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The Diamond Industry: An Investigation on the Competition Post Lab-Grown Diamonds' Entry

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Abstract

Mined diamonds and lab-grown diamonds are both made of pure carbon. The only difference between the two types relies in the origin and in the price. If they are chemically and aesthetically the same, why is someone willing to spend more for natural diamond jewelries? The answer might be consumer perception, since diamonds are still associated to the romantic idea that "a diamond is forever" — a purchase made with love rather than money. However, as natural diamond prices are rising, owing to a considerable gap between demand and supply induced by COVID-19 and the Russia-Ukraine War, more people might switch their jewelry purchases to a more affordable and sustainable alternative: lab-grown diamonds.

To see whether the two types of diamonds compete against each other, concept of competition theory were applied in the research. The latter consisted of an assessment of the relevant market over the geographical and product dimension. The empirical demonstration of supply and demand substitutability provided that the two types of diamonds somewhat belong to the same relevant market, indicating a certain degree of competitiveness between mined and lab-grown diamonds.

Consequently, the natural diamond industry cannot ignore the expanding presence of lab-grown diamonds within the market. For such reason, mining companies are already taking defensive measures to protect their market position. However, the dilemma is whether it is preferable to aggressively compete against the opponent through price manipulation or simply try the best to meet consumers' needs.

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CHAPTER I – The Modern History of the Diamond Industry

Introduction

In the following chapter, we will provide a brief history of the diamond industry, beginning with the discovery of mines in South Africa by Cecil Rhodes (founder of De Beers) who did an exceptional job of securing the company's initial dominance. The mining company was then taken over by another man, Ernest Oppenheimer, the man who established the most enduring monopoly.

The chapter carries out a supply and demand analysis in order to understand the reasons behind such dominance.

1. De Beers: The Secrets Behind The Success

Rarity and luxury come to mind when thinking about diamonds. However, few people are aware that these rare gems are not as scarce as they appear on the market. A look at the history of the raw diamond industry is required to explain the exorbitant prices of these particular stones.

Diamonds were regarded as an extremely limited resources until the nineteenth century when large deposits were discovered in South Africa, igniting the diamond rush. Cecil Rhodes, an English entrepreneur who initially rented water pumps to local mines, entered the diamond market by aggressively acquiring as many mines as he could when he sensed the potential of the business. The company's name derives from the last name of two Dutch Settlers, "De Beer", who discovered diamonds in their farmland which was then sold to form two mining sites: the Big Hole and the De Beers Mine. In 1888, Rhodes established its company under the name "De Beers Consolidated Mines Limited", the fruit of the merger between Barney Barnato's Kimberley Central DMC – a rival diamond mining company – and De Beers mines. The newly consolidated company became the sole owner of all mines in South Africa, and this is just the beginning of De Beers' century-long dominance in the uncut diamond market. Following that, the company implemented several strategies that nourished the monopoly, including supply chain control, the implementation of persuasive marketing schemes, and even negotiations with governments (Kretschmer, 2003).

To acquire control of the distribution route, Rhodes collaborated with his purchasers and founded the Diamond Syndicate, through which distributors would buy solely from Rhodes at a predetermined price and quantity. The common objective was to maintain the scarcity by keeping supply closest to demand (amount of weddings engagements) and stockpile in case of excess supply with the ultimate objective to drive prices up (Goldschein, 2019).

Another major character of the industry is Ernest Oppenheimer, a German businessman who initially collaborated with the Premier Mine (today known as the Cullinan mine), a mining deposit discovered in 1898 which refused to join the Rhodes' distribution net. Ernest Oppenheimer was also an influential figure within the gold industry being the founder of the Anglo-American Corporation of South Africa. De Beers' chairman at that time, Francis Oats, did not understand the threat imposed by the Premier Mine and new mining sites found in German South West Africa and sticked to Rhodes' legacy. In 1905, De Beers successfully acquired the Premier Mine and, in the meanwhile, Oppenheimer humbly purchased shares year after year whenever De Beers would release them. In 1925, the German businessman took over the Diamond Syndicate and in 1929 became the chairman of De Beers (Kanfer, 1993).

To build the longest-lasting cartel in history he understood that "[…] the only way to increase the value of diamonds is to make them scarce, that is to manipulate production" (Strimpel, 2014).

