Columbia Business School

Deconstructing the Price of Diamonds

BY NICOLAS STIER-MOSES[†] AND ASSAF ZEEVI[*]

ABSTRACT

Diamonds are often said to be priceless. Yet ultimately, like any other commodity, they carry a price tag. For casual buyers, trying to understand the fundamental drivers behind this price may seem quite challenging. This case and the accompanying assignment explore some determinants of diamond retail prices via a linear regression framework.

CONTENTS

Background

Since the dawn of time diamonds have signified wealth, status, style or the depth of one's love. Mined for the first time in India over 2,500 years ago, diamonds were first used as religious icons. Brazil took over the title of top diamond exporter in the 1700s when many stones were found in its rainforests, only to hand that role to Africa within 200 years. An aura of romance and mystery stemming from a diamond's ability to disperse light and retain its luster has always surrounded the stone.

The idea of a diamond engagement ring as a sign of commitment in marriage dates back to 1215 when Pope Innocent III declared a 'suitable and fixed' period between offer of espousal and matrimony. The first recorded gifting of a diamond engagement ring was made by King Maxillian to bride Mary Princess of Burgundy, a tradition the Venetians later embraced. But it was only in the mid-20th century that diamond rings shifted from the purview of European aristocrats to symbol of the unbreakable bond between man and wife in many cultures, an idea spawned by South African diamond giant De Beers.

De Beers essentially made the global diamond ring market through its near-monopoly status and clever advertising campaigns. Its iconic motto 'A Diamond is Forever' sparked heretofore non-existent demand for diamond engagement rings in the U.S.; its later 'Eternity' campaign extended it to older married women. (Around that time De Beers discreetly suggested that men set aside one month's salary for a diamond purchase, feeding the American ideal of conspicuous consumption). Gifting diamond rings to royals and celebrities also helped foster a diamond's association with sophistication and romance, immortalized in movies such as 'Breakfast at Tiffany's'.

In the inflationary 1970s diamonds were considered an attractive investment because their value was expected to hold or grow. That proved true, for some time. A diamond bubble developed between 1970 and 1980, when prices of some diamonds shot up forty-fold. But the diamond market crashed by 1981, with rough stone prices down as much as 30%.

But diamonds are hot again. Today shrinking stocks from major suppliers amid growing demand for diamonds from Asia's newly minted middle classes and U.S. non-marriage markets is leading to a 5% spike in diamond prices each year. Jewelers are targeting single professional women over 30, encouraging those holding out for the husband-ring combo to spoil themselves by buying a flawless diamond ring today. Men are also now buying diamonds for themselves. And remarriages are a growing market: better-heeled, older buyers tend to spend more the second time around. Finally, diamonds are going down-market in the U.S.: Wal-Mart sells diamonds today. As a result engagement ring sales are expected to grow around 5% a year through 2016, according to *Modern Jeweler*.[1] Market researcher Mineweb projects a global shortage of some $7 billion in diamonds by 2012.

The broader appeal of the diamond ring outside marriage and its infiltration into many markets has resulted in a vastly different industry in just ten years. As retailer Michael Warren of Warren's Jewelers in Lancaster, Pennsylvania puts it:

---

[1] "Rules of Engagement: Selling the Industry's Bedrock, the Diamond Engagement Ring is a Changing Game, with Higher Price Points and Shrinking Margins," *Modern Jeweler*, October 1, 2007

**Columbia
CaseWorks**

BY NICOLAS STIER-MOSES† AND ASSAF ZEEVI*

> [The engagement ring business] has changed more in the past eight years than in the previous 24 we've been in business. You see it in margins, volume, inventory, even the hours you keep. Eight years ago, I sold fewer solitaires, made higher margins, and had more of a life. There's so much to keep on top of now. The competition is so much closer and larger and the all-important engagement sale is so much more unique, customer-specific, and complex.[2]

Other recent trends have radically changed the industry's financial structure, including a push for more transparency and efficiency in an industry essentially controlled for over a century by a dominant supplier. Spearheading that push was former diamond merchant Martin Rapaport, who proposed a diamond commodity exchange and publishes a widely distributed diamond pricing report. There's also talk of dividends and futures diamonds markets, which appeal to investors fretting about inflation. Rapaport believes a futures market might help reduce margins. Commoditizing diamonds would enable a new breed of investor to add diamonds to his or her portfolio, similar to a stock holding. And a few firms are mulling diamond funds, in a similar structure to art funds.

