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Supermarkets and Gasoline: An Empirical Study of Bundled Discounts

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Abstract

Many supermarkets offer grocery-gasoline bundled discounts, whereby a supermarket customer whose grocery purchase exceeds a certain dollar amount is offered a gasoline price discount. I use the difference-in-differences method and an ideal gasoline price data set to study such programs' effects on retail gasoline competition in a specific market. A program's effect on a gasoline station depends on the features of the program, whether the site is operated by a supermarket, its distance from the nearest supermarket, and the time horizon. How the estimated effects vary with program features and station characteristics helps explain why such programs are offered.

Key Words: bundled discount, supermarkets, gasoline, competition, advertising

JEL Classification Numbers: K21, L4

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1. Introduction

Supermarkets have transformed the retail gasoline industry in several countries. For example, supermarkets accounted for 56 percent of the gasoline sales in France, 28 percent in the United Kingdom, and 44 percent in Australia (Gauthier-Villars 2004; ACCC 2007). In the United States, supermarkets and discount stores started to sell gasoline in the late 1990s, and they captured 5.9 percent of the retail gasoline sales nationwide by the end of 2002 (FTC 2004). A closely related development is that many supermarkets offer grocery-gasoline bundled discount programs, whereby customers whose grocery purchases exceed a certain dollar amount are offered discounts off the pump prices of some gasoline sites.[1] The fact that supermarkets and discount stores offer gasoline price discounts has led several US states to introduce, modify, or enforce what are called sales-below-cost laws.[2]

How do supermarkets' grocery-gasoline bundled discount programs affect competition in gasoline markets? Why do supermarkets sell gasoline and offer such bundled discount programs? In this paper, I take a first step toward addressing these two questions. My emphasis is on the first question.

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[1] Giant Eagle, for example, advertises a "fuelperks!" program that gives its customers 10 cents off per gallon for every $50 in grocery purchases. Many major supermarkets in the United States offer similar bundled discount programs, including Albertsons, BI-LO, Harris Teeter, Jewel-Osco, Kroger, Roundy's, Safeway, Shaw's, Stop & Shop, and Winn-Dixie.

[2] See June 2004 FTC staff letter to the Honorable Gene DeRossett, Michigan House of Representatives, at http://www.ftc.gov/os/2004/06/040618staffcommentsmichiganpetrol.pdf. A supermarket in Colorado was ordered by a court to end its grocery-gasoline bundled discount program because the court found that the gasoline price discount violated Colorado's sales-below-cost law. *Parish Oil Co, Inc. v. Dillon Companies, Inc.*, 2006 WL 2632566 (D. Colo. 2006).

The issue of bundled discounts has recently received considerable interest in the antitrust literature (e.g., Kobayashi 2005a; Greenlee and Reitman 2005; Nalebuff 2005; Rubinfeld 2005; Brennan 2008; Carlton et al. 2008; Greenlee et al. 2008). However, this literature is essentially theoretical. Recognizing this fact, the Antitrust Modernization Commission has called for empirical research on bundled discounts. In its Report and Recommendations, the commission writes that "[t]he Courts, the antitrust agencies, and antitrust practitioners generally would benefit from a more thorough and empirically based understanding of the likely competitive effects of bundled discounts in a variety of settings" (AMC 2007, 100).

There is a large, broader body of literature on bundling, but these studies are largely theoretical as well. In a comprehensive survey of the bundling literature, Kobayashi (2005b) identifies only two empirical papers that study the competitive effect of bundling: one by Hass-Wilson (1987), who compares the prices of contact lenses in states with and without lens-optometrist tying requirements, and the other by Hausman and Sidak (2005), who studies mandatory unbundling of services and facilities in telecommunications.

I study the Perth metropolitan area of Western Australia. This market allows me to credibly identify the short-run marginal effects of three sequential grocery-gasoline bundled discount programs and the combined long-run effect of the three programs on retail gasoline competition. All three programs in the market offered customers a gasoline price discount of 4 Australian cents per liter (about 15 cents per gallon) if their supermarket grocery purchases exceeded a certain dollar amount. Several features of the programs and the market setting made the identification strategy credible and the results interesting.

A major feature is that all three programs were offered through existing gasoline sites. That is, the bundling programs did not change the location or physical characteristics or the wholesale supplier of the gasoline sites involved. The only "treatment" to a bundling gasoline site or its competing sites is the bundling program itself. Unaffected gasoline sites, those that are far away, are the comparison sites.

I implement the difference-in-differences identification strategy with an essentially ideal gasoline price data set. I observe the daily pump price of every gasoline site in the Perth area for a 65-month period. In addition to identifying the price level effects, I can directly observe the changes in gasoline firms' dynamic pricing behavior before and after the introduction of each bundling program because of the presence or absence of conspicuous regular gasoline price

cycles, which are well characterized by the Edgeworth price cycle equilibrium in Maskin and Tirole's (1988) dynamic oligopoly model.[3]

The three bundled discount programs I study differ in whether supermarkets operated the bundling gasoline sites and in scale (i.e., the number of gasoline sites involved). The two major supermarket chains in the market, Coles and Woolworths, each offered a discount program by purchasing the right to operate and cobrand some gasoline sites, and the independent supermarkets in the market offered their program without operating or cobranding the gasoline sites involved. These variations in program characteristics are representative of those observed in the United States.[4]

The two supermarket chains, upon offering their programs, each cut significantly the pump prices at the gasoline sites in their programs, thus intensifying local or market-wide competition, depending on the scale of the program. In the long run, those bundling sites' pump price cuts are smaller but are still significant. Moreover, supermarket-operated bundling gasoline sites that are located closer to a supermarket of the same brand tend to post more competitive pump prices. The gasoline sites involved in the independent supermarkets' program did not cut their pump prices upon offering bundled discounts and had little effect on gasoline competition.

Several bundling theories are helpful for explaining the grocery-gasoline bundled discount programs, but none can capture all the program features or predict all of my findings. One such theory is loss leader advertising, which captures the fact that the bundled discount is applied specifically to the gasoline price, which is easier to advertise than grocery prices, and that a minimum grocery purchase is required. Loss leader advertising can also explain the finding that supermarket-operated gasoline sites located closer to a supermarket of the same brand posted more competitive pump prices: gasoline is a more effective loss leader if supermarkets and gasoline sites are closer. Gans and King's (2006) model, which emphasizes the pricing externality between two firms that together offer a bundled discount but are otherwise

[3] Wang (2009) and de Roos and Katayama (2013) study the gasoline price cycles in the Perth market. Regular gasoline price cycles also occur in Canada (e.g., Eckert 2003 and Noel 2007) and in the United States (e.g., Lewis 2012 and Zimmerman et al. 2013).

[4] In the United States, some supermarkets (e.g., Giant Eagle, Jewel-Osco, and Stop & Shop) offer grocery-gasoline bundled discount programs through gasoline sites they operate, while others (e.g., BI-LO, Roundy's, Shaw's, and Winn-Dixie) have formed partnerships with existing gasoline firms. For example, Shaw's supermarkets, Dunkin' Donuts, and two gasoline firms, Gulf and Irving, once formed an alliance to offer a discount program in the New England area. Neither Shaw's nor Dunkin' Donuts was involved in the operation of the Gulf or Irving stations.

unrelated, helps understand why the independent supermarkets' program had little effect on competition. Price discrimination and increasing efficiency may also explain aspects of the observed price effects. My findings are inconsistent with the argument that these bundling programs are predatory.

This paper is related to Zimmerman (2012), who finds that the entry of supermarkets and discount stores into gasoline retailing in the United States lowered average state-level retail gasoline prices. He does not study bundled discount programs. My research design is similar to those used by Hastings (2004) and Taylor et al. (2010) in their studies of the effect of vertical relationships on competition in gasoline markets. Their research design was based on a single brand conversion or treatment: gasoline sites of a large, independent brand were converted into an oil brand without changes in site location or characteristics. Stations affected by the conversion were the treatment sites, and stations unaffected were the comparison sites. Different from their setting, I observe three separate programs or treatments that vary in characteristics, and I study not only the price level effects but also changes in dynamic pricing behavior.

The rest of the paper proceeds as follows. Section 2 describes the market setting, the bundled discount programs, and the data set. Section 3 studies the effects of the bundling programs on price level and dynamic pricing behavior. Section 4 discusses the potential explanations for my empirical findings. Section 5 concludes.

2. Market Setting, Bundling Programs, and Data

In this section, I document the structure of the Perth grocery and gasoline market and the features and timing of the bundled discount programs. My primary source of information on the bundling programs is company press releases filed with the Australian Stock Exchange.

Coles and Woolworths, both vertically integrated, were the two major supermarket chains in Australia. Before the end of 2005, Coles and Woolworths supplied about 32 percent and 31 percent, respectively, of the grocery market in Western Australia. The rest of the region's grocery market was supplied by Foodland Associated (ACCC 2008). Unlike Coles or Woolworths, Foodland did not operate all the supermarkets that it supplied. Foodland-operated supermarkets accounted for about one third of Foodland's grocery supply, and independently owned and operated supermarkets accounted for the rest (Foodland 2005 annual report).

