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Analysis of the Impacts of the Pennsylvania Milk Marketing Board on Fluid Milk Retail Prices and Processing Volumes [1]

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Executive Summary

This component of the *Study to Support Dairy Growth and Competiveness* reviews evidence regarding two hypothesized effects of the PMMB: price enhancement that could reduce fluid milk sales and incentives to process fluid milk products outside of Pennsylvania.

Both retail prices and supply chain sourcing, processing and distribution decisions are influenced by many factors unrelated to price regulation under the PMMB, so it is challenging to provide a definitive assessment of either with existing data. To provide a context for assessment of the impact of PMMB regulation on retail fluid milk prices, we compare retail fluid milk prices available monthly for 2007 to 2017 in Philadelphia and Pittsburgh to prices observed in three comparison markets for each of these cities, also controlling for differences due to selected transportation and processing costs. We use a detailed national-level spatial economic model to assess the incentives for farm milk assembly and packaged milk distribution across state boundaries in the Northeast assuming a perfectly competitive (cost-minimizing) supply chain for the months of March and September 2016, and compare these outcomes to data about the retail sales and farm milk actually priced under the PMMB.

Our key findings are:

- We find no definitive evidence that suggests that price regulation under the PMMB is a major cause of declining fluid milk sales or decisions about the location of fluid milk processing, and thus, no evidence that major modifications to the PMMB would result in substantive improvement in sales of fluid milk or differences in processing location for same;
- However, we note that assessment of the impacts of PMMB pricing regulation on retail fluid milk prices and fluid milk processing in Pennsylvania is difficult because many factors other than price regulation affect these outcomes and data availability is limited;
- The difference between retail fluid milk prices between Philadelphia and comparison cities (Washington, DC, Baltimore and New York City) varied over time, but the average prices during the 11-year time period analyzed are similar for the four cities for both whole and reduced-fat fluid milk;

[1] The analyses described in this document are one component of the *Study to Support Growth and Competitiveness of the Pennsylvania Dairy Industry*, which has been funded by the Pennsylvania Department of Agriculture and the Center for Dairy Excellence.

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- The difference in retail fluid milk prices between Pittsburgh and comparison markets also varied over time, but average retail fluid milk prices in Pittsburgh were generally higher (by about 10%) than in the most relevant comparison city of Cleveland. However, some of this price difference may occur due to "loss-leader" pricing strategies used by retailers in Cleveland and other comparison cities (Cincinnati and Detroit);
- Price enhancement due to the PMMB does not appear to be a major factor in the observed reduction of fluid milk sales in recent years. Our estimates suggest that the impact of retail pricing regulation under the PMMB at most accounts for less than one-fifth of the decline in fluid milk sales observed in the past five years. Limited impact reflects the fact Pennsylvania prices were either generally lower than those in comparison markets (Philadelphia) or the differences were smaller (Pittsburgh) during the past five years (when the rate of decrease in fluid sales has been somewhat larger than during 2007 to 2013);
- Spatial economic modeling indicates that there are economic incentives other than PMMB regulation for flows of farm and packaged milk across state boundaries in the Northeast and Mideast. Analysis of Pennsylvania, New York and Ohio for March and September 2016 indicated that none of these states would be "self-sufficient" in the sense that all packaged milk sales would be from farm milk produced and processed within the same state;
- Economic incentives in the absence of price regulation would imply that not all farm milk processed at fluid milk plants in Pennsylvania should come from within the state, and about 20% of packaged milk sales in Pennsylvania would be sourced outside the state during March and September 2016. Our modeling predicts that some Pennsylvania farm milk would be processed at fluid plants outside the state and shipped back to Pennsylvania as packaged milk in the absence of price regulation, so the existence of such product movements is not, in and of itself, evidence that PMMB price regulation is an underlying cause;
- A detailed assessment of farm milk assembly to fluid processing plants and distribution flows to Pennsylvania demand locations in March and September 2016 predicted based on spatial economic incentives alone indicates that about three-quarters of fluid milk sales in Pennsylvania would be from milk produced processed and distributed within the state (thus meeting basic criteria for minimum farm milk price regulation by PMMB). However, the proportion of Pennsylvania farm milk production used in these fluid milk sales was less than one-fifth of the total: 18% in March 2016 and 16% in September 2016;
- The volume of Pennsylvania farm milk priced by the PMMB has declined from 2007 to 2016, but these declines are largely in line with declines in fluid milk sales reported by the Northeast and Mideast Federal Milk Marketing Orders and for the US as a whole, which suggests that factors other than price regulation under the PMMB are more important drivers of the observed reductions in fluid milk sales[3];

[3] It is also worth reiterating that in the Phase I report, we note that the total utilization of Pennsylvania farm milk in Class I has remained roughly constant during the past decade. Although this stability cannot be attributed solely to the PMMB, it would be consistent with the fact that the PMMB has limited impact on the allocation of Pennsylvania farm milk to Class I use.

- The percentage of Pennsylvania farm milk priced under the PMMB during 2007 to 2016 is roughly consistent with the predictions of our spatial economic model, again suggesting that the impact of the PMMB on fluid milk processing locations and volumes is limited and is only one of a number of factors that will influence these outcomes;

Background and Study Objectives

The purpose of this document is to assess evidence about the impact the pricing regulation under the Pennsylvania Milk Marketing Board on retail fluid milk prices and the volume of fluid milk processing in the state. This assessment can complement a broader and more qualitative discussion of the likely impacts and benefits of the PMMB, but focuses more specifically on two issues frequently mentioned in discussion of the PMMB. This assessment is challenging because many factors other than PMMB pricing regulation will affect these two outcomes. In addition, institutional arrangements may be affected by PMMB regulation over time, which makes it difficult to separate the effects of PMMB pricing regulation from the path-dependent evolution of industry structure and its impact on outcomes. Ideally, a comprehensive analysis would integrate detailed statistical analyses with a dynamic systems simulation model that would allow a "counterfactual" assessment of what would have happened over time in the absence of PMMB regulation. Given both data and resource constraints, this more comprehensive approach was not possible for this assessment, but a more partial approach still helps to put the potential impact of the PMMB into an appropriate context.

Estimated Retail Fluid Price Impacts of the PMMB

Because the PMMB regulates minimum retail prices for fluid milk sold within Pennsylvania, this might result in price enhancement (relative to prices that would exist in the absence of the PMMB) and negatively affect demand for fluid milk (and thus, Class I utilization of Pennsylvania farm milk).

Assessment of the impacts of minimum retail price regulation under the PMMB is challenging because many factors affect the retail price of fluid milk, including but not limited to, overall supply chain costs and retail pricing strategies. Supply chain costs include milk acquisition costs (influenced by PMMB and Federal Milk Marketing Order regulation, but also the nature of service contracts, say, between cooperatives and fluid milk processors), transportation costs (based on specific farm milk origins, plant destinations and final demand locations), processing costs (determined by locational factors such as wages and utilities, as well as plant volumes). The landed cost of a gallon of fluid milk at a retailer thus depends on many factors, only some of which are directly related to price regulation. And, because of the importance and characteristics of dairy product demand, there are a variety of strategies employed by retailers with dairy product pricing.[4] Wages and utilities costs at retailers will also determine decisions about in-store product pricing, although the relationship to fluid milk prices is less direct because a typical food retailer sells many thousands of "Stock Keeping Units" (SKU, distinctly priced items). The relationship between the landed cost of packaged milk at a retailer and the retail price is also not a simple one. Retailers use different pricing strategies (for example, the so-called 'loss leader' approach would keep retail fluid milk prices close to the acquisition cost to attract customers), and also tend not to fully or immediately transmit increases or decreases in

[4] Russo, David and Edward McLaughlin. "Dairy Product Sales Determined by More Than Price". *Smart Marketing*. Cornell University, March, 1992.

underlying milk costs to consumers in the form of retail prices. If data were available on these various factors over a sufficiently-long time period, a more specific assessment of the impacts of price regulation could be undertaken, although this is still complicated by the degree to which price regulation has affected decisions that in turn determine costs and pricing strategies (so-called institutional factors).

