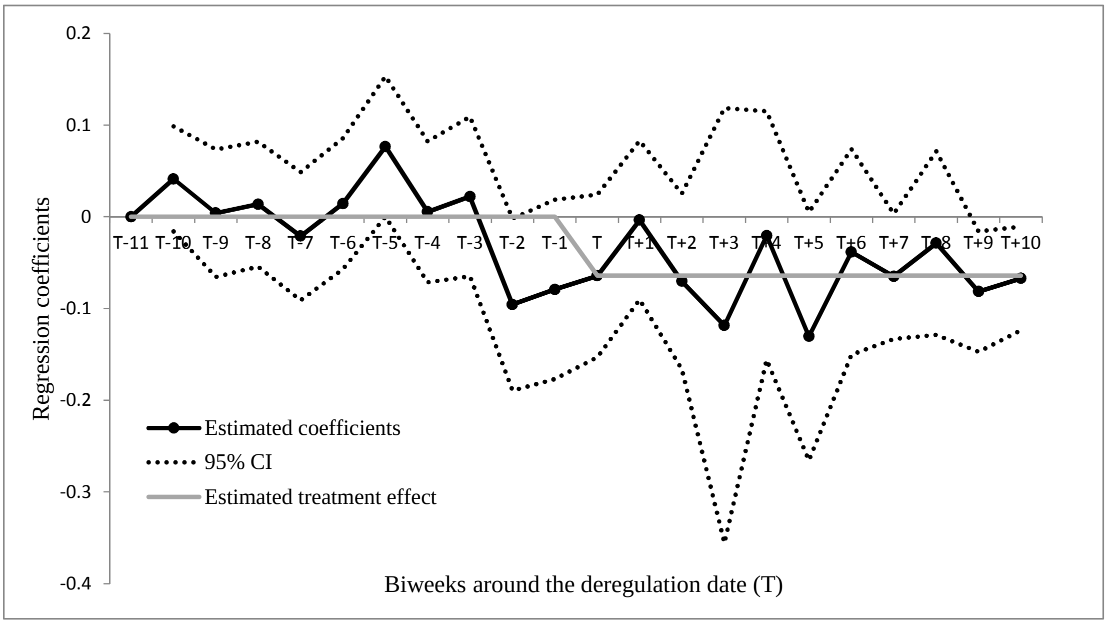
FIGURE A1: THE DISTRIBUTION OF RETAIL PRICES BEFORE AND AFTER DEREGULATION (TREATMENT GROUP)



	Before	After
Mean	0.011	-0.010
Variance	0.038	0.046
1%	-0.478	-0.546
5%	-0.317	-0.370
10%	-0.239	-0.276
25%	-0.109	-0.135
50%	0.018	-0.007
75%	0.135	0.126
90%	0.243	0.243
95%	0.318	0.321
99%	0.495	0.525

Notes: The figure plots the distribution of residuals in the treatment group one year before ("Before") and one year after the policy change ("After"). The residuals come from a regression of the logarithm of the retail price of product variety *i*, in store *j*, and week *t* on store, product variety, month × product fixed effects and a linear and quadratic trend measured in months, and binary indicators for the changes in VAT rates. Sample statistics are reported in the top left corner.
Source: Authors' calculations based on data from the Greek Ministry of Development.

FIGURE A2: DYNAMIC RETAIL PRICE RESPONSE TO DEREGULATION



Notes: Figure A1 plots the regression coefficients from model (2), capturing the dynamic impact of deregulation on the logarithm of retail prices. Each period corresponds to two weeks. The period denoted by T includes the first two weeks following the policy change. The 95 percent confidence interval is based on standard errors clustered at the product variety level. Estimated coefficients are reported in Table A4.