Table 1 presents, by brand, the number of gasoline sites in the Perth market in October 2003 and in three other months. In October 2003, the Perth market had 324 traditional gasoline sites.[5] The vast majority of these gasoline sites carried four oil brands—BP (67), Caltex (87), Shell (48), and Mobil (21)—and two major independent brands, Gull (38) and Peak (20). The rest of the conventional gasoline sites carried minor independent brands or no brand at all. In addition to the conventional sites, the Perth market had 15 supermarket gasoline sites, which were owned and operated by Woolworths.

These Woolworths gasoline sites, all located next to Woolworths' supermarkets, are part of Woolworths' Australia-wide strategy of offering a grocery-gasoline bundled discount program through gasoline sites it has built or acquired since the late 1990s.[6] Woolworths offered a gasoline price discount of 4 Australian cents per liter to customers whose grocery purchases exceeded AU$30 (the equivalent of US$29 as of October 20, 2013). In practice, qualified customers receive discount vouchers that can be used at any Woolworths Plus site for fuel purchases of up to a certain quantity within a period of weeks.

I do not attempt to study the effect of this long-running bundled discount program. My focus is on three new programs to be described below.

Coles started to offer its own bundled discount program in eastern Australian states in 2003.[7] The Coles program also offered a gasoline price discount of 4 cents per liter to grocery customers whose purchases exceeded AU$30.[8] To implement its program, Coles purchased the right to cobrand about 600 Shell-branded gasoline sites in Australia into Shell-Coles Express sites. Coles operated these cobranded sites by directly setting fuel prices and employing station staff. Shell still owned the stations and acted as the exclusive fuel supplier.

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[5] Two gasoline sites on an island are not considered part of the Perth gasoline market.

[6] Woolworths and Caltex joint press release, "Caltex and Woolworths Open First Co-branded Petrol Stations," November 21, 2003.

[7] The program started in the Australian state of Victoria on July 28, 2003. Coles Myer press releases, "Fuel Discounts Are Here," July 27, 2003, and "Coles Myer–Shell Alliance to Extend Fuel Discounts to NSW, ACT & Tasmania," October 30, 2003.

[8] Coles Myer press release, "Fact Sheet on the Coles Myer Shell Alliance," May 23, 2003.

As a response to the Coles program, Woolworths expanded its program to include about 130 Caltex gasoline sites in Australia on various dates.[9] These Caltex sites were all cobranded as Caltex-Woolworths at some stage.[10] Caltex continued to be the fuel supplier to these gasoline sites, and Woolworths set the fuel prices at the cobranded gasoline sites.[11]

In the Perth market, the Caltex-Woolworths program was introduced earlier than the Shell-Coles Express program. Figure 1 shows the timeline of the discount programs that I study.

Five Caltex sites were cobranded as Caltex-Woolworths sites and started to offer bundled discounts during December 2–4, 2003, and two more were cobranded and bundled during February 26–27, 2004. The cobranding and bundling of these seven Caltex-Woolworth sites is the first program I study. A few more Caltex sites were cobranded into Caltex-Woolworths sites between June 2004 and May 2006. I do not study the short-run effects of those sites' bundling, but I study the long-run effects on most of those sites.

On March 15, 2004, 39 of the 48 Shell-branded sites in the Perth area were cobranded as Shell-Coles Express sites and started to offer bundled discounts.[12] This Coles program is the second bundling program that I study.

The site cobranding did not change station characteristics, except that the logo of Coles Express or Woolworths and signs reading "Save 4 Cents per Liter" were added. Neither Coles nor Woolworths decided to own the cobranded gasoline sites—they purchased only the right to cobrand and operate. This fact suggests that were it not for the purpose of offering the bundled discount program, the two supermarket chains may not have engaged in the business of selling gasoline at previously oil-branded sites that were not located right next to their supermarkets.

At the request of the independent supermarkets that it supplied, Foodland Associated started to offer a discount program in the Perth area in mid-June 2004.[13] Foodland offered a 4-

9 Woolworths and Caltex joint press release, "Caltex and Woolworths Open First Co-branded Petrol Stations," November 21, 2003. Most of the approximately 1,780 Caltex sites in Australia are not involved in the discount program.

10 Although the Woolworths Plus sites in the Perth market were rebranded into Caltex-Woolworths between January and April 2005, I use "Caltex-Woolworths" to refer to those sites converted from Caltex, and "Woolworths Plus" to refer to Woolworths' own gasoline sites.

11 Woolworths and Caltex joint press release, "Caltex and Woolworths Complete Co-branded Service Station Arrangement," April 28, 2004.

12 The program started on the same day in the rest of Western Australia (WA). Coles Myer press release, "WA, SA, NT Complete National Petrol Discount Roll-out," March 15, 2004.

cents-per-liter gasoline price discount to customers whose grocery purchases exceeded AU$25 at Foodland-*supplied* independent supermarkets but not at Foodland-*operated* supermarkets. Because only the independent supermarkets issued the discount vouchers, this program was really for the interest of the independent supermarkets. This Foodland program for the independent supermarkets is the third program I study.

The discount vouchers from the Foodland program were eventually accepted at about 50 gasoline sites that carried three different brands.[14] Because these stations did not change their brands, I do not know the precise dates on which they started to accept fuel discount vouchers. However, Foodland's quarterly and annual reports and various newspaper reports allow me to identify the periods during which these sites started to accept discount vouchers.

From mid-June to September 3, 2004, Foodland purchased six Mobil sites, whose locations I can identify, and allowed these sites to accept the discount vouchers issued by the independent supermarkets.[15] Foodland continued to operate those sites under the Mobil brand. This was phase 1 of the Foodland program.

Between October 2004 and January 2005, Foodland expanded its program by purchasing seven more Mobil sites.[16] Unfortunately, I do not know which Mobil sites these are. This was phase 2 of the Foodland program.

Between February and April 2005, Foodland's program was extended to 3 more Mobil sites, 20 Peak sites, and 14 BP-branded sites. Foodland purchased the 3 Mobil sites as well. The 14 BP sites were owned and operated by at least two independent gasoline firms.[17] These BP and Peak sites did not change their brands, and they were reimbursed 3 cents per liter by Foodland for accepting each 4-cents-per-liter discount voucher.[18] This was phase 3 of the Foodland program.

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13 "Foodland Launches Petrol Tie-Up," *West Australian*, June 23, 2004.

14 The list of gasoline sites is at http://www.quickstop.com.au.

15 "Foodland Pumps Up Its Fuel Discount Scheme," West Australian, September 3, 2004.

16 Foodland press releases, "Fiscal 2005 Second Quarter Sales Up 7.8%," February 11, 2005, and "Fiscal 2005 Third Quarter Sales," May 18, 2005.

17 Foodland press release, "Fiscal 2005 Third Quarter Sales," May 18, 2005.

18 This information is confirmed by the Western Australian Department of Consumer and Employment Protection via personal communication.

In November 2005, Foodland's business in Western Australia was sold to Metcash, a large grocery wholesaler. The independent supermarkets continued with the fuel discount program. In December 2006, Metcash sold the Mobil-branded sites to United Petroleum, a large independent discount gasoline retailer in Australia (Western Australia Department of Consumer and Employment Protection 2007). United Petroleum continued to be part of the fuel discount program. Unlike the Shell-Coles Express or the Caltex-Woolworth cobranding, the Mobil to United Petroleum conversion involved a complete change in station ownership, branding, operation, and wholesale supplier.

2.1 Gasoline Price Data

Because of a gasoline price reporting law,[19] I can observe the daily census of the retail pump prices for regular unleaded gas at all the gasoline sites in the Perth metropolitan area from January 1, 2003, through May 31, 2008. This ideal data set allows me to observe changes in pump prices before and after each new bundling program was introduced.

The control sites in most of the regression specifications that I estimate are 19 sites in 13 isolated outer suburbs of the Perth metropolitan area. These 19 sites were never involved in any of the bundling programs, and they were at least five miles away from any of the bundling sites. Because of these 19 sites' isolation, their average pump price during the sample period was much higher than that of the treatment sites (Table 2).

Table 2 shows the average pump prices of several groups of bundling stations and the 19 control sites in various periods. Compared with the 19 control sites, the average pump price of the 5 Caltex sites that were cobranded as Caltex-Woolworths sites during December 2–4, 2003, was lower by 3.3 cents per liter in a three-month period prior to their bundling (column 2) and by 5.4 cents per liter in a three-plus-month period immediately after their bundling (column 3). This rough before-and-after comparison suggests that Woolworths cut the pump prices of the 5 Caltex-Woolworths sites upon bundling.

Compared with the 19 control sites, the average pump price of the 39 Shell sites that were cobranded as Shell-Coles Express sites on March 15, 2004, was lower by 3.1 cents per liter prior to their bundling (column 3) and by 6.7 cents per liter after their bundling (column 4), suggesting

[19] The law, known as the 24-hour rule, requires every gasoline station in the Perth metropolitan area to report its next-day price to the government by 2 p.m. each day. For more information about this law, see http://www.fuelwatch.wa.gov.au. The price data used in this paper were downloaded from this website.

that Coles cut the pump prices of these sites upon bundling. In the long run (columns 6, 7, and 8), the price cuts by these two groups of bundling sites became smaller.

The average pump prices of the 5 Caltex sites and the 39 Shell sites were 1.6 and 1.3 cents per liter, respectively, higher than that of the 15 Woolworths Plus sites prior to their bundling (column 2), but upon bundling, the average pump prices of the 5 Caltex-Woolworths sites and the 39 Shell-Coles Express sites became 0.6 cents per liter lower (column 3) and 0.4 cents per liter higher (column 4) than that of the Woolworths Plus sites. In the long run, the pump prices of the 5 Caltex-Woolworths sites and the 39 Shell-Coles Express sites became about 0.5 and 1.3 cents per liter, respectively, higher than that of the Woolworths Plus sites.