1.1 Supply Analysis

De Beers diamonds were distributed through the Central Selling Organization (CSO), An intermediary based in London that delivered manufacturers' diamonds to the customers that were either polishers or final consumers. Substantially, a subsidiary of DeBeers would purchase diamonds from all producers, even from DeBeers' own mines, then market the stones through the CSO at a determined price and quantity. Ten times a years, a handful of dealers, or "sightholders", are called by De Beers to attend the "sight" at the CSO headquarters to receive a collection of diamonds chosen by DeBeers, according to what the mining company and the dealers wish to sell on the market. The offer is made on a take-it-or-leave-it basis meaning that the collection of diamond is sold on "sight" without the opportunity for the dealer to haggle on price or quantity. At the time, the CSO handled almost 80% of the international diamond trade, allowing DeBeers to establish artificial diamond shortages and price stability. The most effective strategy for DeBeers was supply dominance paired with partial control of mine output, preparation/cutting, and retail (Spar, 2006).

The above model was the winning strategy until the 1950s, when South African diamond stocks began to diminish, coupled with the discovery of new mines in other locations like Russia. Given their exceptional quality and availability, Soviet diamonds posed a serious challenge to the business at the time. However, the industry model leaves ground for cooperation; All players within the market were frightened by one thing only: disrupting the image of scarcity and knocking the prices down. So, fierce competition within the market was harmful for De Beers and the new entrant. Consequently, the Soviets agreed to cooperate and become a member of De Beers' cartel but owing to social and political factors such as anti-apartheid laws in the 1960s and the collapse of the Soviet Union, Russia was pushed farther and further away from De Beers' distribution. This might explain why DeBeers' market share fell from 90 percent in the late 1980s to 80 percent by the early 1990s (Australian Diamond

Figure 1. De Beers' market share over time. From "De Beers – Monopoly Broken". Retrieved from https://www.diamondportfolio.com.au/investor-centre/market-information/de-beers-monopoly-broken/. Copyright 2014 by The Diamond Portfolio

Portfolio, 2018).

1.2 Demand Analysis: The Marketing Strategy Of The Century

Diamonds are universally recognized as a token of love. Where did this concept come from? In 1948, De Beers debuted with its slogan "A diamond is forever", playing with the consumers' sentiments to secure its product success. The goal of this catchphrase was to create a clear gap between price and diamond, the latter being an amulet of love that should not be judged in monetary terms. The message was clear, an enduring piece of jewelry that will be treasured for a lifetime was definitely worth every penny earned over months. Part of the plan was to destroy the resale market and diamond speculations that had a potential effect of decreasing the sentimental value of diamonds and would have fixed the prices to economic fluctuations. De Beers understood that in order to secure its monopoly it had to artificially fix supply and demand whenever it could (Spar, 2006).

For instance, in the 70s, Israeli diamond dealers started to convert their financial assets in diamonds as they thought the stones to be a shield from inflation which was then crashing the country. This type of demand-side speculation was threatening the sentimental value of the gems as the prices would have soon begin to rise speculatively. To impede this, De Beers imposed a drastic price rise on diamonds sold by the CSO and it also dismissed the title of hundreds of dealers to purchase through the CSO (Yu, 2006).

De Beers' reaction to demand shocks is intriguing. In 2004, there was a rapid spike in demand (6% increase in jewelry sales), and producers were unable to keep up with the supply. In any other commodity market, an increase in demand is seen to be a positive factor but De Beers' is negative on any kind of fluctuation as stability is the environment in which the mining company thrives. De Beers' answer was unorthodox: it chose to hike prices by 14 percent, and other large producers soon followed. Figure 2 illustrates the diamond price per carat from 1960 to 2016, where the price increase from 2000 to 2010 is plainly visible:

