ECO 610
Final Exam
Fall 2017

Name: **KEY**

Optional 4-digit number: 1234

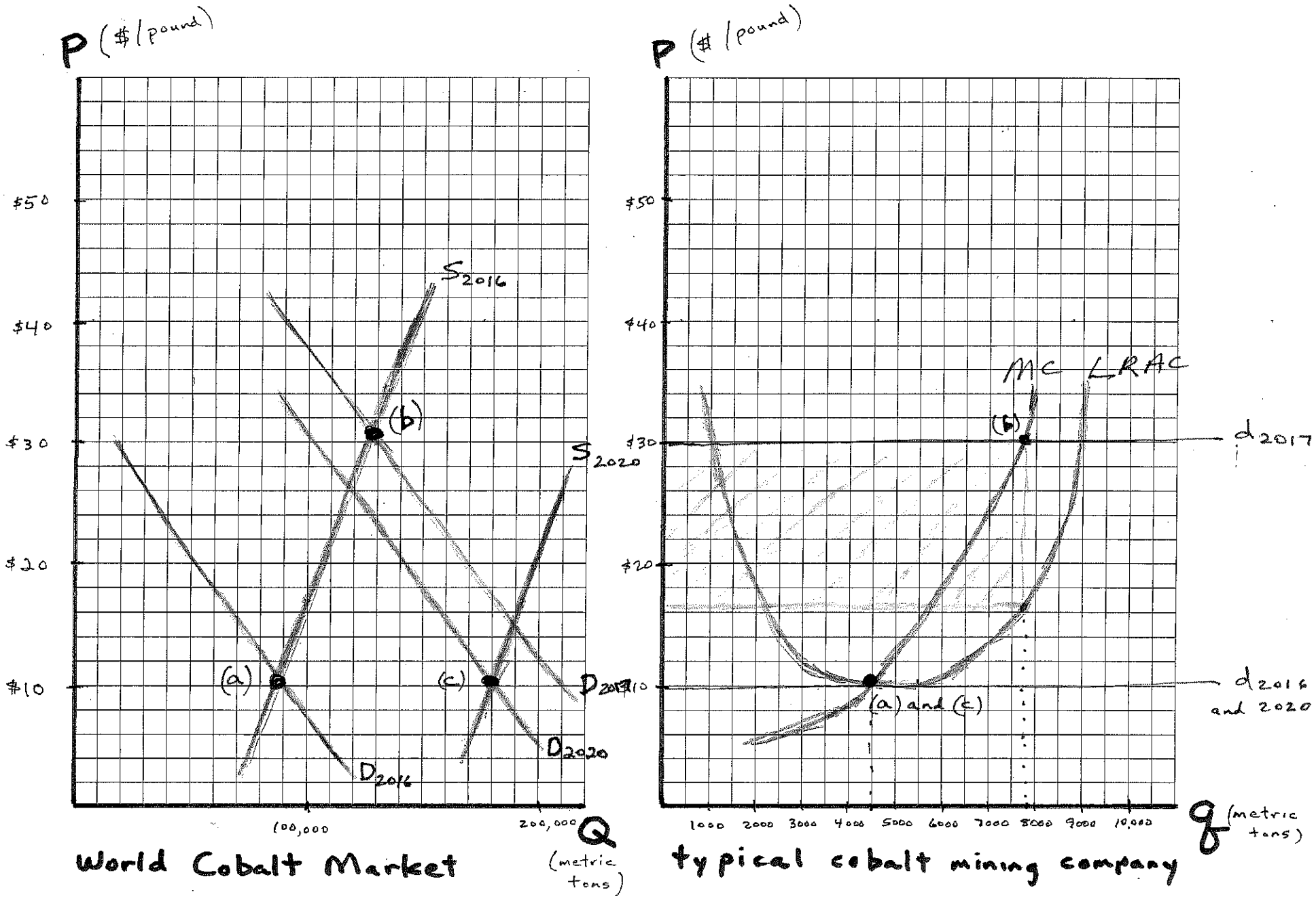
100 points total. Answer each question in the space provided.