3. Effect on Retail Gasoline Competition

Below, I study how the bundling programs affected the level of pump prices (Section 3.1) and briefly discuss the effect on dynamic pricing behavior (Section 3.2).

3.1 Econometric Model

To identify the price level effect of a bundling program, I estimate variations of the following fixed-effect difference-in-differences regression:

$$p_{i,t} = c + \beta bundlebrand_{i,t} + \gamma_1 compete^1_{i,t} + \cdots + \gamma_K compete^K_{i,t} + \alpha_i + \tau_t + e_{i,t}. \quad (1)$$

In equation (1), p_{it} is the pump price of station i on date t, and c is a constant term. The dummy variable $bundlebrand_{i,t}$ is 1 if station i, on date t, is involved in the bundling program under consideration. The dummy variables $compete^1_{i,t}$,…, $compete^K_{i,t}$ denote various groups of competing stations after they have received the treatment. For example, in most regression specifications, $compete^1_{i,t}$ is 1 if station i, on date t, is within one mile of a bundling site under consideration. Gasoline sites that did not receive the treatment (i.e., those stations that were not covered by $bundlebrand_{i,t}$, $compete^1_{i,t}$,…, and $compete^K_{i,t}$) are the comparison sites. The variables $\alpha_i, \tau_t,$ and $e_{i,t}$ denote, respectively, the station fixed effect, the date fixed effect, and the error term.

This research design allows the coefficients β and γ_k to be credibly identified. The only change to a bundling site is the bundling program itself; the location, physical characteristics, and wholesale supplier of the gasoline site remain unchanged. Gasoline sites competing with the bundling sites are indirectly affected by the introduction of the bundling program. The fixed-

effect estimator is consistent even if the locations of the bundling sites are correlated with unobservable time-invariant local market characteristics that also influence pump price.

It is useful to keep in mind the variations in the bundling programs when interpreting the empirical results. The two supermarket chains' programs each involve the offering of a fixed bundled discount as well as the cobranding of gasoline sites. The Foodland program, on the other hand, involves the offering of a fixed bundled discount but not the cobranding of gasoline sites. Both types of bundled discount programs arise endogenously in Gans and King's (2006) theoretical models of bundled discounts (see also Gans 2007).

3.1.1 The Caltex-Woolworths Program

In this section, I focus on the seven Caltex sites that had been cobranded as Caltex-Woolworths sites by late February 2004. These seven sites are located in different suburbs that do not have any Woolworth Plus sites, and they are at least 7.5 miles away from each other. The time period used to estimate equation (1) is January 1, 2003, the beginning of my sample, through March 14, 2004, the day before Coles' program started.

In this case, the dummy variable $bundlebrand_{i,t}$ is 1 if station i, on date t, carries the brand of Caltex-Woolworths. By this definition, $bundlebrand_{i,t}$ is 0 when station i carried the Caltex brand. The dummy variable $compete^{1}_{i,t}$ is 1 for the sites, on date t, that are within one mile of one of the seven Caltex-Woolworth sites. There are nine such sites. Equation (1) also includes two additional dummies that indicate gasoline sites between one and two miles away from a Caltex-Woolworths site and gasoline sites between two and three miles away from a Caltex-Woolworths site. A large number of gasoline stations were more than three miles away from any of the seven Caltex-Woolworths sites.

Model 1 of Table 3 reports the estimated results when the control group includes all of the gasoline stations that are at least three miles away. The estimated coefficient for $bundlebrand_{i,t}$ is statistically significant at the 1 percent level and indicates that Woolworths cut the pump prices of the seven Caltex sites, upon bundling, by an average of 2.75 cents per liter. The estimated coefficients for those stations within one mile and those between one and two miles are also statistically significant and indicate that those sites cut their prices by an average of 0.82 and 0.43 cents per liter, respectively. The estimated coefficient for those stations between two and three miles is not different from zero at the 5 percent significance level.

It is possible that some of the control stations may be competing with one of the Caltex-Woolworths sites even though they are at least three miles away. For example, stations near a

person's house may compete with stations near his or her workplace. It is also possible that upon expanding its bundling program, Woolworths cut the pump prices of its Woolworths Plus sites. These considerations suggest restricting the control group to the 19 gasoline sites that are in isolated outer suburbs of Perth. These 19 sites are all at least 12 miles away from any of the seven sites, so they are not expected to compete with the seven sites in any way.

Model 2 of Table 3 presents the estimated results with the 19 isolated sites as the control sites. Compared with the model 1 results, the estimated price cuts by the bundling sites and the first two groups of competitors are now bigger (in absolute value) by 0.27 to 0.30 cents per liter. This result is expected because stations that might be weakly affected are now excluded from the control group. The estimated coefficient for competitor sites between two and three miles away is still not different from zero.

The identification of the price effects in models 1 and 2 comes partly from the differential timing of the bundling of the seven Caltex sites, which were bundled on different dates. A variation of the identification strategy is to force the pre- and post-comparison to be always between the sites that received the bundling treatment and the 19 control sites. To do so, I focus only on the 5 Caltex sites that were bundled during December 2–4, 2003. To force the timing of bundling for these five sites to be the identical, I ignore all price observations on December 2 and 3.

By focusing on a single discrete change, I can also test whether Woolworths cut the pump price of its Woolworths Plus sites upon expanding its program to the Caltex-Woolworths sites. I add into equation (1) a new dummy variable $Woolworths_{i,t}$ that is 1 for a Woolworths Plus site on and after December 4, 2003, and 0 otherwise. The estimates, reported in model 3 of Table 3, are very similar to the model 2 estimates. The interesting result is that the estimated coefficient for $Woolworths_{i,t}$ is –0.54 cents per liter and is highly statistically significant, indicating that Woolworths cut the pump prices of the Woolworths Plus sites when it expanded its program.

The main findings of this section can be summarized as follows:

Finding 1: (a), after expanding its bundling program to a few previously Caltex-branded gasoline sites, Woolworths cut these sites' pump prices by about 3 cents per liter; and **(b)**, the local competitors of the Caltex-Woolworths site cut their pump prices in response, but the sizes of their price cuts were much smaller.

3.1.2 The Shell-Coles Express Program

Since 39 of the 48 Shell sites were cobranded and bundled on the same day (March 15, 2003), the pre- and post-comparison is always between the affected sites and the 19 control sites. Because of the wide geographical dispersion of the Shell-Coles Express sites, I presume that all gasoline sites in the market other than the 19 isolated sites were affected to some degree.

In this case, $bundlebrand_{i,t}$ is 1 for the 39 Shell sites after they were cobranded as Shell-Coles Express. I include six competitor groups in equation (1) to capture the differential effects of the Coles program: four groups based on distance from a supermarket site, $compete_{i,t}^{k}$, $k = 1,2,3,4$, and two groups of supermarket sites, $WoolworthsPlus_{i,t}$ and $CaltexWoolworths_{i,t}$. I separate the two groups of Woolworths sites because their reaction to the Coles program should be coordinated by Woolworths Plus and may be quite different from nonsupermarket sites' reaction. The variable $WoolworthsPlus_{i,t}$ is 1 for a Woolworths Plus site on and after March 15, 2004, and the variable $CaltexWoolworths_{i,t}$ is similarly defined.

The variable $compete_{i,t}^{1}$ is 1 for those nonsupermarket stations that are within one mile of a supermarket site (i.e., the sites that carry the brands of Shell-Coles Express, Woolworths Plus, and Caltex-Woolworths) on and after March 15, 2004. The variables $compete_{i,t}^{2}$ and $compete_{i,t}^{3}$ are similarly defined. The variable $compete_{i,t}^{4}$ is 1 for those nonsupermarket stations that are between three and five miles of a supermarket site beginning March 15, 2004.

To identify the marginal effect of the Coles bundling program, I restrict the preperiod to January 1 through March 14, 2004, a period during which Woolworths' expansion to five previously Caltex-branded sites had already taken place.[20] I also restrict the postperiod to March 15 through June 15, 2004, when the Foodland program had not yet taken place.

Model 1 of Table 4 reports the estimates. The results indicate that Coles cut the pump prices of the Shell-Coles Express sites by an average of 3.31 cents per liter. Meanwhile, Woolworths cut the average pump prices of the Woolworths Plus sites and the Caltex-Woolworths sites by 2.16 and 1.40 cents per liter, respectively. The four groups of competitor sites cut their pump prices by 0.78 to 1.1 cents per liter.

[20] Two Caltex sites were cobranded into Caltex-Woolworths sites in late February 2004. When estimating equation (1), I ignore the prices of these two sites and their competing sites (i.e., those within three miles) before their respective bundling dates.

Model 2 of Table 4 presents the estimated results when I add into equation (1) three additional dummy variables, $Mobil_{i,t}$, $BP_{i,t}$, and $Peak_{i,t}$, to separate the sites of Mobil, BP, and Peak that later offered bundled discounts from the four distance-based competitor groups. The three additional dummies are similarly defined. For example, $BP_{i,t}$ is 1 if station i is one of the 14 BP-branded stations that were later involved in Foodland's bundling program and if date t is on or after March 15, 2004. The estimated price cuts by the sites of Mobil, BP, and Peak are, respectively, 0.35, 0.26, and 0.70 cents per liter, which are smaller than the price cuts by the other nonbundling competitor sites. Because these sites' smaller price cuts are separated, the estimated price cuts by the other nonbundling competitor sites become slightly larger.