But most experts insist that at best diamonds appreciate with time, and often only retain their value. The increasing sophistication of synthetic stones, considered chemically identical to diamonds suggests that though diamond demand is unlikely to wane, the sustainability of those high prices is an open question. Though the sentimental value of a diamond is unquestionable, no natural shortage of diamonds, price competition over the Internet (Bluenile.com is a favorite) and a paltry resale market make diamonds an unsure financial investment, long-term.

Some 57,000 pounds of diamonds are mined a year. In 2006, about $13 billion in rough cut diamonds were produced – over 60% from Africa. Americans buy over half of the world's $62 billion in diamond jewelry.

What is a Diamond?

Diamonds are highly compressed lumps of coal originating deep within the earth's core which change chemically from carbon into crystal over billions of years of heat and high pressure. Volcanic eruptions brought diamonds to the earth's surface and rivers transported them large distances. Today prospectors dig for diamonds by breaking apart solid lava believed to encase the precious stones in mines and rivers.

Valued for reasons beyond aesthetics including their hardness (they are the hardest naturally sourced mineral), abrasive nature and ability to disperse light, about one-fifth of diamonds are used in industry, for lasers, drill bits and surgical equipment, largely in the auto and aerospace sectors. They also serve as insulation and have high heat conductivity, suggesting that diamonds may have applications in the semiconductor industry. Over many billions of years, diamonds become graphite, experts say.

---

[2] "Rules of Engagement: Selling the Industry's Bedrock, the Diamond Engagement Ring is a Changing Game, with Higher Price Points and Shrinking Margins," *Modern Jeweler*, October 1, 2007

BY NICOLAS STIER-MOSES† AND ASSAF ZEEVI*

The Diamond Trade

Africa is the epicenter of diamond trade where nearly two-thirds of diamonds originate. Its industry employs over 28,000 just in South Africa and kicks back roughly $8.4 billion to the continent. Diamonds account for a whopping 75% of exports for Botswana, the world's biggest producer. Other major African diamond exporters include South Africa, Zimbabwe, Tanzania, Sierra Leone, the Democratic Republic of the Congo, the Ivory Coast, Liberia, the Republic of the Congo and Angola. The stones are also abundant in Brazil, Canada, India, Russia and Australia.

British explorers first blazed a trail to diamond mining in South Africa in the 1870s led by De Beers. The roots of the recent cartel structure were laid then, when wealthy arrivals snapped up most mining claims, creating the environment of artificial scarcity that endures today.

For over a century De Beers dominated the diamond trade, carefully controlling the supply of diamonds to meet demand by stockpiling stones and via deals with other producers to ensure that diamonds reached the market in lockstep with current demand, so that prices never fell. Overt and behind the scenes anti-resale campaigns suggesting that pawning diamond rings would bring bad luck, and reselling was viewed as kept diamond prices high. Allegations of anti-competitive practices in the U.S. finally caught up with the company by the late 1990s. In 2001, De Beers abandoned its near-monopoly status to focus on design and marketing at the high end, instead. The company still produces 40% of the world's rough diamonds, down from over 80% in the 1980s.

Industry Structure

Historically the diamond industry has been concentrated in a few key players on the supply and selling side with hundreds of smaller cutters and polishers in between in a highly fragmented service chain. Adding value thus consisted of many steps across a handful of countries, with each player charging a commission or mark-up along the way. Other diamond producing behemoths include Russia's Alrosa and Australian mining giants Rio Tinto and BHP Billiton. Cartier and Harry Winston are principal luxury good sellers on the retailing side.

Between that so-called 'Mine to Mistress' loop a host of wholesale diamond cutters and polishers gather in Antwerp, London, New York, Tel Aviv, Amsterdam, Johannesburg and Surat, India, though new centers are popping up in China, Thailand and tax-free Dubai. Today the world's biggest cutting and polishing spot is India. The country exported around $12 billion worth of cut and polished diamonds in 2005. Some two-thirds of all diamonds eventually end up in the U.S., many via Manhattan. Over much of the last century near the city's famous 'Diamond Alley' on 47th St., generations of Jewish families specialized in cutting, sizing and pricing diamonds. But today roughly 80% of all rough diamonds change hands in Antwerp before being forwarded for polishing and cutting to India, China or one of the other smaller diamond finishing centers. Diamond gemstones are next sold to wholesalers and retailers on over 25 global diamond exchanges, or bourses.

China is also becoming an important diamond jewelry manufacturing center. Today it lags only India in that category. Some $1.2 billion of rough diamonds were processed in China last year. Experts expect China's share that market to grow from 10% today to 26% in 2015 as it moves up the value chain from a low-cost production

hub to a high-tech, higher-end manufacturing center using sophisticated equipment, skilled labor and the latest designs.