1. (20 pts.) Read the attached article on the global cobalt market from the WSJ 11/30/17. Cobalt is mined by a number of companies in different places around the globe. Since the beginning of the year, cobalt prices have increased from around $10/lb to $30/lb. As you can see in the attached chart, cobalt prices had been in the $10 to $15 range for a number of years. Since you work for a major battery manufacturer supplying automobile manufacturers in North America, your bosses have asked you to explain what is going on. The CEO and most of the board members have MBA's, so they understand commodity market models. Now for the framework of your report:
   a) What does long-run equilibrium look like in the global cobalt market? Is long-run equilibrium price closer to $10 per pound or $30 per pound? What does that suggest to you about minimum LRAC for producing cobalt? Draw diagrams for the market and for a typical cobalt mining company that are consistent with your description of long-run market equilibrium.

From 2007 until 2016 cobalt prices hovered between $10 and $15 per pound. Prior to 2006 they were in the same range. After a short run-up in 2006 and 2007, they returned to what appears to be the long-run norm. That would suggest that mining firms can produce cobalt for $10-$15 per pound and earn a normal return on their investment, i.e. the minimum long-run average cost of producing cobalt is in that range. The long-run equilibrium in the cobalt market in 2016 is labeled (a) in the diagrams.

   b) What does the future hold? Do you anticipate that prices will stay at $30 per pound, or do you see them returning to a lower level? If so, what level? And how long do you think the adjustment process will take? Draw diagrams for the market and for a typical cobalt mining company consistent with your explanation of 2016 prices being $10/lb, 2017 prices being $30/lb, and 20?? prices being whatever you are predicting.

There has been a surge in demand for cobalt in 2017, as the article describes. Prices have tripled from their 2016 level. At these prices, cobalt miners will earn significant economic profits, as indicated by the shaded area in the firm diagram. The 2017 short-run equilibrium is labeled (b) in the diagrams. Over time, we would expect new firms to enter the market and for existing firms to expand their capacity. The result is a shift to the right of the market supply curve. Another phenomenon that may occur is the development of alternatives to cobalt for automobile batteries. If this happens, the market demand for cobalt may shift back somewhat to the left. Both the increase in supply and decrease in demand will have the effect of lowering the price of cobalt. We predict that prices will eventually return to the $10-$15 range. (labeled (c) in the diagrams.)


P ($/pound)
$50
$40
$30
$20
$10
S_{2016}
S_{2020}
(a)
(b)
(c)
D_{2016}
D_{2020}
100,000
200,000
Q (metric tons)
World Cobalt Market
P ($/pound)
$50
$40
$30
$20
$10
MC
LRAC
(b)
d_{2017}
(a) and (c)
d_{2016} and 2020
1000 2000 3000 4000 5000 6000 7000 8000 9000 10,000
q (metric tons)
typical cobalt mining company

WSJ 11/30/17

Will a Shortage of Cobalt Kill Electric-Vehicle Makers?

Wedged between iron and nickel on the periodic table, cobalt has suddenly emerged as the electric-car killer.

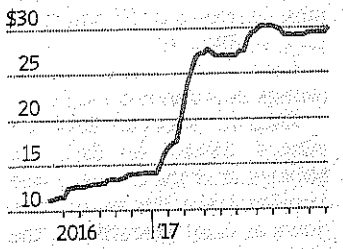
The once-obscure metal, a critical part of batteries, has nearly tripled in price since last summer as concerns grow about whether there will be enough cobalt to meet demand.

The ingredients for a shortage are there: Output is concentrated in the politically unstable Democratic Republic of Congo and refining is dominated by China. Demand is set to soar as companies from Tesla to Volkswagen ramp up production of electric vehicles.