The finding that the nonbundling sites three to five miles away from a supermarket-operated gasoline site also cut their pump prices suggests that even the 19 control sites may have been affected. If so, my estimates of the Coles program's effect would be a lower bound of the true effect. To gauge the extent to which the 19 isolated sites might be affected, I compare these sites' retail prices with the potential cost of importing gasoline from Singapore. BP operates the only refinery in Western Australia, but its pricing of wholesale gasoline is constrained by potential imports from Singapore (ACCC 2007), the major refining center in the Asia-Pacific region. For example, Mobil imported its gasoline from Singapore, Gull bought most of its gasoline from BP but imported some from Singapore, and Woolworths bought gasoline from an independent importer up to the end of 2003. Caltex and Shell bought fuel from BP through contracts, and the gasoline price that they paid BP was determined by what is called the import parity pricing (IPP) method. The IPP-based import cost is exogenous of the Perth gasoline market, so it can serve as a control.

I have access to the confidential daily IPP import cost for the entire sample period.[21] I run a regression in which the dependent variable is the daily difference between the 19 isolated sites' average pump price and the IPP import cost, and the explanatory variable is a time dummy that equals 1 for March 15–September 30, 2004, and 0 for January 1, 2003–March 14, 2004. The estimate, shown in model 3 of Table 4, indicates that the 19 sites' average pump price was reduced by 0.78 cents per liter. This suggests that the estimates in models 2 and 3 are smaller than the true effects of the Coles program.

[21] The import cost data were provided by the Western Australia Department of Consumer and Employment Protection.

The main findings of this section can be summarized as follows:

Finding 2: (a), upon bundling the Shell-Coles Express sites, Coles cut their pump prices by about 3.3 cents per liter in the short run; and **(b)**, all groups of competing sites in the Perth area cut their pump prices in response, though the sizes of their price cuts vary by brands and by distance from a supermarket gasoline site.

3.1.3 The Foodland Program

As mentioned before, Foodland's bundling program differs fundamentally from the two major supermarket chains' programs in that Foodland did not operate all the bundling sites involved in its program. The Peak and BP sites involved in the program continued to set their own pump prices. Foodland operated and set the pump prices of the Mobil-branded sites, but Foodland did not operate the independent supermarkets that issued the 4-cents-per-liter discount vouchers. For these reasons, I focus on the gasoline sites involved in the program and ignore their competing sites. The findings of this section imply that Foodland's program had minimal influence on gasoline sites not involved in the bundling program.

Recall that the Foodland program proceeded in three phases. The first phase was the bundling of 6 Mobil sites between mid-June and September 3, 2004. The second phase was the bundling of 7 additional Mobil sites between October 2004 and January 2005. The third phase was the bundling of 3 more Mobil sites, 20 Peak sites, and 14 BP sites between February 1 and April 30, 2005. Because I do not know the precise dates of bundling for any of these gasoline sites, I ignore the observations during the bundling periods. For example, for the first phase, I ignore the observations between June 15 and September 3, 2004. Because I cannot separate the 7 Mobil sites bundled in phase 2 from the 3 Mobil sites bundled in phase 3, I treat the 10 Mobil sites bundled in phases 2 and 3 together.

For the first phase, the preperiod is March 15 through June 15, 2004, when Woolworths' program expansion had taken place, and the postperiod is September 4 through December 31, 2004. For this case, the dummy $bundlebrand_{i,t}$ takes the form of $Mobil_{i,t}$, which is 1 for the 6 Mobil sites on and after September 4, 2004. In this case, the only other sites I use to estimate equation (1) are the 19 isolated control sites. The estimated coefficient for $Mobil_{i,t}$, reported in model 1 of Table 5, is negative but statistically significant only at the 10 percent level.

For the 10 Mobil sites bundled in phases 2 and 3, the preperiod is March 15 through September 30, 2004, and the postperiod is May 1 through August 31, 2005. The dummy $Mobil_{i,t}$

is now 1 for the 10 Mobil sites on and after May 1, 2004. The point estimate, reported in model 2 of Table 5, is positive and not statistically significant.

For the Peak and 14 BP sites bundled in phase 3, the preperiod is March 15, 2004, through January 31, 2005, and the postperiod is May 1 through August 31, 2005. For these sites, I define two bundling dummies, one for the Peak sites ($Peak_{i,t}$) and one for the 14 BP sites ($BP_{i,t}$). The estimated coefficients, reported in model 3 of Table 5, are positive and statistically significant.

The main finding of this section can be summarized as follows:

Finding 3: some of the Mobil-branded sites cut their pump prices upon bundling while other Mobil-branded sites did not change their pump prices. The Peak sites and the 14 BP sites slightly increased their pump prices upon bundling.

3.1.4 The Long-Run Effect

In this section, I study the long-run effect of the three bundling programs. I define the long run to be the period after June 1, 2006, when regular price cycles reemerged (see section 3.2) and over three years had passed since the Coles program began. For the long-run regressions, I define the preperiod to be the first 11 month of 2003, and I ignore the period from December 1, 2003, through May 31, 2006.

To identify the long-run effect, I include in equation (1) five bundling dummies ($ColesExpress_{i,t}$, $CaltexWoolworths_{i,t}$, $Mobil_{i,t}$, $BP_{i,t}$, and $Peak_{i,t}$), one for each of the five gasoline brands involved in the three bundling programs, and two competitor dummies ($WoolworthsPlus_{i,t}$ and $Competitor_{i,t}$). These dummy variables are all similarly defined. For example, $CaltexWoolworths_{i,t}$ is 1 if station i is a Caltex-Woolworths site and time t is during a period after June 1, 2006. A total of 15 Caltex sites were cobranded into Caltex-Woolworths sites by May 2005. For simplicity, I do not include multiple nonbundling competitor dummies: $Competitor_{i,t}$ is 1 for any nonbundling sites that are within five miles of a bundling site. The control sites are the 19 isolated sites.

During my sample period, other than the bundling programs, the only other event that had a considerable influence on competition in the Perth gasoline market is the sale of the Mobil sites to United Petroleum in December 2006. I study the effect of this brand conversion in Appendix B. In this section, I ignore the price observations of the United Petroleum sites.

The estimated results are reported in model 1 of Table 6, where the long run is defined as the period from June 1, 2006, through May 31, 2007, and in model 3, where the long run is

defined as the period from June 2007 through May 2008. The estimated long-run effects on the pump prices of the Shell-Coles Express, Caltex-Woolworths, and Woolworths Plus sites are, respectively, –1.37, –2.36, and –1.13 cents per liter in model 1 and –0.85, –2.21, and –0.98 cents per liter in model 2. Though still significantly negative, these long-run effects are much smaller than the corresponding short-run effects.

In models 2 and 4 of Table 6, I examine whether the long-run price cuts by the Shell-Coles Express sites (or the Caltex-Woolworths sites) vary by their driving distances from the nearest Coles (Woolworths) supermarket. To do that, I add into equation (1) two interaction terms, the interaction between $ColesExpress_{i,t}$ and the driving distance between station i and its nearest Coles supermarket[22] and the interaction between $CaltexWoolworths_{i,t}$ and the driving distance between station i and its nearest Woolworths supermarket.

The estimated coefficients for the Shell-Coles Express–distance interaction term in models 2 and 4 are, respectively, 0.12 and 0.08 cents per liter, and both are statistically significant at the 1 percent level. These estimates indicate that the price cuts by a Shell-Coles express site is smaller by 0.12 or 0.08 cents per liter if the driving distance between the gasoline site and the nearest Coles supermarket is increased by 1 mile. The estimated coefficients for the Caltex-Woolworths–distance interaction term in models 2 and 4 are positive but are not statistically significant. Two possible reasons for the insignificance of the Caltex-Woolworths–distance interaction term are the small number of Caltex-Woolworths sites (15) and the small range of driving distances between these sites and their nearest Woolworths supermarkets (between 0.1 and 2 miles). In comparison, the number of Shell-Coles Express sites is 39 and the driving distances between these sites and their nearest Coles supermarkets range from 0.1 to 8 miles.

The estimates indicate that the average long-run price cuts by the Caltex-Woolworths sites are about 1 cent per liter larger than those of the Shell-Coles Express sites. This is consistent with the fact that the average driving distance between a Caltex-Woolworths site and the nearest Woolworths supermarket is about 1 mile, but the average driving distance between a Shell-Coles Express site and the nearest Coles supermarket is about 1.9 miles.

[22] Because $ColesExpress_{i,t}$ is 0 for any site that did not carry the brand of Shell-Coles Express, there is no need to measure the distance between non-Shell-Coles Express sites and Coles supermarkets.

Recall from Table 2 that in the long run, the average pump price of the Woolworths Plus sites is considerably smaller than that of the Caltex-Woolworths sites, which is significantly smaller than that of the Shell-Coles Express sites. All the Woolworths Plus sites are located next to Woolworths supermarkets.