However, because most of the data mentioned above are not readily available, we adopt the simpler approach of comparing observed retail fluid milk prices in cities in the Northeast region. This approach is less rigorous in the sense of not controlling for other factors that would influence differences in fluid milk prices among the cities—and thus, differences cannot be definitively attributed to price regulation—but we control for selected cost factors by assessing differences in the wholesale value (landed cost) of fluid milk at the cities included in the analysis using U.S. Dairy Sector Simulator (USDSS, a large-scale spatial economic model), which accounts for differences in transportation and processing costs. We can also qualitatively assess the impacts on landed per-gallon cost of differences in Class I differentials in the region. These observed price differences provide some context for assessment of the impacts of price regulation under PMMB, but can also provide a response to the question "Are retail fluid milk prices in selected Pennsylvania cities different from those in other cities in the Northeast (and Mideast) region?"

The data used for this comparison are monthly average prices for selected regional cities (Figure 1) collected and reported by Federal Milk Market Administrators in different federal order milk marketing areas. As noted in the documentation for these price series, the data are defined as:

> *As collected by Federal milk order market administrators based on a survey conducted one day between the 1st and 10th of each month (excluding Fridays and weekends) in selected cities or metropolitan areas. One outlet of the largest and second largest food store chains and the largest convenience store chain are surveyed. The price represents the most common brand in nonreturnable plastic containers[5].*

Thus, these are not comprehensive statistical assessments of all retail fluid milk prices, but attempt to capture what is in essence a weighted average price most commonly paid by consumers. Data are reported for both whole milk and reduced fat (2%) milk products. The two Pennsylvania cities included are Philadelphia and Pittsburgh, which based on demand calculations for the USDSS model in 2016, account for 30% and 24% of total Pennsylvania consumption of fluid milk, respectively. We analyze data for the 11 years from 2007 to 2017, because we believe this longer-term perspective is necessary to provide an appropriate perspective on potential impacts.

[5] "Retail Milk Prices Report", USDA, Agricultural Marketing Service, Market Information Branch, December 15, 2017. (RMP-1217).

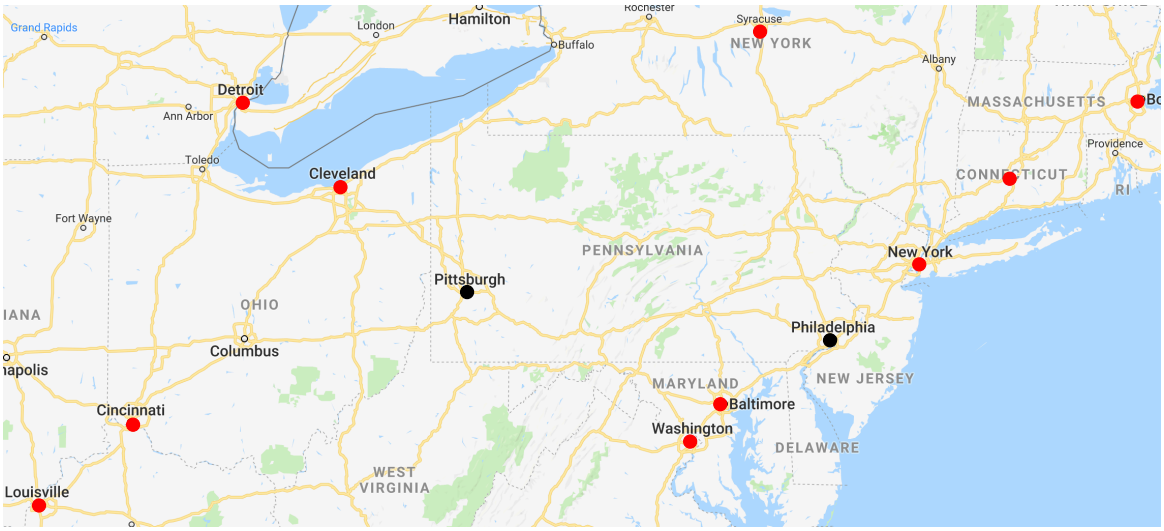

Figure 1. Cities Considered in the Fluid Milk Retail Price Comparison

Based on geographical designations defining Federal Milk Marketing Orders (the Northeast and Mideast orders), we compare Philadelphia retail fluid milk prices to those other in three other Northeast Order cities: Washington, DC, Baltimore and New York City[6]. Pittsburgh retail prices are compared to those in three other cities located in the Mideast Marketing Area, Detroit, Cleveland and Cincinnati. For context, some comparison data for additional cities (Hartford, CT, Syracuse, NY and Boston, MA, Detroit, MI, Louisville, KY) are also reported.

Based on the Class I differential zones in the region (Figure 2), differences in the gallon-equivalent Class I differential for the Philadelphia comparison cities are less than $0.01/gallon (Table 2) and generally so for Pittsburgh comparison cities also[7]. These differences assume that fluid milk was first received at a processing plant in the same price zone as the city in which the milk was received (which is likely unrealistic), but suggest that any differences in retail prices due to class I differentials are likely to be small in the key comparisons.

[6] The reported price series for New York City uses data for Fort Lee, NJ (in the New York City metropolitan area) rather than within the actual city boundaries, presumably to control for the specific nature of food retailing (smaller, higher-cost stores) within the boroughs of New York.
[7] Detroit is the exception, because its $1.80/cwt Class I differential results in a gallon-equivalent difference of $0.026/gallon from Pittsburgh.

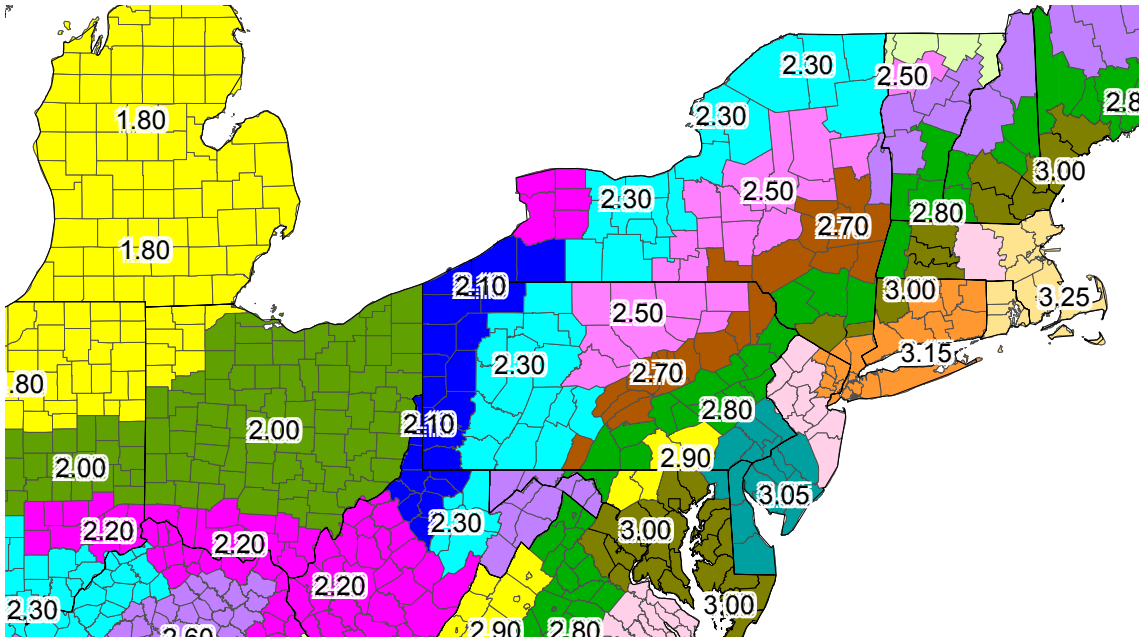

Figure 2. Federal Milk Marketing Order Class I Differential Zone Map for the Analyzed Region of the Northeast