Recent Changes

In only ten years the diamond industry has changed radically. The end of De Beers' near-monopoly paved the way for new players from Russia and Israel and unleashed a flurry of new diamond exploring activity in Africa and elsewhere. New vertically integrated business models that shorten the supply chain are enabling upstarts to speed ahead. Consolidation among arrivals has also helped them to reap savings and synergies along the supply chain and capture more value-added business.

According to Daniel White, UK business director of Diamond Trading Company, the largest supplier of diamonds in the world:

> The trend in the diamond industry is to shorten the supply chain. Previously there would be nine or even 10 steps between the rough coming out of the mine and the shop window. Companies are realising it makes sense financially to consolidate the pipeline and take part in more of the process. As a result, the end consumer now faces a wider array of diamond brands than before as new and established diamond jewelry purveyors jostle to position themselves and compete for our attention.[3]

Newcomers include Israel's Lev Leviev (named after the company's founder), which is now the world's largest diamond cutter and polisher. The group also owns the world's biggest private diamond mine and is a top private seller of rough stones. The Russian émigré began as an apprentice diamond cutter and is now ranked at 278 on Forbes' List of International Billionaires. Today his employees polish and cut stones in Israel, Armenia, India and the Ukraine. Meanwhile, Russia's Alrosa, second only to De Beers for its diamond market share, is expanding diamond exploration in Africa.

Fresh arrivals from South Africa are harnessing unconventional technology including aerial imaging from slow-moving zeppelins to pinpoint stones. In tandem, diamond-rich African nations with freshly-elected democratic governments like Liberia are demanding a larger stake in natural resource extraction, reviving a long-dormant diamond industry. So far they've nearly always come up empty, exacerbating already scant supply, since no notable diamond discoveries have been made since the early 1990s. Soaring demand from Asia and De Beers depleting its earlier inventory have worsened the diamond shortage.

Blood Diamonds

Public pressure to end the widespread practice of cooperation with corrupt governments has helped created a niche industry akin to the fair trade coffee movement certifying diamonds sourced from a country that does not fund wars. Historically many diamonds made their way out of Africa via smuggling or were sold in exchange for arms or other illicit goods to ensure a steady and unfettered supply of stones. Horror stories abounded about the

---

[3] "Diamond retailing: Buyers Dazzled by High-carat Choice," *Financial Times*, March 30, 2006

ill treatment of child miners and use of human jewel mules to shuttle stones across borders. Cries to curtail the smuggling and sale of these so-called 'conflict diamonds' led to international diamond trade certification agreements.

This U.N.-backed 'Kimberley Process' certifies that diamonds were shipped in tamper-proof containers, accompanied by documents confirming a gem's border crossing and route to ensure their 'conflict-free' nature. Niche ethically mined diamond businesses have also popped up. In 2005, Two Stanford Business School alums, for example, founded 'Brilliant Earth' a web-based venture that facilitates the purchase of diamonds from Canada, which (not surprisingly) is a top source of conflict-free stones. Only 11% of U.S. jewelers had a policy on conflict diamonds in 2004. Less than 1% of diamonds today are said to be tainted by conflict, down sharply from 15% in the 1990s.

Pricing a Diamond

Diamonds differ from semi-precious metals which have a fixed price per gram that fluctuates with demand. Originally valued for their weight, or 'carat', many other qualities play into diamond values today.

For a rough guess of diamond prices, many turn to the top industry rag, the Rapaport Diamond Report, which lists polished diamond prices. Organizations grading diamonds include the Gemological Institute of America, Diamond High Council, European Gemological Laboratory and International Gemological Institute.

Though diamonds are illiquid, their high value per unit weight makes them an attractive store of wealth since they are compact and can be moved easily (per ounce and based on quality diamonds are worth about 1800 times their equivalent weight in gold.) Other clues to a diamond's value include the whiteness of a diamond and its ability to refract light, both of which would positively impact its price. A brilliant, colorless and flawless diamond is the ideal. Those looking at diamonds as an investment would be wise to hold on to it for between five and ten years, to allow for appreciation, experts say.

Period pieces in their original settings, links to a celebrity owner like Elizabeth Taylor, and jewelry from luxury goods makers like Cartier may command more resale value than an off-the-shelf Kay Jewelers model. Some also advise going as closely to the source as possible for cut and polished stones, rather than a retailer, to trim commissions and mark-ups for dealers, cutters and retailers, and insist that buyers always request a certificate. Finally, buying offshore may eliminate value-added taxes.