The estimated long-run effects on the Mobil, BP, and Peak bundling sites are –0.61, 0.69, and –0.16 cents per liter, respectively, for the June 2006–May 2007 period. For the June 2007–May 2008 period, I do not consider the Mobil sites because they were converted into United Petroleum sites, and the estimates for the Peak and BP sites are 1.02 and –0.12 cents per liter. Recall that the short-run marginal effects of the Coles program on these sites were negative and that the short-run marginal effects of the Foodland program on these sites were positive for the Peak sites and the 14 BP sites and slightly negative or zero for the Mobil-branded sites. The long-run effect on the nonbundling sites within five miles of a bundling site is –0.55 cents per liter in model 1 and –0.14 cents per liter in model 2.

The main findings of this section can be summarized as follows:

Finding 4: (a), the estimated long-run effects on the Caltex-Woolworths sites, the Shell-Coles Express sites, and the Woolworth Plus sites are still negative, but the magnitudes of the price decreases are much smaller than the corresponding short-run effects; and **(b)**, in the long run, supermarket-operated bundling gasoline sites that are closer to a supermarket of the same brand tended to post more competitive pump prices.

3.2 Effect on Dynamic Pricing Behavior

A unique feature of this study is that in addition to identifying the effects on price levels, I also observe how the bundling programs affected dynamic price competition.

Appendix A shows the daily Perth market average pump price and the daily IPP import cost from July 1, 2003, through May 31, 2008. In the first 11 months of 2003, the Perth market average pump price exhibited regular cycles, a form of dynamic oligopoly pricing. Figure 2(a) shows a sample of these cycles, using the daily brand average pump prices of four firms. Gasoline firms hiked their prices sequentially and then decreased their prices gradually. During the first 11 months of 2003, it was always the case that one or more of the three largest gasoline brands—BP, Caltex, and Shell—hiked the price first. If one of the three largest brands did not lead a price cycle, it always hiked its price on the second day. Mobil never led and almost always hiked its price on the second day of a cycle. Woolworths Plus, Gull, and Peak hiked their prices on the second or third day of a cycle.

The Caltex-Woolworths program did not disrupt the price cycle dynamics, but the newly bundled Caltex-Woolworths sites' behavior along the price cycles became very different from the Caltex sites and similar to those of the sites of Woolworths, Gull, or Peak. The Caltex-Woolworths sites no longer hiked their prices on the first day of a cycle and they did not always follow on the second day of a cycle. This is consistent with finding 1(a), that the relative pump price level of these Caltex-Woolworths sites was significantly cut upon bundling.

The Coles program, which is much larger in scale, disrupted the gasoline price cycle dynamics. Figure 2(b) indicates that the price cycles lost regularity in April 2004. This is because Coles, unlike Shell in 2003, stopped acting as a price leader: the Shell-Coles Express sites stopped hiking price on the first day of a cycle and stopped always following on the second day. These observations are consistent with finding 2(a), that the relative pump price level of the Shell-Coles Express sites was significantly cut upon bundling.

The observation that the Caltex-Woolworths program did not disrupt price cycle dynamics but the Coles program did is consistent with finding 1(b), that only local competitors responded to Woolworths' new program, and finding 2(b), that all groups of competing sites in the Perth area cut their prices in response to the Coles program. The scale of Woolworths' new program was relatively small: only a few Caltex sites were cobranded into Caltex-Woolworths sites in late 2003 and early 2004, so this program affected only local competition and did not disrupt the market-wide price cycle dynamics. The Coles program was much larger: the vast majority of the Shell sites were cobranded into Shell-Coles Express, so this program disrupted price cycle dynamics and intensified competition throughout the Perth area.

Foodland's bundling program did not have a notable effect on pricing dynamics. The dynamic pricing behavior of Mobil, Peak, and the 14 independently owned BP-branded sites did not experience a noticeable change upon bundling.[23] This is consistent with finding 3, that these sites did not cut their pump prices significantly upon bundling.

Price cycles returned and disappeared from time to time in late 2004 and in 2005. A new pattern of price cycles emerged in May 2006, which remained in effect until April 2008. For the new price cycles, BP was almost always the first to hike prices, and Caltex was occasionally a coleader. Importantly, the Shell-Coles Express sites appeared more ready to hike their prices than they had been before. This can be seen from Figure 2(c), which shows six price cycles in

[23] Note that the 14 independent BP-branded sites were never price leaders, even before bundling.

late 2006. Woolworths Plus continued to be among the last to hike prices for nearly all cycles. These findings are consistent with finding 4(a), that the price cuts by the Shell-Coles Express sites in the long run were smaller than their cuts in the short run, and the finding from Table 2, that Shell-Coles Express sites' pump prices became higher than those at Woolworths Plus in the long run.

4. Explanations

In this section, I examine the extent to which existing theories capture the salient features of the programs and explain my empirical findings.

4.1 Loss Leader Advertising

Loss leader advertising is typically not considered part of the bundling literature, but it is a theory of the pricing of a bundle of products. The basic idea of loss leader advertising, as formalized by Lal and Matutes (1994), is that retailers advertise the price of a good (the loss leader) at a discount to attract buyers, who then also buy unadvertised goods on which retailers earn their profits. The Lal and Matutes theory emphasizes economy of scale in shopping and views loss leader advertising as a price commitment device. Their theory suggests that the loss leader product should have a relatively low advertising cost and be bought relatively often. DeGraba (2006) formalizes loss leader pricing as a price discrimination strategy in a competitive setting. His theory suggests that a product can be a loss leader if customers who purchase the product tend to buy more units of other goods than those customers who do not.

Lal and Matutes' theory captures why the grocery-gasoline bundled discount is applied specifically to gasoline price but not to grocery prices: gasoline price is much easier and cheaper to advertise than grocery prices: the price of gasoline is posted on highly visible price boards at a minimum cost. DeGraba's (2006) theory would also be applicable if supermarket customers who drive tend to purchase larger quantities of groceries than those who do not. Both theories can explain why the 4-cent-per-liter price discount is conditional on grocery purchase. For loss leader advertising to be effective, consumers must buy some amount of unadvertised goods as well. Absent a grocery purchase requirement, many consumers may buy the discounted gasoline only, especially if supermarkets and gasoline sites are not located next to each other.

The logic of the Lal and Matutes model also provides an explanation for finding 4(b), that supermarket-operated bundling gasoline sites that are located closer to a supermarket of the same brand tended to post more competitive pump prices in the long run. The idea is that

gasoline is a more effective loss leader if supermarkets and gasoline sites are nearby. For example, cutting the pump price at a Woolworths Plus site that is adjacent to a Woolworths supermarket affects the supermarket choice of two types of marginal consumers: those whose grocery purchases exceed $30 and, because of economies of scale in shopping, those whose grocery purchases are less than $30 as well. Because many Shell-Coles Express and Caltex-Woolworths sites are not adjacent to a supermarket of the same brand, cutting their pump prices affects the supermarket choice of a smaller number of buyers.

4.2 The Gans and King Model

Gans and King (2006) present a model of bundled discounts with two pairs of firms and two unrelated products. They study what happens if pairs of firms, prior to setting stand-alone product prices, can commit to a bundled discount to those consumers who buy both goods from the pair. This setup is in line with the way the grocery-gasoline bundled discounts are offered. However, they presume that the two products are identical and the discount is off the price of the bundle, so their model cannot explain why the discount is applied specifically to gasoline prices.

Bundled discount may be profitable in their model because of price discrimination: those who buy both goods from the pair are given a discount, and those who buy a single product from the pair pay a higher stand-alone price. This model makes clear predictions as to when bundled discounts may arise. The model emphasizes that once a bundled discount is offered, the stand-alone prices of two otherwise unrelated products become related, thus generating a pricing externality between the two products. The externality is internalized if two firms are integrated in that a single entity sets the stand-alone prices of both products. The model predicts that if only one pair of firms is integrated, the integrated pair offers a bundled discount, but the nonintegrated pair does not. If both pairs are integrated, neither pair offers one. What happened in the Perth market is inconsistent with these predictions: the Foodland program, in which supermarkets and gasoline firms were not integrated, appeared after the two supermarket chains' programs, in which supermarkets and gasoline firms were integrated.

However, my findings highlight the importance of a pricing externality that arises if pair of firms offering a bundled discount are not integrated. The finding that the Peak and BP sites actually increased their stand-alone pump prices upon bundling suggests that if the two major supermarket chains had not operated the gasoline sites in their programs, those sites' pump prices would not have been cut significantly upon bundling. Loss leader advertising does not work well for a pair of unintegrated firms: loss leader advertising theories presume that a single firm sets the prices of both the loss leader product and some other product.

4.3 Price Discrimination and Increasing Efficiency

Since Stigler's (1968) seminal paper, price discrimination is often cited as a reason for bundling.[24] The minimum grocery purchase requirement may be interpreted as a form of quantity discount. Gasoline price discount vouchers may also play a role similar to that of mail rebates. Consumers who buy from the bundling sites and use the 4-cent-per-liter discount voucher may be, on average, more price sensitive than those who buy from the nonbundling sites or those who buy from the bundling sites but do not use the discount voucher.

Increasing efficiency is another common reason for bundling (Evans and Salinger 2005). The grocery-gasoline bundling programs allow a bundling gasoline site to sell more gasoline. The two supermarket chains operated about 25 percent of the Perth gasoline sites in 2005 but accounted for 65 percent of the gasoline sales (Western Australia Department of Consumer and Employment Protection 2007). Because Woolworths' original discount program involves its own gasoline sites located next to its supermarkets, economies of scope in selling may arise and consumers can enjoy economies of scale in shopping. However, economies of scope and scale cannot explain the Foodland program because the gasoline firms involved were otherwise unrelated both to each other and to the supermarkets that issued the discount vouchers.