Table 1. Class I Zone Differentials in Cities Analyzed and their Gallon-equivalent Values

Class I Differential in Zone, $/cwt	ities Analyzed in Zone	Gallon-equivalent Class I Differential Value, $/gallon	Difference from Philadelphia Zone, $/gal	Difference from Pittsburgh Zone, $/gal
1.80	**Detroit**	**0.155**	**-0.108**	**-0.026**
2.00	**Cleveland**	**0.172**	**-0.090**	**-0.009**
2.10	Pittsburgh	0.181	-0.082	--
2.20	**Cincinnati**	**0.189**	**-0.073**	**0.009**
2.30	Louisville	0.198	-0.065	0.017
2.50	Syracuse	0.215	-0.047	0.034
2.70		0.232	-0.030	0.052
2.80		0.241	-0.022	0.060
2.90		0.250	-0.013	0.069
3.00	**Baltimore, Washington, DC**	**0.258**	**-0.004**	**0.077**
3.05	Philadelphia	0.262	--	0.082
3.10		0.267	0.004	0.086
3.15	**New York City, Hartford**	**0.271**	**0.009**	**0.090**
3.25	Boston	0.280	0.017	0.099

The difference in retail fluid milk prices between Philadelphia and comparison cities for both whole and reduced fat milk has varied over time (Figures 3 and 4). From 2007 to 2010, retail fluid milk prices in Philadelphia were generally below those in the three comparison cities. From 2010 to 2015, Philadelphia prices were generally higher than those in the comparison cities (sometimes by more than $0.75/gallon), but for the last two observed years, Philadelphia prices were in general below those in comparison cities. At a minimum, these changes over time suggest that there is not a fixed relationship between retail fluid milk prices in Philadelphia and comparison cities, which in and of itself suggests that price regulation may not be the most important driver of price differences. In addition, prices in Philadelphia are not consistently higher than those in comparison cities, as might be expected if there were substantive price enhancement due to minimum price regulation. Finally, differences in average prices over time indicate different patterns for different products. On average during the 2007 to 2017 period, whole milk prices in Philadelphia were $0.08 to $0.10/gallon *higher* than those in the three comparison cities (Table 2), but Philadelphia prices for reduced-fat milk averaged $0.05 to $0.09/gallon *lower* than those in comparison cities (Table 2).

We can use these average price differences to compare with the expected wholesale price difference at demand locations based on analysis with the USDSS spatial economic model for March and September 2016 that accounts for transportation and processing costs. The observed price differences are modified by the expected cost difference to determine the difference in prices due to “other factors”. As noted above, this is not the same as the impact of PMMB price regulation, but it provides a context for assessment of the likely magnitude of impacts.

The differences in retail prices due to other factors between Philadelphia and Washington, DC, Baltimore and New York are generally small, with a maximum value of $0.06/gallon for Philadelphia (that is, Philadelphia had a higher price) compared to New York City. On a percentage basis, the difference due to other factors between Philadelphia and the other three cities are generally small, and ranged from -0.3% to 1.6% of the prices in the three comparison cities.

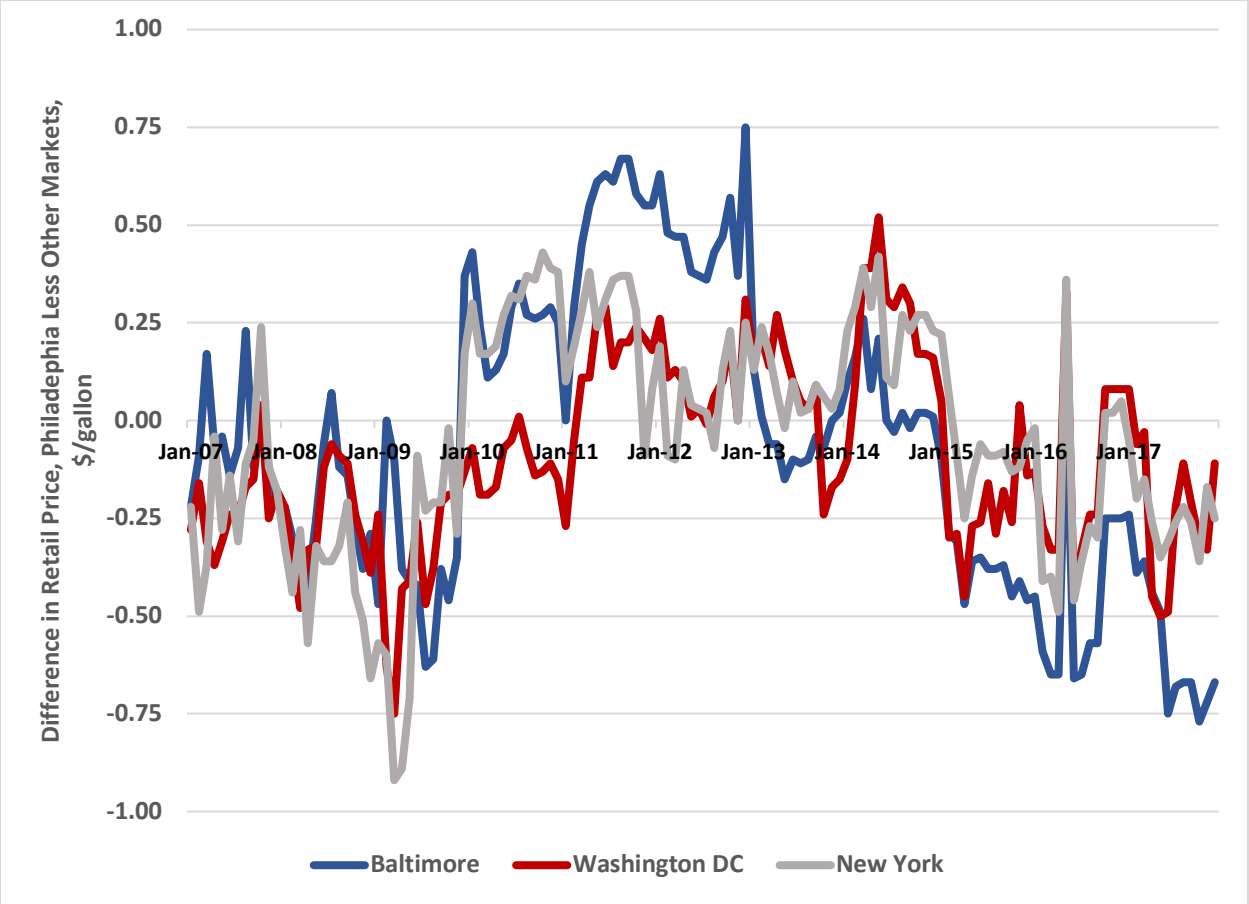

Figure 3. Difference in Reduced Fat Retail Fluid Milk Price Between Philadelphia and Three Other Northeast US Cities, 2007-2017