With the price of cobalt hitting $30 a pound, investors have poured into shares of companies that mine or own rights to the metal. Canada's **Cobalt27 Capital**, which believes there is already a deficit in supply that will worsen, is up 162% this year.

Pedal to the Metal

Price of cobalt US 99.8% a pound as tracked by CRU International



"I don't think automobile manufacturers are as concerned about price as availability," says George Heppel, a consultant at materials research firm CRU International who says the shortage could peak in 2021.

But the dreaded shortage of cobalt is a bit more complicated than industry projections would suggest. As anyone who remembers the fears around rare earth metals will agree, high prices have a way of boosting supply and reducing demand. With the cost of cobalt alone having risen to over $800 for some leading electric models—about as much as that of aluminum or plastic per vehicle—mother necessity is calling.

Like cobalt, rare earths aren't so rare. China's move to restrict exports in 2010 exacerbated the perceived shortage, sending the prices of some varieties up 10-fold. Companies such as **Molycorp**, Rare Element Resources and **Quest Rare Mineral**, which all had some connection to reserves, saw their shares surge based on supposedly rosy prospects. Since then, all have lost nearly all of their value.

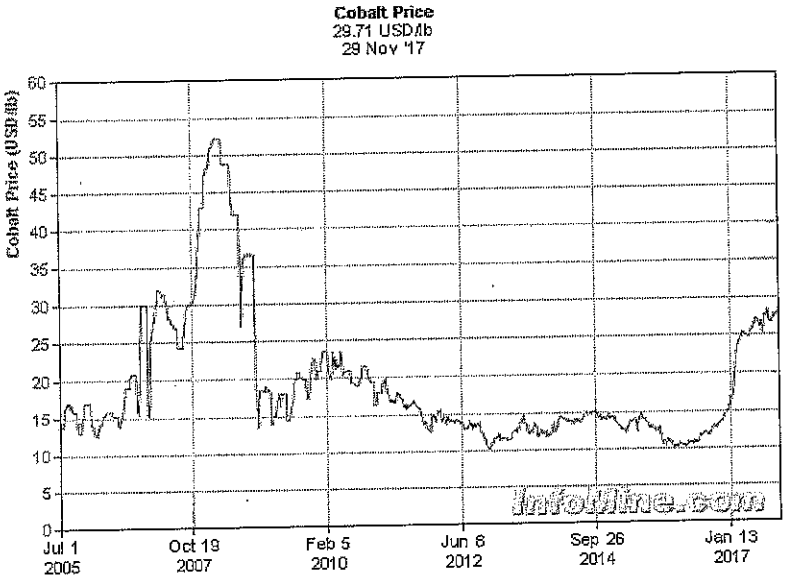
Already, Mr. Heppel explains, other users of the metal, for example in the pigments industry, are searching for alternatives. Meanwhile, some batteries, such as a design by Tesla, use less of the metal. Lower-performing batteries use none at all, and those batteries' capabilities may improve with technological tweaks.

Supply will react, too. Companies that operate copper and nickel mines, where cobalt is co-produced, are targeting expansion, and there are some pure-play cobalt mines being planned that could start producing shortly after the projected shortage hits. For electric vehicles, this looks more like a speed bump than a cliff.