4.4 Predation

Various groups argue that supermarkets offer grocery-gasoline bundled discounts for the purpose of predation: supermarkets sell gasoline at a discount in the short run to drive small competitors out of the gasoline market so that supermarkets can charge a high gasoline price in the long run.[25] Supermarkets indeed sell gasoline at a large discount in the short run. Upon offering the 4-cent-per-liter bundled discount, Coles and Woolworths cut the stand-alone pump prices of their bundling sites significantly in the short run (findings 1(a) and 2(a)). As a result, during most months between March 2004 and May 2005, the retail prices of the supermarket-operated gasoline sites were, after the 4-cent-per-liter discount, lower than the IPP import cost.

However, the predation argument is inconsistent with finding 4(a), that the effects on the pump prices of the Caltex-Woolworths and the Shell-Coles Express sites are still negative in the long run. The 4-cent-per-liter discount was not eliminated in the long run, either. The two major

[24] Both the DeGraba (2006) model and the Gans and King model are based on price discrimination.

[25] In an older version of the predation argument in gasoline markets, major oil firms were said to be the predators (Barron et al. 1985; Blass and Carlton 2001).

supermarket chains' particularly aggressive pricing behavior in the short run can be alternatively viewed as a temporary price promotion upon entering a new product market.

In addition, the supermarkets' bundling programs had a small impact on the number of small gasoline firms in the market before regular price cycles were restored in May 2006. Peak, Gull, and Woolworths Plus posted the most competitive pump prices in 2003, and they were the last to hike their prices in each cycle. Thus, Peak and Gull could have been candidates for predation. Yet from October 2003 to May 2006, the number of Peak sites increased by three and the number of Gull sites decreased by only six (Table 1). The number of gasoline sites carrying small, independent brands or no brands decreased, but only by eight.

Finally, the logic of single-product predation may be inappropriate for a multiproduct setting (Carlton et al. 2008). Even if gasoline is priced below marginal cost, supermarkets may not incur any losses: increased grocery sales may immediately recoup any losses in gasoline sales. Hence, the more appropriate antitrust question seems to be whether the grocery-gasoline bundled discount programs are a harmful exclusionary device. The setting of supermarkets and gasoline does not fit into the standard model in which bundling may be anticompetitive. In the standard model, a monopoly firm in one market faces competition in a second market, and a bundled discount scheme offers a price discount on the monopoly product conditional on the purchase of the competitive product. Bundling or tying two products can help the monopoly firm monopolize the competitive market (Whinston 1990) or maintain its monopoly status in the first market (e.g., Carlton and Waldman 2002; Nalebuff 2004). The markets for grocery and gasoline in the Perth area are both oligopolistic, and the discount applies to the price of gasoline, the product thought to be more competitive.

5. Conclusion

A large theoretical literature considers bundling in general and bundled discounts in particular, but empirical studies of bundling are rare. In this paper, by having access to an ideal gasoline price data set, I have been able to study the competitive effects of three bundling programs on the pump prices of different groups of gasoline sites. My findings suggest that grocery-gasoline bundled discount programs offered by supermarkets that operate the bundling gasoline sites are more likely to have a significant competitive effect in retail gasoline markets, and that the size of such programs' effect on a gasoline site depends on the scale of the program, the time horizon, and the characteristics of the gasoline site.

In this paper, I have also taken an initial step in addressing the question of why supermarkets offer grocery-gasoline bundled discount programs. This step is preliminary because I do not have access to grocery price or quantity data. My evidence suggests that several existing theories may be useful for explaining the bundled discount programs. In particular, loss leader advertising captures some of the crucial features of the programs and offers a reasonable explanation for my finding that supermarket gasoline sites that were located closer to supermarkets of the same brand experienced bigger price cuts and posted more competitive pump prices. It would be fruitful for future research to collect grocery price and quantity data to identify whether gasoline price discounts promoted the sales of supermarket groceries.

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Figures and Tables

Figure 1. Timelines of the Three Bundled Discount Programs

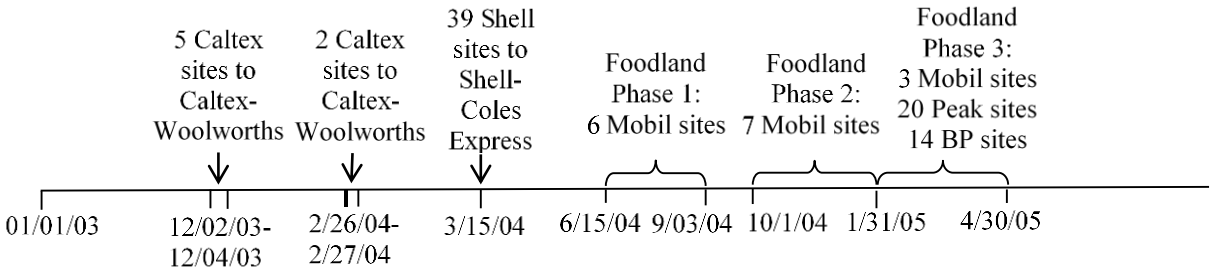
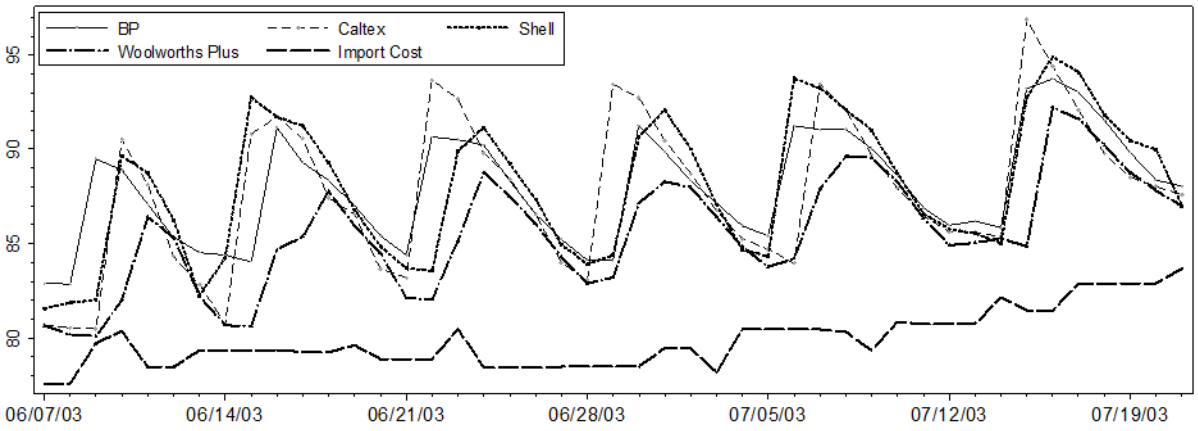


Figure 2. Daily Brand Average Retail Pump Price of Four Firms and IPP Import Cost

(a) 06/07–07/21/03



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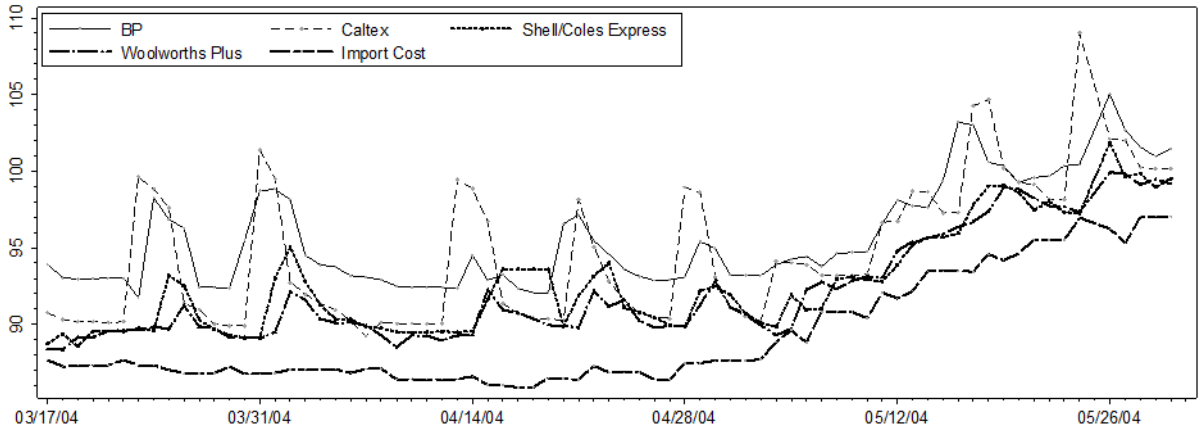