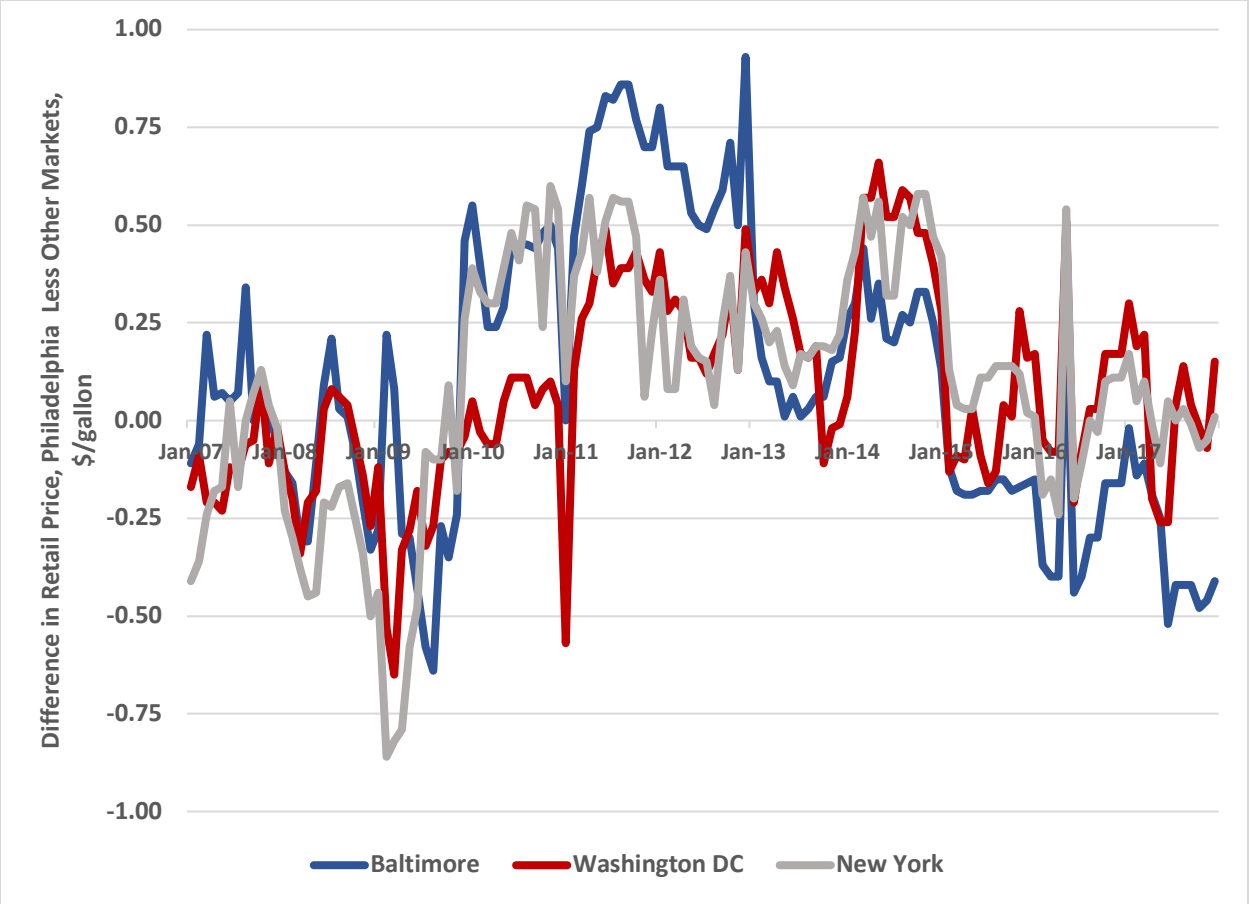

Figure 4. Difference in Whole Milk Retail Price Between Philadelphia and Three Other Northeast US Cities, 2007-2017

Overall, the evidence indicates that fluid milk retail price differences are relatively small between Philadelphia and comparison cities and roughly consistent differences expected based on selected supply chain costs. Although this could suggest limited retail price enhancement relative to other markets, this observation is potentially consistent with three explanations. The first is that PMMB price regulation does not markedly enhance average Philadelphia retail fluid milk prices relative to those in other cities. An alternative explanation is that average retail fluid milk prices are enhanced over a broader geographical area, but in such a way that differences among comparison cities are minimized[8]. A third possibility is that the PMMB enhances retail prices, but these (coincidentally) rather closely match the magnitude of the difference in other factors affecting in retail prices in the three comparison markets. Although it is not possible to determine definitively which of these explanations (or their combination) is most appropriate, the third explanation (relying as it does on the coincidence of PMMB price enhancement in Philadelphia closely matching the different in other factors influencing retail prices in other markets) is less likely.

In contrast to the price relationships between Philadelphia and comparison cities, retail fluid milk prices in Pittsburgh tend to be more consistently higher for both whole and reduced-fat milk than prices in comparison cities (Figures 5 and 6). Prices observed in the Cleveland market were above those in Pittsburgh during much of 2015 and 2016, but retail fluid milk prices were often as much as $0.50/gallon more in Pittsburgh during 2007 to 2017. These observed patterns are likely due at least in part to the low-cost pricing strategy adopted by the Kroger chain for stores in Cincinnati and Detroit, and the sharp increase in the difference between Cincinnati and Pittsburgh in mid-2017 is due to an ongoing "price war" between Kroger and its competitors in that market[9]. Because Kroger does not operate stores in the Cleveland area, that market serves as the better comparison to Pittsburgh prices, although supermarket fluid milk pricing strategies in that market may also be influenced by Kroger's low-cost pricing approach. Average whole milk prices were $0.40/gallon higher in Pittsburgh than in Cleveland during the 11-year period analyzed, and reduced-fat prices averaged $0.26/gallon higher in Pittsburgh than Cleveland during that period (Table 3). Accounting for selected costs differences using the USDSS, the difference due to other factors between average Pittsburgh retail fluid milk prices and those in Cleveland were $0.35/gallon. This difference is about 10% of the price in Cleveland. As for Philadelphia, a number of explanations could be consistent with the observed differences. The first is that there is no price enhancement due to the PMMB, but other factors (i.e., costs not analyzed by the USDSS and supermarket pricing strategy) explain the difference in observed prices. A second is that there is some price enhancement for retail fluid milk prices in western Pennsylvania relative to comparison markets that may be due to PMMB. It is also possible that some combination of the two effects explains the observed differences. The magnitude of the difference does suggest, however, that the evidence in support of the hypothesis that price enhancement occurred relative to comparison cities is somewhat stronger for the Pittsburgh market than for the Philadelphia market.

[8] This is consistent with the observation in the qualitative discussion piece that the PMMB provides a pricing benchmark for a wider geographic area in the Northeast, in addition to Pennsylvania.
[9] See for example, the news article https://www.wcpo.com/money/consumer/dont-waste-your-money/price-war-cincinnati-grocers-slash-milk-prices

Table 2. Differences Between Philadelphia Retail Fluid Milk Prices and Comparison Cities, 2007 to 2017 and USDSS Estimated Diference for 2016

Philadelphia Less Price in:	Average Difference in Whole Milk Price, 2007-2017, $/gal[a]	Average Difference in Reduced Fat Milk Price, 2007-2017, $/gal[a]	Difference in USDSS (2016)[b]	Difference Attributed to Other Factors[c]
Baltimore	**0.10**	**-0.07**	**0.00**	**0.02**
Boston	0.39	0.26	0.03	0.29
Cincinnati	1.19	1.02	0.03	1.08
Cleveland	0.51	0.38	0.03	0.42
Detroit	0.92	0.79	0.05	0.80
Hartford	0.20	0.05	-0.01	0.13
Louisville	0.80	0.66	0.05	0.69
New York	**0.10**	**-0.05**	**-0.03**	**0.06**
Syracuse	0.71	0.70	0.09	0.61
Washington DC	**0.08**	**-0.09**	**0.00**	**-0.01**

[a] Simple average of difference between Philadelphia reported monthly price and that reported in city listed in the first column.

[b] Difference in marginal value of a gallon of fluid milk (wholesale-equivalent value) between Philadelphia and the specified city location. This suggests the expected difference in per gallon values based on transportation and processing costs. Note that the USDSS aggregates fluid milk categories so does not allow direct assessment of marginal values of whole and reduced-fat milk products.

[c] Calculated as the difference between the simple average of average differences in whole milk and reduced fat milk less the (expected) wholesale cost difference based on transportation and processing cost differences. This thus represents the difference in retail prices that is due to "other factors" rather than the subset of assessed direct cost factors.

Note: Negative value means that the Philadelphia price is less than the price reported in comparison city. Positive value means that the Philadelphia price is more than the price reported in comparison city.