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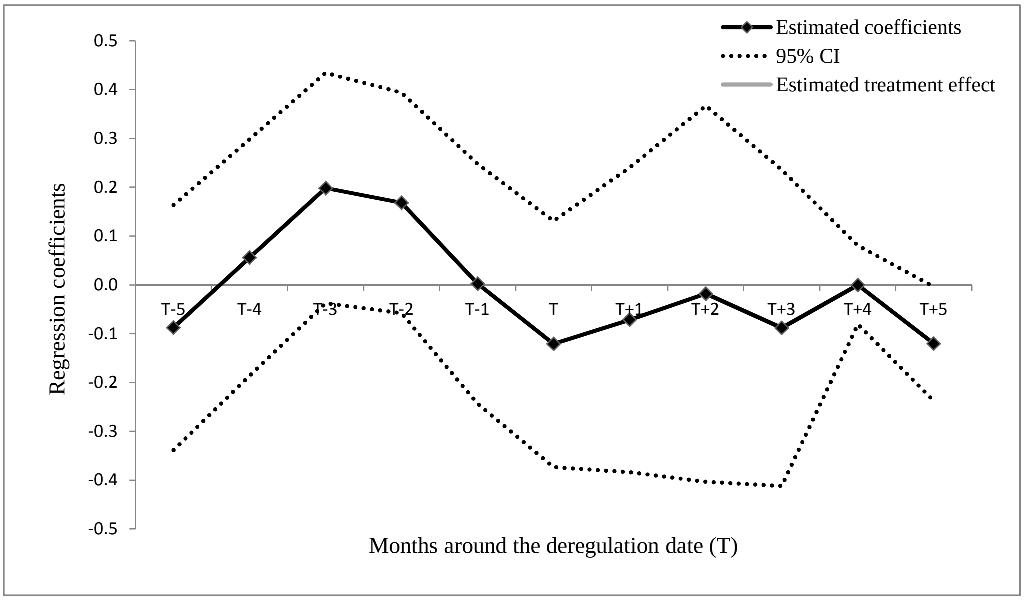
FIGURE A3: DYNAMIC WHOLESALE PRICE RESPONSE TO DEREGULATION



Notes: Figure A2 plots the regression coefficients from model (2), capturing the dynamic impact of deregulation on the logarithm of wholesale prices. Each period corresponds to one month. The period denoted by T includes the first month following the policy change. The 95 percent confidence interval is based on standard errors clustered at the product variety level. Estimated coefficients are reported in Table A5.

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TABLE A1- MAXIMUM WHOLESALE AND RETAIL MARKUPS

Product	Wholesale maximum markup	Retail maximum markup (supermarkets and grocery stores)	Retail maximum markup (street markets)
Potato	8%	25%	23%
Dry onions	10%	20%	17%
Artichoke, cucumber, tomatoes, strawberry	10%	25%	22%
Zucchini, cauliflower, beetroot, lettuce, spinach, cabbage, broccoli, greens, leek, peas, carrots, fresh onions, peppers, okra, eggplant	10%	30%	27%
Apricot	10%	35%	32%
Peach	10%	35%	30%
Grapes, beans	12%	28%	25%
Bananas	12%	30%	27%
Zucchini, cauliflower, beetroot, lettuce, spinach, cabbage, broccoli, greens, leek, peas, carrots, fresh onions, peppers, okra, eggplant	12%	35%	32%

Source: Ministerial decision A2-1045 (Gazette B' 1502/22-6-2011)

TABLE A2 - TEST OF MEANS FOR REGULATED AND UNREGULATED PRODUCTS

Estimation method	(1) Unregulated 2011	(2) Regulated 2011	(3) p-value Ha: diff != 0	(4) Unregulated 2006-2011	(5) Regulated 2006-2011	(6) p-value Ha: diff != 0
Cultivation area (1000 hectares)	9.680	9.042	0.938	11.536	9.725	0.845
	(4.407)	(3.050)		(11.536)	(3.437)	
Harvested production (1000 tonnes)	266.940	158.828	0.413	260.176	269.697	0.975
	(155.196)	(45.992)		(158.902)	(114.702)	
Yield (100 kg/hectares)	167.560	211.584	0.512	161.248	207.063	0.506
	(26.925)	(26.053)		(27.385)	(25.949)	