(c) 10/05–12/25/06

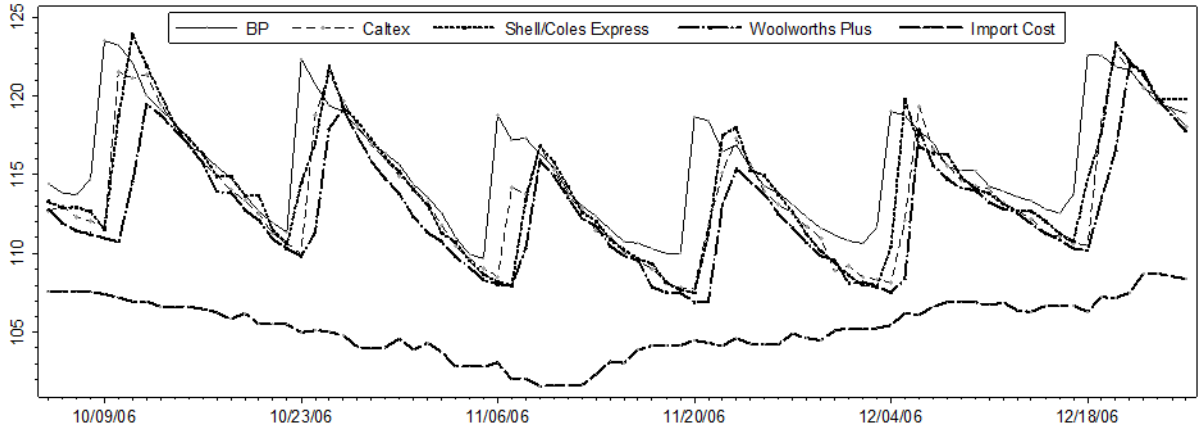


Table 1. Site Distribution, by Brand and Period

Brands	Oct 2003	May 2004	May 2006	May 2008
BP	67	70	69	65
Caltex	87	80	58	45
Caltex-Woolworths	—	7	19	24
Woolworths Plus	15	16	16	16
Shell	48	9	8	5
Shell-Coles Express	—	40	45	49
Mobil	21	20	17	0
United Petroleum	—	—	—	15
Gull	38	39	32	29
Peak	20	22	23	20
Small/no brands	43	37	35	32
Entire market	339	340	322	300

Notes: Caltex-Woolworths refers only to those sites that were converted from Caltex sites. One Coles Express site in the May 2004 column was a new site (not converted from a Shell site).

Table 2. Average Pump Prices (Cents per Liter), by Brand and Period

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Gasoline sites (post-bundling brand)	09/01/03 to 11/30/03	12/04/03 to 03/14/04	03/15/04 to 06/15/04	05/01/05 to 07/31/05	06/01/06 to 12/31/06	01/01/07 to 12/31/07	01/01/08 to 05/31/08
5 Caltex sites	90.1						
(Caltex-Woolworths)	—	89.7	93.1	104.0	122.9	124.0	139.9
39 Shell sites	89.8	92.0	—	—	—	—	—
(Shell-Coles Express)	—	—	93.6	103.7	123.8	124.8	140.9
14 BP sites	90.7	93.0	98.0	107.9	126.4	127.3	144.0
16 Mobil sites	89.1	91.2	96.1	106.7	124.2	—	—
(United Petroleum)	—	—	—	—	—	122.2	139.7
20 Peak sites	87.9	89.8	94.1	105.1	123.1	123.6	139.8
15 Woolworths Plus sites	88.5	90.3	93.2	103.6	122.4	123.5	139.5
19 isolated sites	93.4	95.1	100.3	111.6	127.9	127.9	144.2

Notes: The 5 Caltex sites were cobranded as Caltex-Woolworths sites during December 2-4, 2003. The 39 Shell sites were cobranded as Shell-Coles Express sites on March 15, 2004. The Mobil sites were converted to United Petroleum in December 2006.

Table 3. Effects of Caltex-Woolworths Program

VARIABLES	Model 1	Model 2	Model 3
$bundlebrand_{i,t}$	–2.75***	–3.02***	–3.06***
	(0.11)	(0.12)	(0.12)
$compete^1_{i,t}$	–0.82***	–1.12***	–1.18***
	(0.09)	(0.10)	(0.10)
$compete^2_{i,t}$	–0.43***	–0.71***	–0.72***
	(0.09)	(0.11)	(0.12)
$compete^3_{i,t}$	0.23*	–0.06	–0.13
	(0.13)	(0.15)	(0.16)
$Woolworths_{i,t}$	—	—	–0.54***
			(0.09)
Constant	93.58***	94.10***	91.89***
	(0.15)	(0.35)	(0.35)
Observations	145,443	22,969	20,250
R-squared	0.82	0.82	0.82
Station FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes

Notes: The treatment is the cobranding and bundling of 7 Caltex sites during December 2–4, 2003, and February 26–27, 2004. The dependent variable is daily station specific pump prices. All the nonconstant independent variables are dummies that equal 1 for the indicated groups of gasoline sites after they have received the treatment. $bundlebrand_{i,t}$ indicates the Caltex-Woolworths sites, and $compete^1_{i,t}$, $compete^2_{i,t}$, and $compete^3_{i,t}$ indicate, respectively, sites that are <1 mile, 1–2 miles, and 2–3 miles from a Caltex-Woolworths site. $Woolworths_{i,t}$ is 1 for the original Woolworths Plus sites after the treatment event occurred. The three equations in this table differ in the number of treated Caltex-Woolworths sites and in the gasoline sites in the control group. See Section 3.1.1 for details.

Robust standard errors are in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

Table 4. Effects of Shell-Coles Express Program

VARIABLES	Model 1	Model 2	Model 3
$bundlebrand_{i,t}$	–3.31***	–3.31***	—
	(0.11)	(0.11)	
$compete^{1}_{i,t}$	–1.10***	–1.21***	—
	(0.10)	(0.10)	
$compete^{2}_{i,t}$	–1.07***	–1.17***	—
	(0.10)	(0.10)	
$compete^{3}_{i,t}$	–0.78***	–0.88***	—
	(0.10)	(0.11)	
$compete^{4}_{i,t}$	–0.87***	–1.01***	—
	(0.10)	(0.10)	
$Woolworths_{i,t}$	–2.16***	–2.16***	—
	(0.12)	(0.12)	
$CaltexWoolworths_{i,t}$	–1.40***	–1.40***	—
	(0.16)	(0.16)	
$Mobil_{i,t}$	—	–0.35***	—
		(0.12)	
$BP_{i,t}$	—	–0.26**	—
		(0.12)	
$Peak_{i,t}$	—	–0.70***	—
		(0.11)	
post	—	—	–0.78***
			(0.05)
Constant	91.34***	91.39***	11.98***
	(0.19)	(0.18)	(0.14)
Observations	54,783	54,783	11,525
R-squared	0.79	0.79	0.62
Station FE	Yes	Yes	Yes
Time FE	Yes	Yes	No

Notes: The treatment is the cobranding and bundling of the 39 Shell-branded sites on March 15, 2004. The dependent variable is daily station specific pump prices for the first two equations and the daily difference between the 19 control sites' average pump price and the IPP import cost for the third equation. All the nonconstant independent variables, except for the postvariable, are dummies that equal 1 for the indicated groups of gasoline sites after they received the treatment. $bundlebrand_{i,t}$ indicates the 39 Coles Express sites. $compete^{1}_{i,t}$, $compete^{2}_{i,t}$, $compete^{3}_{i,t}$, and $compete^{4}_{i,t}$ indicate, respectively, nonsupermarket gasoline sites that are <1 mile, 1–2 miles, 2–3 miles, and 3–5 miles from a supermarket gasoline site (either Woolworths Plus or Caltex-Woolworths). $Woolworths_{i,t}$, $CaltexWoolworths_{i,t}$, $Mobil_{i,t}$, $BP_{i,t}$, and $Peak_{i,t}$ indicate, respectively, Woolworths Plus, Caltex-Woolworths, Mobil, 14 BP sites, and Peak. The variable of post is a time dummy that equals 1 for dates between January 1, 2003, and March 14, 2004, and 0 for dates between March 15 and September 30, 2004.

Robust standard errors are in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

Table 5. Effects of Foodland Program

VARIABLES	Model 1	Model 2	Model 3
$Mobil_{i,t}$	–0.24*	0.12	—
	(0.14)	(0.09)	
$BP_{i,t}$	—	—	0.19***
			(0.06)
$Peak_{i,t}$	—	—	0.30***
			(0.06)
Constant	106.28***	96.18***	96.83***
	(0.78)	(0.75)	(0.38)
Observations	5,210	9,248	22,017
R-squared	0.88	0.95	0.95
Station FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes

Notes: The treatment is the Foodland bundling program. The dependent variable is daily station specific pump prices. All the nonconstant independent variables are dummies that equal 1 for the indicated groups of gasoline sites after they received the treatment. $Mobil_{i,t}$, $BP_{i,t}$, and $Peak_{i,t}$ indicate, respectively, Mobil, the 14 BP sites, and Peak.

Robust standard errors are in parentheses.