Above all, since diamonds can cost buyers a month's salary or more, gemologists and trade specialists advise diamond buyers to familiarize themselves with grade and market value. Last year, over 80% of engagement rings sold in the U.S. had an average selling price of $3,200 for a full-carat ring, up from 80 to 85 points in 2005 priced at roughly $2,600. Near-perfect diamonds as small as 6 carats can demand upwards of $8 million at auction.

Columbia CaseWorks

BY NICOLAS STIER-MOSES† AND ASSAF ZEEVI*

Today the four 'Cs' dictate a diamond's price: cut, clarity, color and carat. These grading standards were codified by the Gemological Institute of America (GIA), which will grade and certify diamonds, although they do not provide appraisals. Certification from the GIA can sustain a diamond's value over time.[4]

Comparing price per carat between similar diamonds is a starting point, achieved by dividing diamond costs by its carat weight. The four variables below normally dictate a diamond's price. (In the questions that follow you will explore this in more detail.)

CUT:
Considered by some as the primary factor influencing a stone's beauty and cost because facet width and depth determine a diamond's sparkle and brilliance. Cuts are rated class 1 to 4, based on shape and symmetry, with the most popular shapes round, marquise, rectangular, square, oval and pear.

CLARITY:
The whiteness of a stone, and the absence or presence of flaws. Ratings range from 1F (flawless) to very, very slight (VV2 1-2), very slight (VS 1-2), slight (S1 1-2) and pique (P 1-3) for noticeable flaws.

COLOR:
A near-perfect diamond is white; yellow-tinged diamonds demand less of a premium. The industry uses a grading system of D to Z with D applying to rare, completely colorless diamonds, progressing through the alphabet in shades of yellow to a near-brown at Z. Symmetry is also key, or how a diamond's facets align, to get the best play in light.

CARAT (WEIGHT AND SIZE):
The rarity of larger diamonds allows them to command a higher price. One carat weighs roughly 200 milligrams.

---

[4] Liberman, Si, "Diamond District in new York City Still Sparkles," *The Daily News*, Dec. 19, 2007

Questions

The following questions explore the pricing of diamonds via linear regression (in all such regressions use 'price' as the dependent variable). The referenced data set can be found in the file `DiamondPricing.xls` downloadable from the course web page. In your answers provide the explanations, exhibits and regression output tables that you feel are needed to support the discussion and conclusions.

1. Produce a *scatter plot* of 'price' versus the explanatory variable 'carat.' Compute the correlation coefficient between the two variables and comment on the nature of the scatter plot and the extent of dependence observed.

2. Run a simple regression using 'carat' as the explanatory variable.
   a.) What is the correlation coefficient between the two?
   b.) What is the p-value for the coefficient of 'carat'?
   c.) Is the intercept statistically significant?
   d.) Inspect the scatter plot from question 1 and the regression line, and comment on the fit of the line to the data. (Discuss both in terms of quantitative and qualitative measures.)

3. Run a regression using 'carat', 'width', 'depth', 'height', and 'volume' as explanatory variables.
   a.) Comment on the R-squared and p-values.
   b.) Compare the quality of the fit with that obtained in question 2.
   c.) Using step-wise variable selection, arrive at a model in which all variables are significant. Provide the final regression output, and explain the steps taken to arrive at this model. Compare this model with that in part.a.) and discuss possible reasons for the removal of some of the variables.

4. Run a simple regression using 'color' as the explanatory variable. First make 'color' a discrete-valued variable, and then use dummy variables. Compare the two models.

5. Run a regression using 'carat' and the dummies for 'color' as the explanatory variables.
   a.) Consider a 1.5 carat diamond with color grade 'F'. What is the predicted price of this diamond?
   b.) What is the predicted price for a diamond of the same size but of color grade 'J'?
   c.) If you have a budget of $20,000 to spend on a diamond, what is the expected maximum size that this would buy for each color grade ('F' and 'J')?
   d.) Use your regression model to conclude which color grade ('D' through 'J') is the cheapest-per-carat and most expensive-per-carat (in a statistically significant manner). Discuss your conclusions and explain any assumptions that are needed to support them.

6. Run a regression using *all* explanatory variables.
   a.) Use step-wise variable selection to arrive at a final model. Comment why you selected this model and any underlying assumptions.
   b.) Predict the price of the two candidate diamonds X and Y whose characteristics are given in the spreadsheet. Give 95% prediction confidence intervals. Is one of the two diamonds more expensive in a statistically significant manner?