—Spencer Jakab

Historical Cobalt Prices and Price Chart

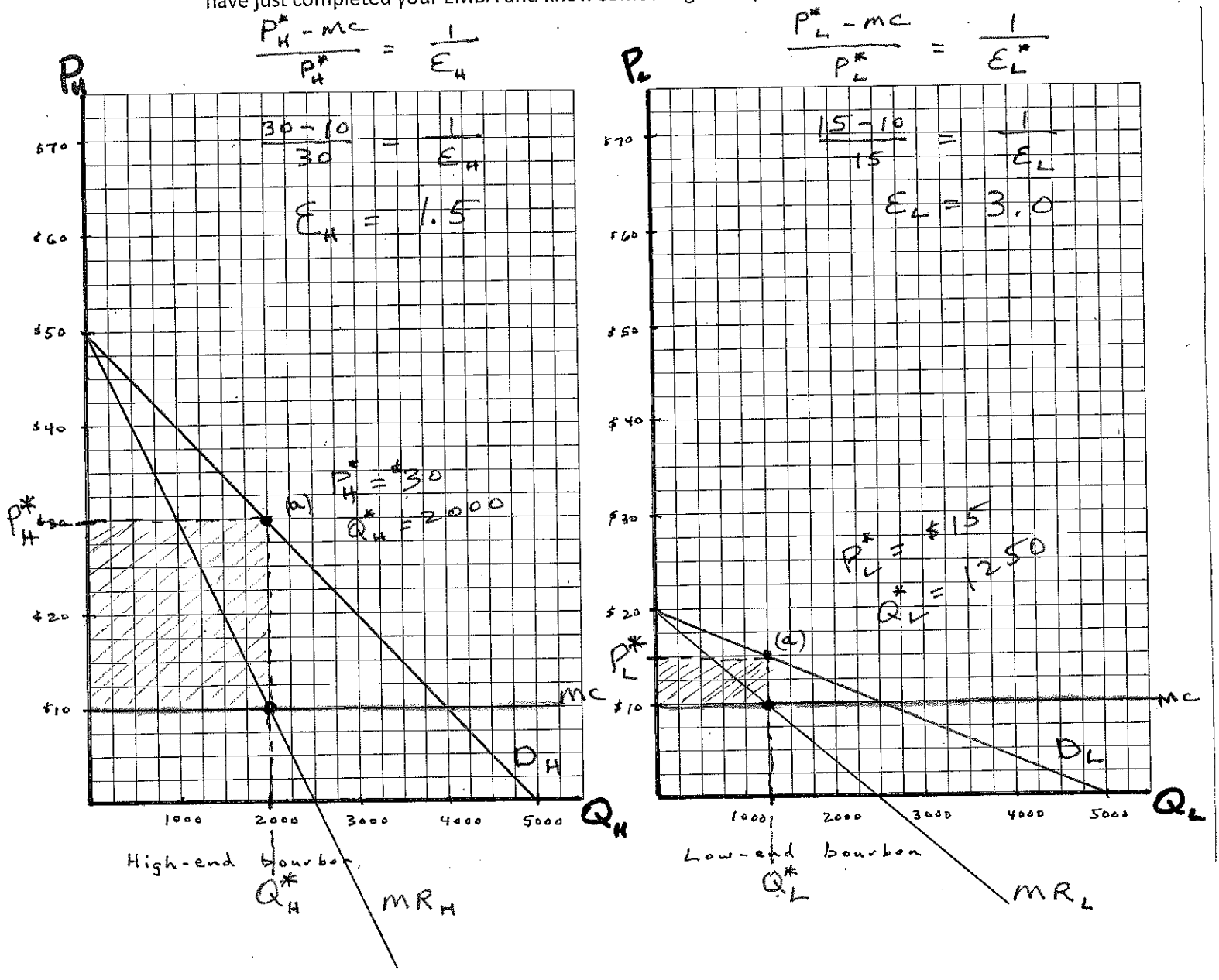
Cobalt Price 29.71 USD/lb (65,500.00 USD/t | 55,054.72 EUR/t) 29 Nov 2017 - 52 Week Low 13.61 USD/lb 52 Week High 3



2. (20 pts.) A major distilling company that is a market leader in producing and selling bourbon approaches you for help with their pricing strategy. There are two distinct segments to the market for their brands. Among high-end customers, monthly demand is given by $Q_H = 5000 - 100P_H$, where Q is the number of cases of 750 ml bottles and P is the price per 750 ml bottle. Among low-end customers, monthly demand is given by $Q_L = 5000 - 250P_L$. You really don't do anything substantially different in producing the high-end bourbon and the low-end bourbon other than letting one sit around in a warehouse for a longer time, and in fact sometimes when you have leftover high-end bourbon you just mix it in with the low-end bourbon. So for purposes of answering this question, take the marginal cost of producing a 750 ml bottle of either quality bourbon to be constant at $10.