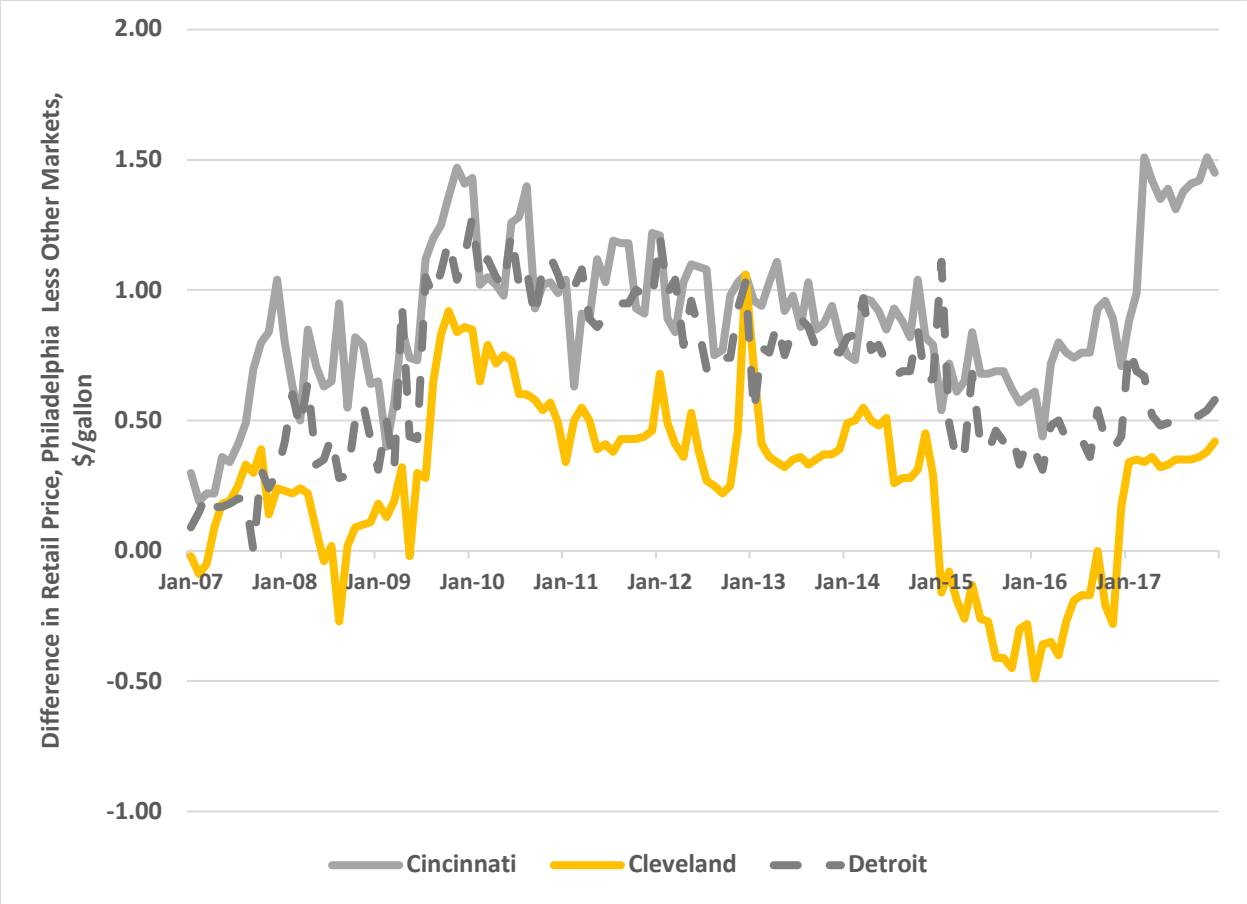

Figure 5. Difference in Reduced Fat Retail Fluid Milk Price Between Pittsburgh and Three Comparison Cities, 2007-2017

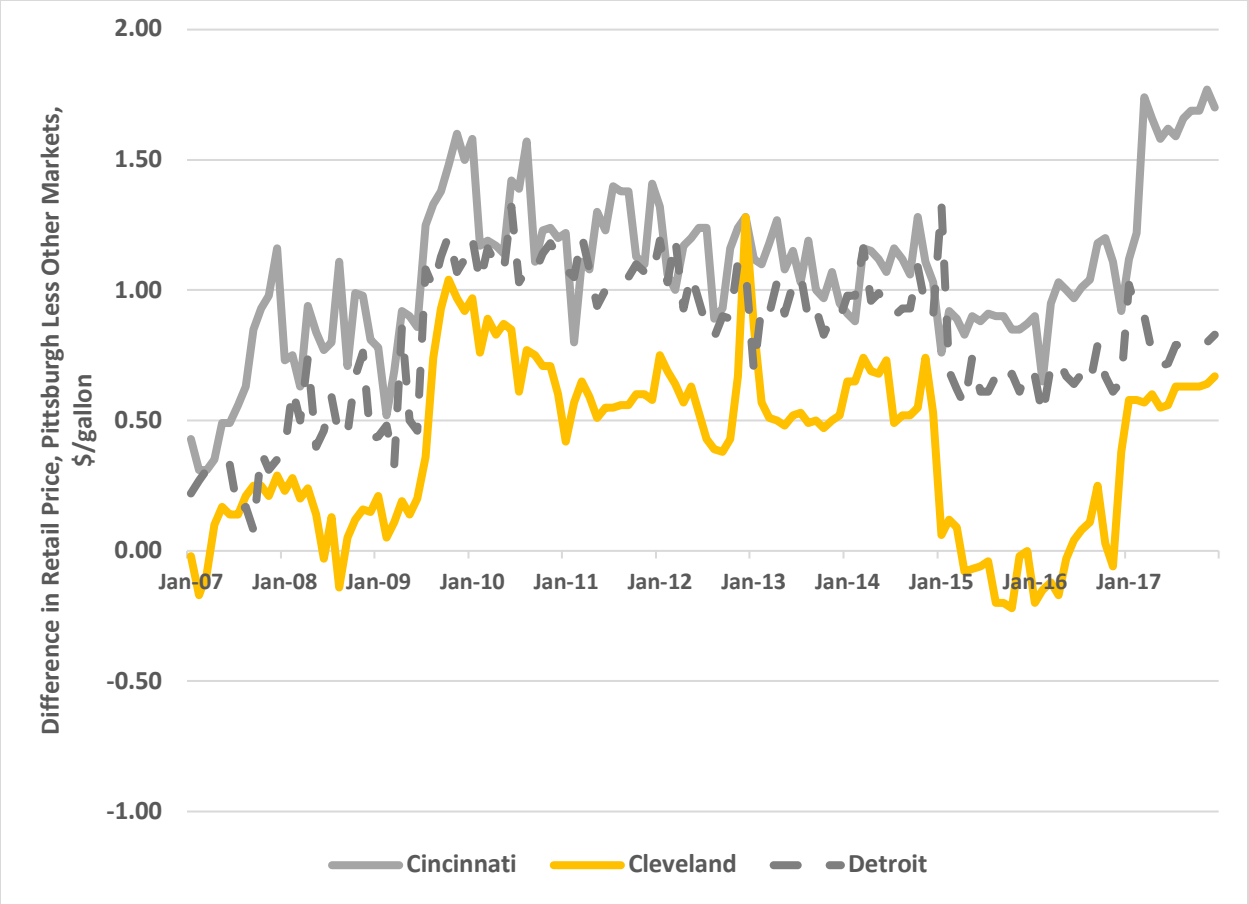

Figure 6. Difference in Whole Milk Retail Price Between Pittsburgh and Three Other Comparison Cities, 2007-2017

Table 3. Differences Between Pittsburgh Retail Fluid Milk Prices and Comparison Cities, 2007 to 2017 and USDSS Estimated Difference for 2016

Pittsburgh Less Price in:	Average Difference in Whole Milk Price, 2007-2017, $/gal[a]	Average Difference in Reduced Fat Milk Price, 2007-2017, $/gal[a]	Difference in USDSS (2016)[b]	Difference Attributed to Other Factors[c]
Baltimore	-0.01	-0.19	-0.05	-0.05
Boston	0.28	0.14	-0.02	0.22
Cincinnati	1.08	0.90	-0.02	1.01
Cleveland	**0.40**	**0.26**	**-0.02**	**0.35**
Detroit	0.81	0.67	0.00	0.74
Hartford	0.09	-0.07	-0.06	0.06
Louisville	0.69	0.54	0.00	0.62
New York	-0.01	-0.17	-0.08	-0.01
Syracuse	0.60	0.58	0.04	0.55
Washington DC	-0.03	-0.21	-0.05	-0.07

[a] Simple average of difference between Pittsburgh reported monthly price and that reported in city listed in the first column.