Notes: Standard errors are reported in parenthesis below means. Unregulated group includes: apples, pears, lemons, oranges and mandarins. Regulated group includes products affected by markup regulation: apricots, atrichokes, beans, beetroot, berries (exl strawberries), beans, cabbage, carrot, cauliflower, broccoli, celery, cherries, courgettes, cucumbers, eggplants, peas, figs, garlic, leeks, lettuces, melons, nectarines, onions, peaches, peas, plums, potatoes, peppers, spinach, strawberries, sweet lupins, tomatoes, table grapes, watermelons.
Source: EUROSTAT, Crops products - annual data [apro_cpp_crop]
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TABLE A3- PRODUCT CLASSIFICATION

Treatment Group	Control Group	Super Market Control Group
Apricot	**Apple**	**Beer**
Apricot (Diamantopoulou)*	Apple (Golden)*	Amstel can 6x330
Apricot (common)*	Apple (Golden-imported)	Kaiser can 6X330
Artichoke	Apple (Grand Smith)*	**Biscuits**
Artichoke (common)*	Apple (Grand Smith-imported)	Pti beur Papadopoulou 225gr
Artichoke (imported)	Apple (Starkin)*	**Brandy**
Banana	Apple (Starkin-imported)	Metaxa 3* 700ml
Beans	**Lemon**	**Cereals**
Bean Barbouni*	Lemon (common)*	Kellog's Special K 500gr
Bean Barbouni (imported)	Lemon (imported)	**Condensed milk**
Bean Tsaouli*	**Mandarins**	Nounou 410gr
Beetroot	Clementin mandarin*	Nounou light 170gr
Broccoli	Clementin mandarin (imported)	**Flour**
Broccoli (common)*	Mandarin (common)*	Giotis flour 1kg
Broccoli (imported)	**Orange**	**Pasteurised milk**
Cabbage	Valencia orange	Delta full fat 3.5% 1lt
Carrot	Orange (navalines-merlin)*	Nounou family full fat 1lt
Cauliflower	**Pear**	Olympos full fat 1lt
Cauliflower (common)*	Pear (imported)	Chocolate milk Milko
Cauliflower (imported)	Pear Krystali*	**Rice**
Cherry	Pear Krystali (imported)	Carolina 3A 500gr
Cherry (petrokeraso)*		**Rum**
Cherry (crisp)*		Bacardi 1lt
Cucumber		**Spaghetti**
Cucumber small*		Misko 500gr
Cucumber large*		**Toast bread**
Eggplant		Karamolegkos
Tsakonian eggplant*		**Toast**
Eggplant (common)*		Friggania papadopoulou 510gr
Eggplant (imported)		**Whisky**
Fresh onion		Jonnie Walker red 1lt
Grapes		**Wine**
Grape (common)*		Kourtaki retsina
Sultana grapes (raisin)*		
Greens		
Kiwi		
Kiwi (common)*		
Kiwi (imported)		
Leek		
Lettuce		
Lettuce (common)*		
Lettuce (brown)*		
Melon		
Melon (common)*		
Melon (Argitis)*		
Melon (Thrace)*		
Nectarine		
Okra		
Thick okra*		
Fine okra*		
Onion		
Onion (common)*		
Onion (imported)		
Peach		
Peas		
Pepper		
Pepper (longish)*		
Florinis peppers*		
Green pepper (large)*		
Green pepper (large-imported)		
Potato		
Potato (common)*		
French potato		
Potato (imported)		
Potato Cyprus		
Spinach		
Strawberry		
Tomato		
Tomato (common)*		
Tomato (imported)		
Watermelon		
Zucchini		
Zucchini*		
Zucchini (imported)		

Notes: The table reports information on the classification of all the products (and their varieties) used in the estimation. All products were also covered in the wholesale data. A star (*) indicates the product varieties matched in the wholesale data.