a) Sketch the demand, marginal revenue, and marginal cost curves for each market segment. Indicate what price and output will maximize profit in each segment.

b) The head of marketing approaches you and asks if you can give her a back-of-the envelope estimate of the own-price elasticity of demand for each type of bourbon. She knows that you have just completed your EMBA and know something about the inverse-elasticity pricing rule.



3. (10 pts.) See the attached article from the WSJ 11/24/17. Take the information on sales by each of the major paint producers and calculate the industry HHI. Explain how you get your answer and show your work. There are a number of smaller producers not listed in the chart, but you can ignore them for purposes of answering this question.

Total industry sales = 65.2

$$HHI = \sum_{i=1}^{n} s_i^2 = \left(\frac{15.8}{65.2}\right)^2 + \left(\frac{14.3}{65.2}\right)^2 + \left(\frac{10.7}{65.2}\right)^2 + \left(\frac{4.8}{65.2}\right)^2 + \left(\frac{4.3}{65.2}\right)^2 + \left(\frac{4.1}{65.2}\right)^2 + \left(\frac{3.6}{65.2}\right)^2 + \left(\frac{2.9}{65.2}\right)^2 + \left(\frac{2.6}{65.2}\right)^2 + \left(\frac{2.1}{65.2}\right)^2$$

$$HHI = .1551 * 10{,}000 = 1551.$$

WSJ 11/24/17

Paint Industry Draws Excitement

The otherwise quotidian world of paint is turning into a feeding frenzy of merger activity. Money is to be made betting on the prime targets.

The latest news: Japan's **Nippon Paint** is interested in **Axalta Coating Systems**, pushing aside a bid by Dutch rival **Akzo Nobel**, which itself has been a target for industry leader **PPG Industries**. It is unclear what price Nippon has offered for Axalta, though it will need to be more than its current enterprise value of $11.7 billion including debt.

Akzo's retreat before a smaller rival isn't as odd as it sounds. This year, the Dutch company refused to negotiate over three separate bids from Pittsburgh-based PPG, which vies with Cleveland-based **Sherwin-Williams** for the top spot in the global paints industry. Investors, noisily led by New York activist **Elliott Management**, wanted Akzo to negotiate.

Chairman Antony Burgmans blocked PPG by invoking arcane clauses of Dutch law, leaving him little credit with investors to draw on in support of a punchy takeover. The Axalta deal, billed as a "merger of equals," always looked like a poison pill to keep PPG away, but investors were happy to swallow it as long as Akzo could promise merger synergies without a hefty takeover premium. Nippon's all-cash offer has made that impossible.

Nippon Paint is making a huge bet. With an enterprise value equivalent to $10.6 billion, it is slightly smaller than Axalta. The offer looks serious, though. The Japanese company has no net debt and a clear ambition to be a global player.

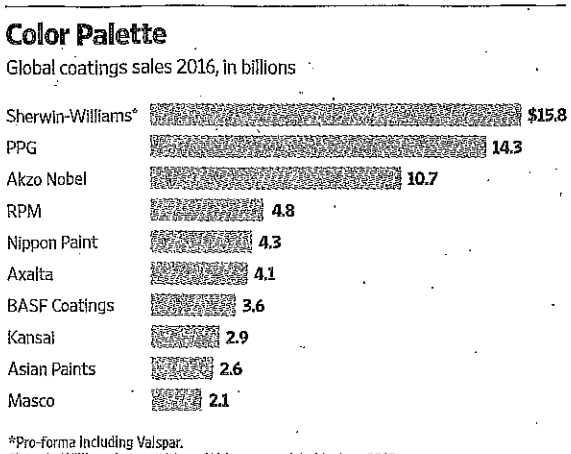
Crucially, Nippon Paint's key shareholder implicitly stands behind its management. Almost two-fifths of the company's shares belong to **Wuthelam Holdings**, the investment vehicle of Singaporean billionaire Goh Cheng Liang. Mr. Goh distributed Nippon paint for decades before his son, now director of the board, spearheaded a 2014 merger.