[b] Difference in marginal value of a gallon of fluid milk (wholesale-equivalent value) between Pittsburgh and the specified city location. This suggests the expected difference in per gallon values based on transportation and processing costs. Note that the USDSS aggregates fluid milk categories so does not allow direct assessment of marginal values of whole and reduced-fat milk products.

[c] Calculated as the difference between the simple average of average differences in whole milk and reduced fat milk less the (expected) wholesale cost difference based on transportation and processing cost differences. This thus represents the difference in retail prices that is due to "other factors" rather than the subset of assessed direct cost factors.

Note: Negative value means that the Pittsburgh price is less than the price reported in comparison city. Positive value means that the Pittsburgh price is more than the price reported in comparison city.

Example of Impact of Price Enhancement on Fluid Milk Sales

Although it is not possible to definitively assess the impact of PMMB on fluid milk sales because we cannot determine precisely the impact of PMMB on prices, we can undertake an example calculation that suggests relevant information about the likely magnitude of impact. To do so, we *assume* that the impact of the PMMB on whole milk and fluid prices is equal to the value of the impact of "other factors" for one comparison city (New York for Philadelphia and Cleveland for Pittsburgh) for the whole and reduced-fat milk retail prices. This assumes that all differences are due to price regulation, which is likely to overestimate the impact of PMMB retail pricing regulation. To capture the potential effect of low-cost pricing strategies for fluid milk in the Cleveland market and assess what would be the likely maximum possible impact of PMMB price regulation on fluid milk sales, we assume that half of the price difference between Cleveland and Pittsburgh is attributable to supermarket pricing strategies. We then use previously-reported fluid milk demand elasticities[10] to assess the impact on fluid milk sales of this magnitude of retail price difference. The basic calculation is undertaken in percentage terms (the definition of a price elasticity is the percentage change in sales for a percentage change in price), and is given as:

% Change in Sales =

(Reported Own-Price Elasticity)(% Change in Price)

+ (Reported Cross-Price Elasticity[11])(% Change in Other Product Price)

These calculations suggest that IF price enhancement by the PMMB is as assumed based on comparisons to average values in other cities, the impacts on fluid milk sales would differ by Pennsylvania city and product. In Philadelphia, price enhancement of $0.10/gallon would result in an example reduction in whole milk sales of 3.5%. However, the impact on reduced-fat milk sales would be positive, due to both lower reduced-fat retail milk prices and cross-price effects (the higher price of whole milk). The average effect (assuming equal sales volumes for whole and reduced-fat milk) would be a reduction in sales of less than 1%. To put this into context, combined sales for fluid milk products in both the Northeast and Mideast Milk Marketing Orders declined by about 15% during 2007 to 2017. To the extent that this decrease is representative of demand changes in Pennsylvania, the estimate of price enhancement would thus need to be more than fifteen times higher on a value and percentage basis (about $0.90/gallon at the average difference due to other factors value of $0.06/gallon) to explain the full reduction in fluid milk sales based on the reported elasticity values. This seems unlikely based on the evidence from the retail price comparisons, and so suggests that minimum price regulation under the PMMB is not the principal cause of reductions in fluid milk sales in the eastern part of the Pennsylvania.

The assumed average price enhancement during 2007 to 2017 in Pittsburgh is somewhat larger than for Philadelphia, and thus would have a larger impact on sales for both whole and reduced-fat milk, an average of 4.7% for whole and low-fat milk. These effects would account for less than a third of the observed decline in fluid milk sales. Thus, although a negative impact of

[10] There are many such studies reporting a wide range of values, but for the purposes of this example, we use "US Fluid Milk Demand: A Disaggregated Approach", authored by Davis et al., and published in 2012 (*International Food and Agribusiness Management Review*, 15:25-50.)

[11] A "cross-price" elasticity accounts for the fact that a change in the price of another product may affect the demand for a product under consideration. In this case, an increase in price of whole fat milk will affect both the sales of whole fat milk (a decrease) but also the sales of reduced-fat milk (typically, an increase).

price enhancement due to PMMB on fluid milk sales is possible in the western part of Pennsylvania, but it does not appear to be major factor driving the decline.

If the Philadelphia and Pittsburgh markets are considered representative of effects elsewhere in Pennsylvania and the effects weighted according to the relative size of the two markets, the overall effect of the PMMB on fluid milk sales in the state would be approximated as -2.6%. This is less than one-fifth of the observed decline in fluid milk sales and thus rather strongly suggests that the retail pricing regulation under the PMMB is not the major driver of declines in fluid milk sales.

Table 4. Example Calculations of the Impact of Price Enhancement on Fluid Milk Sales

Fluid Milk Product, Impact	Philadelphia[a]	Pittsburgh[b]
Whole Milk Sales Analysis		
% Change in Whole Milk Sales	-3.5%	-6.2%
Difference in Own-Price	0.10	0.20
% Change in Own-Price	2.6%	5.3%
Own-Price Elasticity Value	-1.28	-1.28
Change in Cross-Price	-0.05	0.13
% Change in Cross-Price	-1.3%	3.6%
Cross-Price Elasticity Value	0.14	0.14
Reduced-fat Milk Sales Analysis		
% Change in Reduced Fat Milk Sales	1.6%	-3.3%
Change in Own-Price	-0.05	0.13
% Change in Own-Price	-1.2%	3.6%
Own-Price Elasticity Value	-1.00	-1.00
Change in Cross-Price	0.10	0.42
% Change in Cross-Price	2.6%	2.6%
Cross-Price Elasticity Value	0.14	0.14
Average Effect	-0.9%	-4.7%

[a] Philadelphia uses New York City as the comparison market.
[b] Pittsburgh uses Cleveland as the comparison market, assuming that half of the price difference is attributable to retail pricing strategies.

Estimated Impacts on Fluid Milk Processing in Pennsylvania of the PMMB

Another issue that has been mentioned frequently in discussions concerning the PMMB is that the structure of the pricing regulation could provide incentives for fluid milk processing to be shifted to other states, even when the intended market for the milk is within Pennsylvania. As with the assessment of retail pricing, many factors will determine where farm milk is sourced for fluid processing, where fluid milk is processed and distribution routings from plants to customers. From a supply chain perspective, many factors influence the location and capacity utilization of a processing facility, including but not limited to the cost of major inputs (farm milk for fluid processing), transportation costs to the facility, operations costs (including labor, utilities, taxes, etc.) distribution costs, and institutional factors such as relationships with supply chain partners. Because fluid milk processing capacity is an expensive investment, construction of new facilities tends to be infrequent in any one region.

The available information is insufficient to assess each of these factors for the current locations of fluid milk processing and therefore the potential role of PMMB price regulation in plant

location and utilization decisions. Thus, we again adopt a simpler approach that draws upon the USDSS spatial economic model[12]. Because the USDSS determines the combination of farm milk assembly, processing locations and distribution routes for all dairy products in the continental US (i.e., including but not limited to fluid milk products) that minimizes overall supply chain costs, we can use the results of the model as a competitive benchmark for comparison with available data, that is, as what might be expected to occur in the absence of any price regulation. This approach identifies a set of outcomes consistent with spatial economic factors and differences would be suggestive of the impact of other factors, including PMMB regulation.