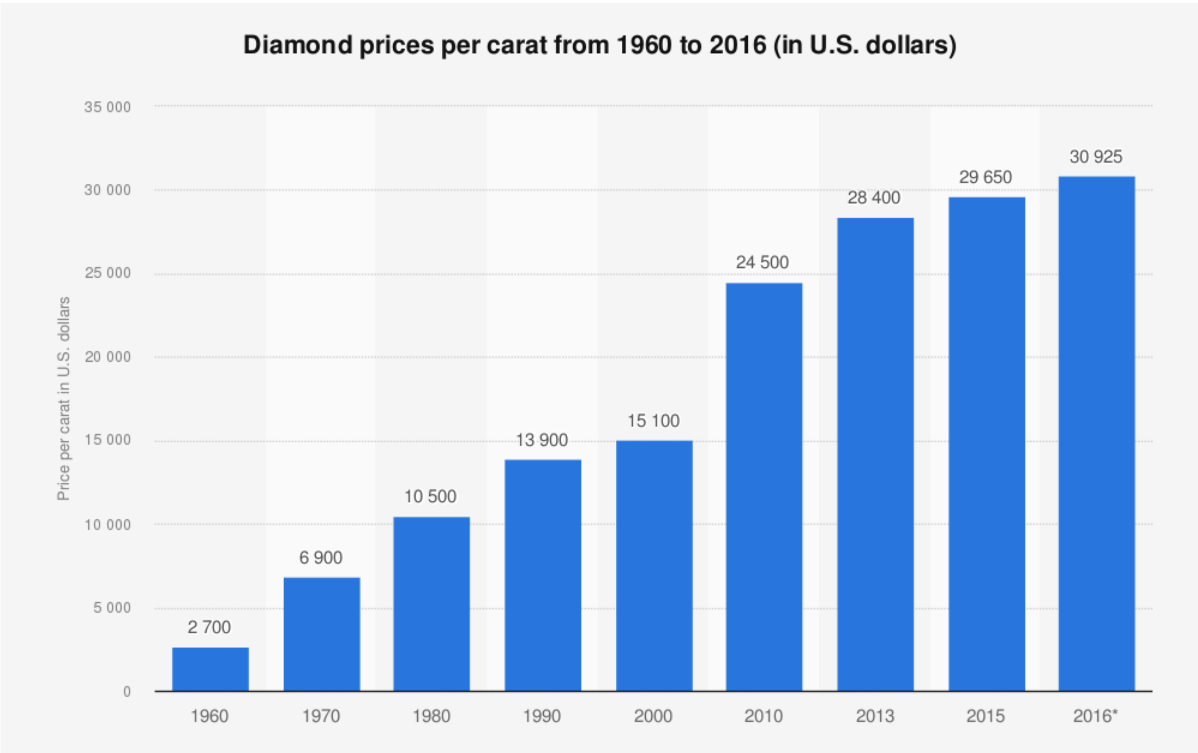


Figure 2. Diamond prices per carat from 1960 to 2016 (in U.S. dollars). From "Statista". Retrieved from https://www.statista.com/statistics/279053/worldwide-sales-of-polished-diamonds/

Even though De Beers' stockpile reduced to zero after this move, what is important for the company was maintaining the long-term stability within the industry because price shocks of the market could turn to a permanent shift on consumers' sentiment for diamonds and speculation. What is fundamental is not to shatter the image of "valuable and scarce" of the gems.

The information gathered until now gives a taste of the market dominance of De Beers. It is interesting how the latter can manipulate supply and demand to its own advantage and making everyone play by the rules of the cartel as also other players fix their behavior to De Beers' strategies. Interestingly enough, there is no other firm in history which had enough market power to dictate what and how consumers should purchase, leaving little freedom to the downstream level and buying power to the customers. This means that also the demand is basically constructed by De Beers. This explains the reason behind the 2004 price increase that had some arguable effects on the diamond sale in the short-run and, despite this, the major producers followed De Beers' footsteps. As a result, the industry remained intriguingly robust and consistent under De Beers ruling.

2. Building A Cartel: The De Beers' Approach

An effective and reliable retaliation system is a critical instrument for protecting collusion and exercising market control. For instance, the success of De Beers' punishment mechanism was influenced by its high market share which gave him the power to exploit its dominant position. Precisely, whenever an independent rough diamond producer refused to join De Beers' distribution system, it essentially flooded the market with its stockpiled diamonds similar to those offered by its rivals, lowering the profitability of the industry as a whole. So, De Beers purposely sacrificed its own profits which raises anticompetitive concerns and imply an abuse of dominant position (McConnell, 2018).

Essentially, to maintain its dominant position, De Beers tried with all its efforts to control market supply (see chapter 1, paragraph 1 "Supply Analysis") so, for years, dealers and cutters bow-down before De Beers as it was the only source of diamond supply. De Beers was able to maintain its leading position for decades, even after the entry of new mining companies but this dominance did not last forever. Due to historical events that tempered competitive constraints, smaller rivals gradually withdrew from the cartel over time, challenging the position of De Beers.