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TABLE A4 - DYNAMIC IMPACT OF DEREGULATION ON RETAIL PRICES

Estimation method	FE
Dependent variable	ln(Retail Price)$_{ijt}$
Treat$_i$ × Post$_{t-10}$	0.041
	(0.029)
Treat$_i$ × Post$_{t-9}$	0.004
	(0.035)
Treat$_i$ × Post$_{t-8}$	0.014
	(0.034)
Treat$_i$ × Post$_{t-7}$	-0.021
	(0.035)
Treat$_i$ × Post$_{t-6}$	0.014
	(0.036)
Treat$_i$ × Post$_{t-5}$	0.076*
	(0.038)
Treat$_i$ × Post$_{t-4}$	0.005
	(0.039)
Treat$_i$ × Post$_{t-3}$	0.022
	(0.044)
Treat$_i$ × Post$_{t-2}$	-0.096**
	(0.047)
Treat$_i$ × Post$_{t-1}$	-0.079
	(0.049)
Treat$_i$ × Post$_t$	-0.064
	(0.044)
Treat$_i$ × Post$_{t+1}$	-0.004
	(0.043)
Treat$_i$ × Post$_{t+2}$	-0.070
	(0.048)
Treat$_i$ × Post$_{t+3}$	-0.119
	(0.119)
Treat$_i$ × Post$_{t+4}$	-0.021
	(0.068)
Treat$_i$ × Post$_{t+5}$	-0.130*
	(0.068)
Treat$_i$ × Post$_{t+6}$	-0.038
	(0.056)
Treat$_i$ × Post$_{t+7}$	-0.065*
	(0.034)
Treat$_i$ × Post$_{t+8}$	-0.029
	(0.050)
Treat$_i$ × Post$_{t+9}$	-0.082**
	(0.033)
Treat$_i$ × Post$_{t+10}$	-0.067**
	(0.028)
Observations	56,523
Adjusted R^2	0.861
Clusters	72
Store FE	yes
Product variety FE	yes
Month x Product FE	yes
Year-month trend and square	yes

Notes: The dependent variable is the logarithm of the retail price of product variety *i*, in store *j*, and week *t*. Each period corresponds to two weeks. The period denoted by T includes the first two weeks following the policy change. All regressions include binary indicators for the changes in VAT rates. Standard errors clustered at the product variety level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

Source: Authors' calculations based on data from the Greek Ministry of Development.

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TABLE A5 - DYNAMIC IMPACT OF DEREGULATION ON WHOLESALE PRICES

Estimation method	FE
Dependent variable	ln(Wholesale Price)$_{it}$
$Treat_i \times Post_{t-5}$	-0.088
	(0.125)
$Treat_i \times Post_{t-4}$	0.056
	(0.121)
$Treat_i \times Post_{t-3}$	0.198*
	(0.118)
$Treat_i \times Post_{t-2}$	0.168
	(0.113)
$Treat_i \times Post_{t-1}$	0.002
	(0.123)
$Treat_i \times Post_t$	-0.121
	(0.126)
$Treat_i \times Post_{t+1}$	-0.071
	(0.156)
$Treat_i \times Post_{t+2}$	-0.018
	(0.192)
$Treat_i \times Post_{t+3}$	-0.088
	(0.162)
$Treat_i \times Post_{t+4}$	-0.000
	(0.040)
$Treat_i \times Post_{t+5}$	-0.121**
	(0.058)
Observations	764
Adjusted R^2	0.936
Clusters	59
Product FE	yes
Month x Product FE	yes
Year-month trend and square	yes

Notes: The dependent variable is the logarithm of the wholesale price of product variety *i* in month *t*. Each period corresponds to one month. The period denoted by T includes the first month following the policy change. All regressions include binary indicators for the changes in VAT rates. Standard errors clustered at the product variety level are reported in parenthesis below coefficients: *significant at 10%; **significant at 5%; ***significant at 1%.

Source: Authors' calculations based on data from the Greek Ministry of Development.