For the purposes of this component of the analysis, we used results for March and September 2016, the latest update of the detailed USDSS datasets. We analyze the detailed results of farm milk assembly shipments, fluid milk processing volumes at specific locations, and distribution routes from fluid milk processing plants to locations for final demand. This allows us to assess the extent to which fluid milk consumed in Pennsylvania has spatial economic incentives to be produced and processed within the state—thus meeting the general conditions to be eligible for farm milk price regulation under the PMMB. We also compare selected results for the states of Pennsylvania, New York and Ohio.

The spatial economic incentives represented by the USDSS suggest a number of outcomes that might be considered counterintuitive. First, a high proportion—but not all—of the farm milk used at fluid processing plants in Pennsylvania would be expected to come from farm supply locations within the state (Table 5). About 8% of farm milk used in processing would come from outside the state, with the most notable shipments to fluid processing indicated for the northwestern part of Pennsylvania. Second, there are economic incentives for shipments of packaged milk from fluid milk processing plants in other states (primarily New York and New Jersey) to Pennsylvania cities. About 18% of packaged fluid milk consumed in Pennsylvania cities would make economic sense to source from outside the state. Together, these results suggest that Pennsylvania should not inevitably be "self-sufficient" in the sense that all shipments of farm milk to fluid and all fluid processing for consumption in Pennsylvania should occur within state boundaries.

[12] A detailed description of the USDSS model is available in the companion report "Analysis of Economic Incentives for Additional Dairy Processing Capacity in Pennsylvania."

Table 5. Summary of Farm Milk Assembly at Fluid Plants and Distribution of Packaged Milk from Fluid Plants from USDSS Model for Pennsylvania, New York and Ohio, March and September 2016

State, Variable	Farm Milk to Fluid Plants			Shipments of Packaged Fluid Milk from Plants to Demand Locations	
	March	September		March	September
Pennsylvania	*(mil lbs/mo)*	*(mil lbs/mo)*		*(mil lbs/mo)*	*(mil lbs/mo)*
PA to PA	228	222		156	150
Other State to PA	19	21		30	34
PA to Other State	341	327		81	84
Total	588	570		267	268
PA to PA	38.8%	38.9%		58.3%	56.1%
Other State to PA	3.3%	3.8%		11.3%	12.7%
PA to Other State	58.0%	57.3%		30.4%	31.3%
% of PA Fluid from PA	92.2%	91.2%		83.8%	81.6%
New York					
NY to NY	196	231		177	213
Other State to NY	59	56		90	51
NY to Other State	29	65		50	63
Total	284	352		317	327
NY to NY	62.8%	65.7%		48.3%	65.2%
Other State to NY	18.9%	15.8%		24.6%	15.6%
NY to Other State	9.1%	18.6%		13.5%	19.2%
% of NY Fluid from NY	76.9%	80.6%		66.3%	80.7%
Ohio					
OH to OH	144	148		116	117
Other State to OH	0	0		89	92
OH to Other State	134	156		22	26
Total	278	304		227	234
OH to OH	51.8%	48.7%		51.0%	49.8%
Other State to OH	0.0%	0.0%		39.4%	39.1%
OH to Other State	48.2%	51.3%		9.6%	11.1%
% of OH Fluid from OH	100.0%	100.0%		56.4%	56.0%

The basic results about "self-sufficiency" in fluid milk processing also apply to New York and Ohio (Table 5). About 20% of farm milk processed in New York fluid plants comes from out of state (much of this amount comes from Pennsylvania), and the proportion of fluid milk consumed in New York that is processed in plants in the state is only two-thirds of the total in March—and less than the proportion in Pennsylvania in both March and September. In Ohio, all the farm milk used in fluid processing in the state originated within the state, but only somewhat more than half of fluid milk consumed in Ohio is processed at a fluid plant in the state. Overall, these results suggest that for these Northeast states, "self-sufficiency" in fluid milk should not be considered the normal or expected outcome based on spatial economic considerations alone.

Another relevant outcome predicted by the spatial economic incentives represented in the USDSS is that a large proportion of Pennsylvania farm milk will be used in fluid processing in both March and September. However, a larger volume of this milk sent to fluid processing is shipped out of state than is processed at fluid plants in Pennsylvania (Table 5). In addition, about one-third of packaged fluid milk processed in Pennsylvania would be expected to be shipped out of state to demand locations (Table 5) in New Jersey, New York, Maryland, Delaware, West Virginia, Ohio, North Carolina, South Carolina. There are also spatial economic incentives for shipments of Pennsylvania farm milk to other states for processing and then back to Pennsylvania for consumption as packaged milk: about 6% of packaged fluid milk consumption in Pennsylvania has this characteristic in March and September. Taken together, these results suggest that farm milk assembly and fluid milk distribution routes that cross state boundaries in the Northeast (and into the mid-Atlantic) have an underlying spatial economic logic. As a result, the existence of these flows across state borders does not constitute strong evidence that they arise from price regulation under the PMMB.

We also further examined the specific sets of farm milk assembly and packaged fluid milk distribution flows to assess what spatial economic incentives suggest about the amount of farm milk that would be expected to qualify for minimum pricing regulation under the PMMB, based only on the criteria that the packaged fluid milk consumed at demand locations in Pennsylvania was also processed and sourced from farms within the state (Table 6). Although about 75% of total packaged milk consumption in Pennsylvania would be from farm milk expected to qualify for minimum farm milk price regulation under the PMMB, it is important to note that about 25% of packaged milk sales would not, based spatial economic incentives, although retail minimum pricing would still apply. Moreover, less than about 20% of Pennsylvania farm milk would be expected to be priced according to PMMB minimum pricing regulations. These results serve as a relevant basis for comparison to observed outcomes, to be discussed subsequently. In practical terms, these results suggest that observations that a relatively small proportion of the state's farm milk is supported by PMMB pricing, in and of itself, is not strong evidence that the program is not achieving its intended purposes or is providing substantive incentives to avoid price regulation through plant location and processing capacity utilization decisions.

Table 6. Summary of Expected Volumes of Packaged Milk and Farm Milk Meeting Basic Criteria for PMMB Minimum Farm Milk Price Regulation Based on Spatial Economic Incentives, March and September 2016

Model-Predicted Outcome	March	September
Packaged Milk That Meets PMMB Criteria, mil lbs/mo	144	146
Total Fluid Consumption, mil lbs/mo	194	200
% of Packaged Milk that Meets PMMB Criteria	74.3%	73.2%
Farm Milk Meeting PMMB Criteria, mil lbs/mo	159	152
Farm Milk Production, mil lbs/mo	867	943
% of Farm Milk that Meets PMMB Criteria	18.3%	16.1%

Note: For the purposes of the above, "meets PMMB criteria" implies that packaged fluid milk consumed in Pennsylvania locations was processed at a fluid milk plant in Pennsylvania and the farm milk supplying that plant was also sourced in Pennsylvania. Thus, production, processing and consumption all occurred within the boundaries of the state of Pennsylvania, which makes the milk eligible for minimum farm-level pricing.

Volume of Milk Priced Under the PMMB

The foregoing assessment of outcomes under a perfectly competitive spatial market can be complemented by an assessment of the actual volumes of farm milk priced by the PMMB, and their comparison in percentage terms. From 2007 to 2016, the amount of farm milk priced by the PMMB declined from an average of 133 million lbs per month to 107 million lbs per month (Figure 7) and from 15% of the total Pennsylvania milk production to about 12%[13]. However, this reduction in milk priced is most appropriately considered in reference to the patterns of overall fluid milk product sales in the main Federal Milk Marketing Orders to which Pennsylvania farms ship, the Northeast and Mideast orders. Overall fluid milk sales declined in the Northeast and Mideast orders in a pattern very similar to the decline in milk priced under the PMMB (Figure 8), although the trend for the PMMB is somewhat more negative. The declines in the milk price by PMMB and the Northeast order are highly correlated (0.92) and also align with the overall decline in annual US fluid milk sales, which occurred at a somewhat slower rate than the declines in the Northeast. Thus, although the amount of farm milk priced under the PMMB has declined, much of this decrease appears due to general patterns of demand and not to the specific regulatory policies in place under the PMMB.