*** p<0.01, ** p<0.05, * p<0.1.

Table 6. Long-Run Effects

VARIABLES	Model 1	Model 2	Model 3	Model 4
$ColesExpress_{i,t}$	–1.37***	–1.57***	–0.85***	–0.99***
	(0.07)	(0.07)	(0.07)	(0.08)
$ColesExpress_{i,t}$ * distance from nearest Coles supermarket	—	0.12***	—	0.08***
		(0.02)		(0.02)
$CaltexWoolworths_{i,t}$	–2.30***	–2.36***	–2.03***	–2.10***
	(0.07)	(0.10)	(0.08)	(0.10)
$CaltexWoolworths_{i,t}$* distance from nearest Woolworths supermarket	—	0.06	—	0.07
		(0.07)		(0.07)
$Woolworths_{i,t}$	–1.13***	–1.13***	–0.98***	–0.98***
	(0.08)	(0.07)	(0.08)	(0.08)
$Mobil_{i,t}$	–0.78***	–0.78***	—	—
	(0.07)	(0.08)		
$BP_{i,t}$	0.37***	0.37***	1.02***	1.02***
	(0.07)	(0.07)	(0.08)	(0.08)
$Peak_{i,t}$	–0.17**	–0.17**	–0.17**	–0.17**
	(0.07)	(0.07)	(0.07)	(0.07)
$competitor_{i,t}$	–0.55***	–0.55***	–0.14**	–0.14**
	(0.06)	(0.05)	(0.06)	(0.06)
Constant	93.42***	93.42***	93.45***	93.45***
	(0.15)	(0.19)	(0.15)	(0.15)
Observations	174,166	174,166	168,702	168,702
R-squared	0.98	0.98	0.99	0.99
Station FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes

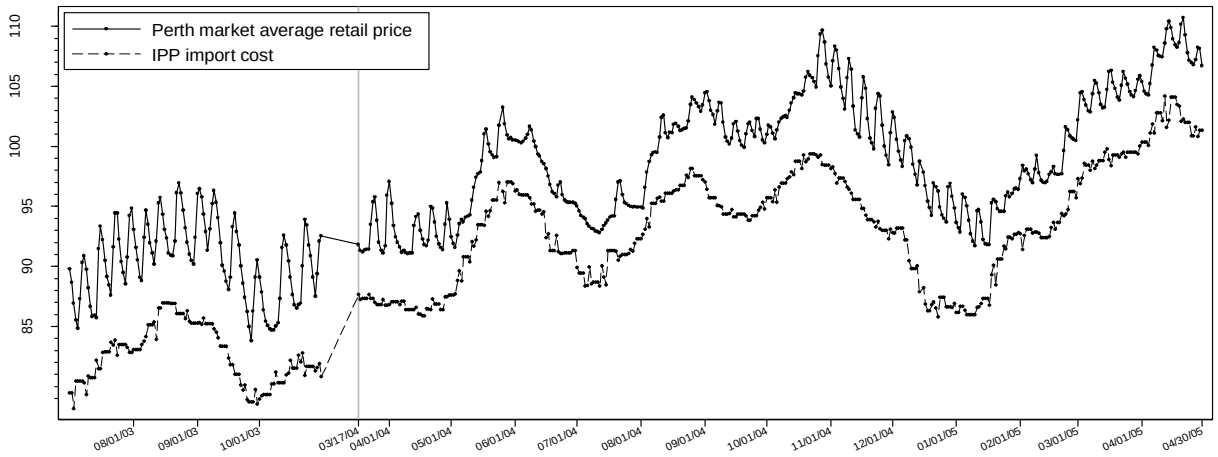
Notes: The dependent variable is daily station specific pump prices. All the nonconstant independent variables are dummies that equal 1 for the indicated groups of gasoline sites after some specific time. Competing sites refer to those that compete with any of the bundling sites.

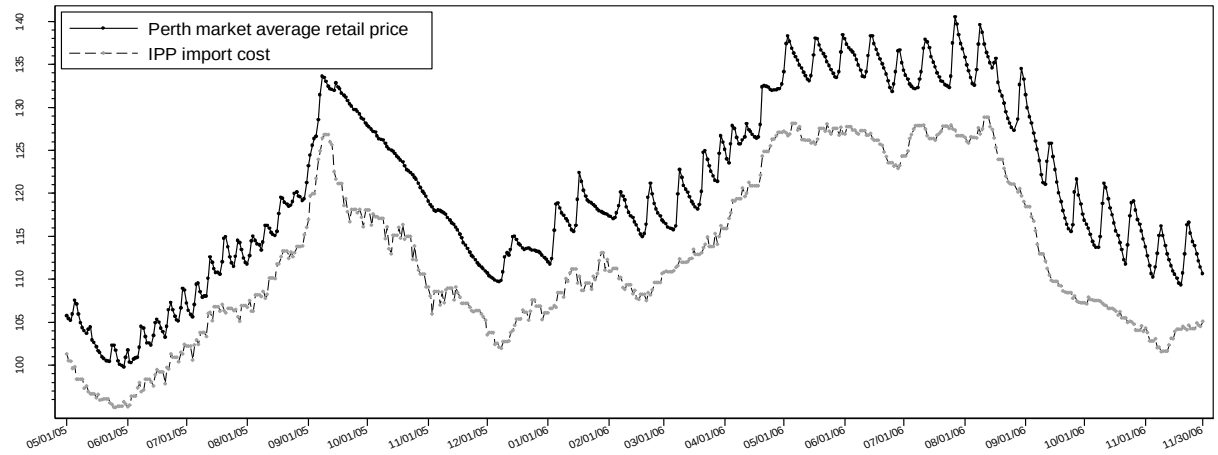
Robust standard errors are in parentheses.

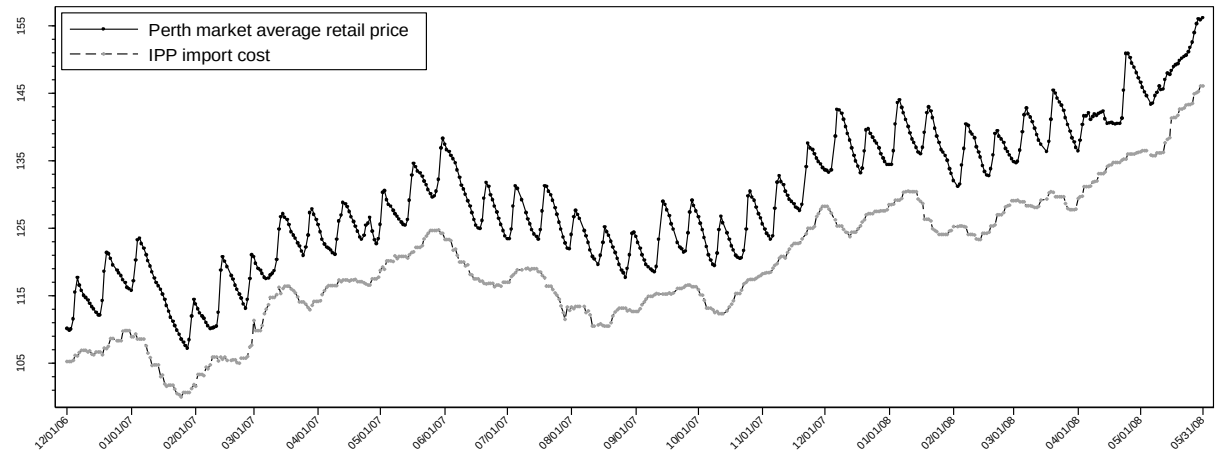
*** p<0.01, ** p<0.05, * p<0.1.

Appendices

Appendix A: Daily Perth Market Average Retail Pump Price and IPP Import Cost, July 1, 2003–May 31, 2008







Appendix B: The United Petroleum Conversion

In this appendix, I estimate the effect of the United Petroleum conversion on the pump prices of the gasoline sites that underwent the brand conversion. This conversion did not affect the price cycle dynamics, so its influence should be limited to local markets.

I use equation (1) to estimate the effect of the United Petroleum conversion. The treatment variable $bundlebrand_{i,t}$ is 1 if station i at time t carried the brand of United Petroleum and 0 otherwise. I ignore the competitor dummies in equation (1) and use the 19 isolated stations as the control sites. The sample period used to estimate this specification is June 1, 2006, through May 31, 2008.

Model 1 of Table A reports the estimates when the sample is restricted to the period from June 1, 2006, to December 31, 2007. Model 2 reports the estimates when the postperiod is restricted to the first five months of 2008. The estimated effect on the pump prices of the previously Mobil-branded sites is –1.39 cents per liter in 2007 and –0.49 cents per liter in the first five months of 2008. The estimate for 2007 is much smaller than the estimated pump price cuts by the Shell-Coles Express or Caltex-Woolworths sites in the short run, and the estimate for 2008 is smaller than the estimated price cuts by these supermarket sites in the long run.

The Mobil to United Petroleum conversion is somewhat similar to the Shell to Shell-Coles Express cobranding (or the Caltex to Caltex-Woolworths cobranding) in that the operator of the gasoline sites changed. Some readers may infer from this analogy that if they had cobranded and operated the previously oil-branded sites without offering a fixed bundled discount, Coles or Woolworths would have cut those sites' pump prices as well. However, it is unlikely that the two supermarkets chains, without offering the fixed bundled discount, would have chosen to operate those gasoline sites, most of which are not adjacent to their supermarkets. Even with the bundled discount, the two supermarket chains did not choose to own those sites. United Petroleum, on the other hand, purchased the full ownership of the Mobil-branded sites.

Table A. United Petroleum Conversion

VARIABLES	Model 1	Model 2
United	–1.39***	–0.49***
	(0.08)	(0.09)
Constant	135.37***	135.78***
	(0.37)	(0.37)
Observations	17,910	11,309
R-squared	0.91	0.96
Station FE	Yes	Yes
Time FE	Yes	Yes

Notes: The dependent variable is daily station specific pump prices.

Robust standard errors are in parentheses.

*** p<0.01, ** p<0.05, * p<0.1.