Akzo's inability to compete with Nippon Paint leaves it vulnerable. PPG has done its best to temper expectations of another round of bidding, but this could just be a negotiating ploy. The numbers should still work: The dollar has weakened against the euro this year, but PPG's share price has outperformed Akzo's, which is still 18% below the level of PPG's final bid. PPG's "put-up-or-shut-up" quiet period expires next month.

There is an outside chance **Sherwin-Williams** could also be interested in Akzo. In the spring it had its hands full with the acquisition of smaller rival Valspar, but this was completed in June.

In a consolidating market it makes sense to own the takeover targets. It is clearer than ever that these include Akzo Nobel as well as Axalta.

—Stephen Wilmot



4. (25 pts.) Ralph and Colleen play a game. Sometimes they both select their strategy at the same time; sometimes Ralph chooses his strategy first and Colleen chooses her strategy after she sees what Ralph has decided; and sometimes Colleen goes first and Ralph chooses second. The payoff matrix for this game is as follows, where Ralph's payoff is listed first and Colleen's payoff is listed second:

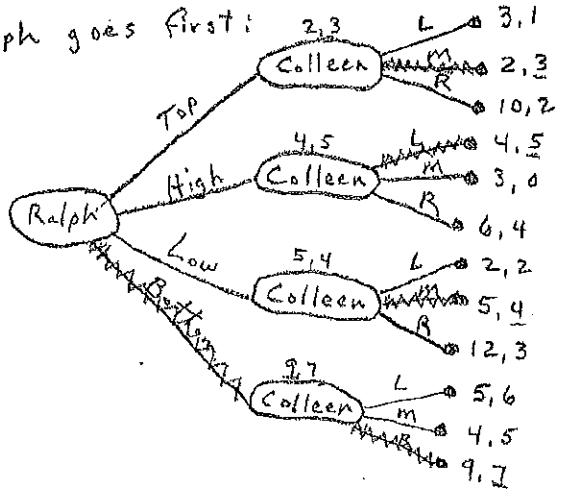
		Colleen		
		Left	Middle	Right
Ralph	Top	**3, 1**	**2, 3**	**10, 2**
	High	**4, 5**	**3, 0**	**6, 4**
	Low	**2, 2**	**5, 4**	**12, 3**
	Bottom	**5, 6**	**4, 5**	**9, 7**

a) Suppose Ralph and Colleen choose their strategies simultaneously. How do you think the game will turn out? Use the solution concepts we developed in class and explain your answer in a step-by-step fashion.

Ralph's best responses to each of Colleen's strategy options and Colleen's best responses to each of Ralph's strategy options are indicated above. For Ralph, the High strategy is dominated by the Bottom strategy, so a rational Ralph would never choose High and it can be eliminated. Also, Top is never a best response for Ralph, because either Low or Bottom is a better response than Top for each of the three strategy options for Colleen. So Top can be eliminated from consideration as well. Given that Ralph will never play Top or High, Left is dominated by Right for Colleen. Hence Left can be eliminated for her. We are left with the 2x2 payoff matrix consisting of the Low and Bottom strategies for Ralph and the Middle and Right strategies for Colleen. Ralph has a dominant strategy of Low, and predicting that play, Colleen will choose to play Middle. Low for Ralph and Middle for Colleen is a Nash equilibrium, because each player's chosen strategy is a best response to the strategy chosen by the other player.