The percentage of farm milk actually priced under the PMMB during 2007 to 2016 ranges from 10.3 to 17.1%, which is roughly similar to the proportion predicted by the spatial economic incentives analyzed with the USDSS model. In the specific months analyzed, the actual milk priced under the PMMB was lower than that predicted by the USDSS, 13% compared to 18% for March 2016 and 12% compared to 16% for September 2016. This suggests that price regulation under the PMMB may have some impact on fluid milk processed in Pennsylvania, but it is important to note that the USDSS does not account for all factors that will influence the location and volume of fluid milk processed—mentioned above—and thus price regulation is

[13] Data for these analyses were provided by the PMMB from their accounting records, and the authors gratefully acknowledge their cooperation in doing so.

only one component that might explain the differences between model-predicted and actual outcomes.

Taken together, these comparisons suggest that the price regulation under the PMMB may have an impact on fluid milk sales and volumes processed, but the impact is probably not large relative to the impact of other factors influencing the observed patterns over the past 10 years.

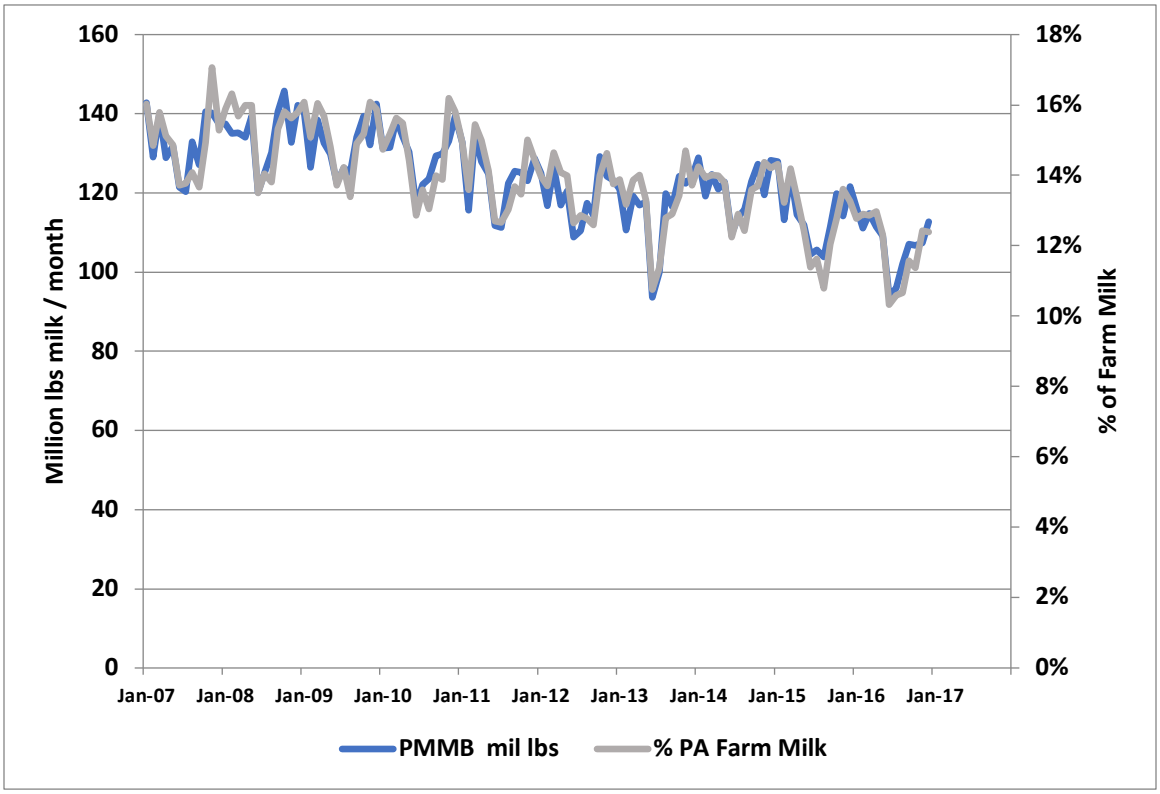

Figure 7. Farm Milk Priced by PMMB and Percentage of Pennsylvania Milk Production, 2007-2016

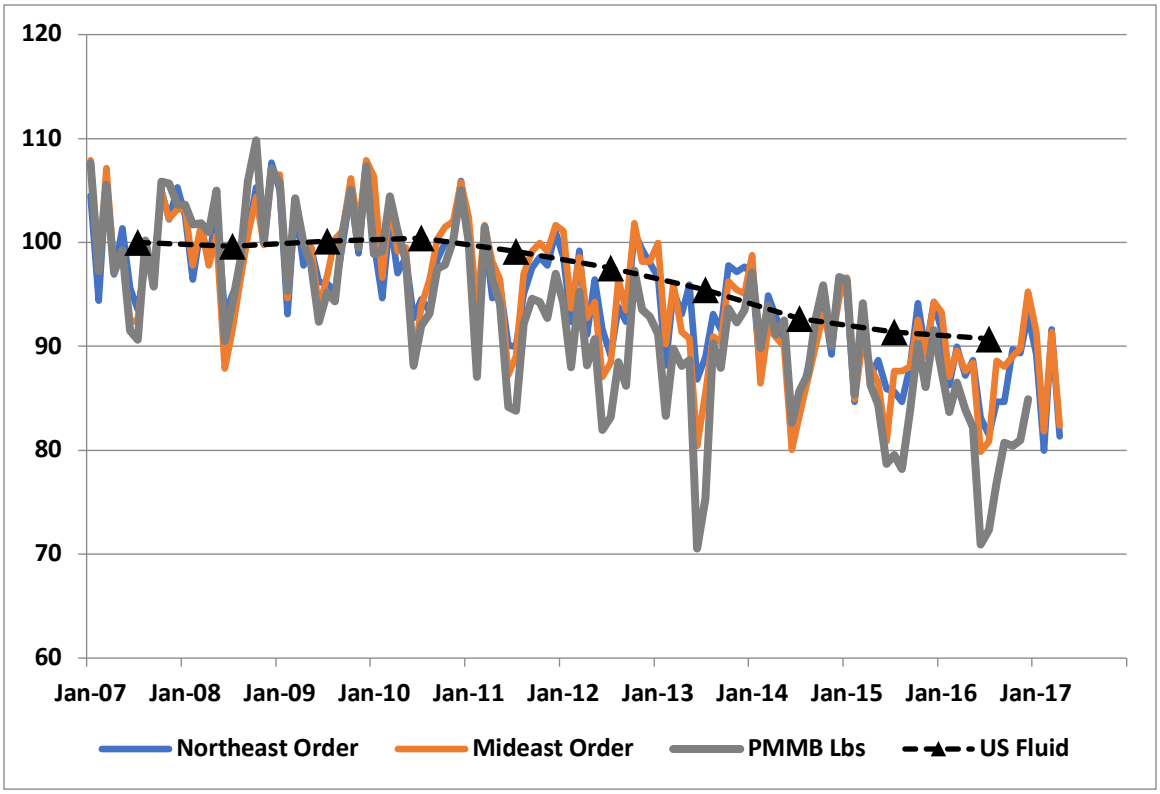

Figure 8. Index Values[14] for Farm Milk Priced by PMMB, Fluid Milk Sales in the Northeast and Mideast Federal Milk Marketing Orders, and Total Annual US Fluid Milk Sales, 2007-2017

[14] Index is defined as Average Monthly Value for 2007 = 100 for the three monthly series and 2007 Annual Value = 100 for US fluid milk sales.