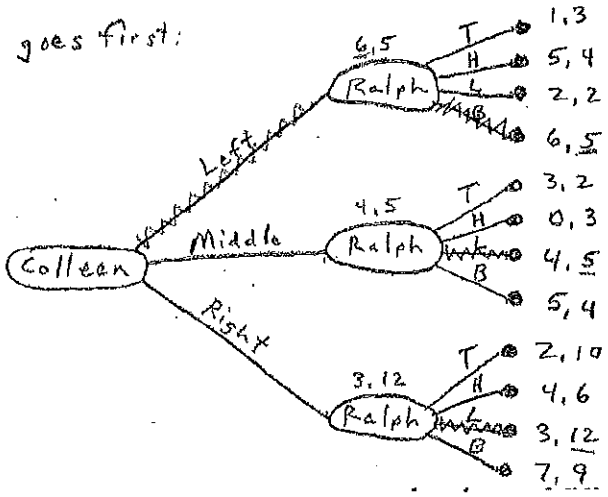
b) Now suppose that Ralph and Colleen decide to play the game sequentially, with one of them going first and the other one going second. The one who goes second chooses their strategy after seeing the strategy choice of the one who went first. They flip a coin to see who goes first, and Colleen wins. If you were Ralph, how much would you be willing to pay Colleen to let you go first? Draw the two game trees and explain how the game is likely to turn out in each case.

Ralph goes first:



SPNE is Ralph plays Bottom and Colleen plays Right. Ralph receives payoff of 9 and Colleen receives 7.

Colleen goes first:



SPNE is Colleen plays Left and Ralph plays Bottom. Colleen receives a payoff of 6 and Ralph receives 5.

Both Ralph and Colleen are better off if she goes second.

Since going first would earn you $4 more than going second, you would pay any amount less than that.

5. (10 pts.) Perform a Porter's Five Forces analysis of the market for pizza restaurants in West Liberty, KY.

Bargaining power of suppliers: not a factor for pizzas. Inputs are supplied competitively.
Bargaining power of buyers: not a factor. Many household customers.
Threat of substitutes: Pizza restaurants have some market power to the extent that households really, really want a pizza for dinner.
Threat of entry: until some guy had the bright idea of buying pizzas in Morehead and driving into town each day and hawking them out the back of his truck for a lower price that we were charging, life was good.
Internal rivalry: With two firms producing pretty much the same product, the possibility of suppressing competition and earning above-normal returns was promising for the two incumbent pizza restaurants. And then some outsider came in and spoiled it all.

6. (15 pts.) Some short-answer questions:
   a) Why would a firm in a monopolistically competitive market like the restaurant industry remain in business if they are earning zero economic profit?

Zero economic profit means that the firm is earning normal accounting profits on their investment, and doing just as well as the could do in their next best alternative. So no incentive to exit the restaurant industry and do something else.

   b) What popped the cork monopoly?

Some entrepreneur from across the Atlantic figures out a new use for recycled plastic—artificial corks for wine bottles. Cheaper, of more consistent quality, easier to re-cork the bottle—what's not to like? So the agricultural cooperative that had monopolized the natural cork market found their monopoly pricing power severely constrained.

   c) What are three sources of barriers to entry?

Ownership of an essential resource or raw material.
Significant economies of scale relative to market demand.
Legal barriers such as patents or licensing or regulations.

   d) Pick one of the three categories of price discrimination and give an example of it.

1st degree: walk down the demand curve, Dry Ridge Toyota. Two-part price, set price of beer at marginal cost and extract all surplus via a cover charge.
2nd degree: self-selecting quantity discounts, cell-phone pricing plans.
3rd degree: market segmentation, airline pricing for business vs. leisure travelers.

   e) Why do cartels tend to be unstable?

If a cartel is successful in collectively restricting output and raising market price, then each individual member could earn more profits by cheating on their cartel quota and expanding output to the point where P=MC. If multiple cartel members chisel on the agreement in this way, the cartel will cease to be effective in raising price above the competitive level.