By definition, diamonds are durable goods so, according to the Coase Conjecture, De Beers would have eventually lost its market power given the durability and expectations that characterize the market of durable goods. The key concern here is customers' ability to engage in price arbitrage: if they expect diamond prices to decline in the future, they will most likely postpone their purchase. Thus, the cartel might maximize its profits by deceiving people that prices would never fall but will always climb (Church & Ware, 2000).

Indeed, the Central Selling Organization had a policy of never decreasing prices but rather it raised prices for decades, even above the inflation rate. The CSO maintained this strategy regardless of economic fluctuations and the forgone profits because it simply could not shatter the image of diamonds. To accomplish so, it had to exercise substantial control on supply and withhold excess gem production by keeping a stockpile of stones to be released whenever was necessary. It also controlled the supply through exclusive supply contracts with cartel members and by buying diamonds in the open market from other competitors. Even during the worst diamond bubble in the 80s, De Beers was able to maintain its prices, withholding stockpiled diamonds to stop the imminent price fall after the burst of the bubble. The crash was made even worse the Soviet Union dumped its diamonds in the market, but the cartelist still managed to sustain its strategy (Boyajian, 1988). Figure 2 is the proof of the success of De Beers' market manipulation as the average price for diamonds during the period 1980-1990 (comprising the years of the bubble) increased by 32.4% US dollars globally (from $10,500 per carat to $13,900 per carat).

2.1 Price Fixing: De Beers and General Electric Co.

De Beers was already accused of price fixing right after World War II, an anticompetitive practice condemned under the Sherman Act. In 1994, De Beers and General Electric were charged for price conspiracy of industrial diamonds, used to manufacture cutting and polishing tools. The class-action lawsuits were brought by individuals and businesses in US domestic market for diamond products, accusing De Beers of monopolizing the US market. The two parties involved were found guilty of provoking an artificial rise in list-prices through communication of future prices with each other. The charges against General Electric were eventually dropped for lack of evidence. On the other hand, De Beers pleaded guilty for such violations and agreed to pay a $10 million fine as part of the agreement to re-enter the lucrative US market for diamonds (Labaton, 2004) (Department of Justice, 1994).

2.2 Supply Manipulation: De Beers and Alrosa's Trade Agreement

De Beers' market position was resilient enough to keep prices stable even when the Soviet Union released an estimated $1 billion US dollars outside the cartel. On the other hand, De Beers was able to curb competition by establishing an exclusive arrangement with Alrosa. A trade relationship between the two firms has existed since 1959, but it was only in 2001 that it was brought to the attention of EU antitrust regulators during a merger inquiry by the Commission.

In 2001, ALROSA and De Beers signed a five-year $4 billion trade agreement, allowing De Beers to purchase $800m worth of diamonds from the Russian mining company (Bloomberg, 2001). However, the two parties announced to the Commission that the agreement ended in 2001 in the hope to obtain an exemption provided by Article 101 (3) TFEU. In the preliminary assessment, the Commission found that such agreement contributed to the enrichment of De Beers' current and future market-maker share; it also constrained the competition between the parties, excluding Alrosa from operating as a supplier in the market. The judgment by the Commission confirmed indeed an abuse of dominant position by De Beers. Upon these findings, the parties proposed to gradually reduce the purchase over the five-year to come. The Commission found that the only way to meet the requirements of Art. 102 TFEU was a complete phase-out by the De Beers from the agreement. In 2006, the Commission closed the proceedings after De Beers accepted to engage in determined binding commitments. However, Alrosa challenged the Commission decision before the General Court (GC) as it considered the commitments to be excessive to the competitive concerns proposed by the authority. The CG overturned the Commission's decision, declaring that the latter was not permitted to obstruct the dominant firm from purchasing from its direct competitor, and that even if there was evidence of an ad hoc sale agreement between the parties, this would not have violated competition rules. However, the ECJ annulled the CG's decision and rejected Alrosa's pleas, confirming on 29 June 2010 the Commission's application of Article 102 TFEU as definite judgement to the case. The ECJ also implied that the undertakings shall not strengthen their dominant position by engaging in abusive behavior by harming competition. The Commission has the authority to forbid such action to preserve consumer welfare (Mische & Višnar , 2010).

2.3 De Beers and Alrosa's Relationship Post-Agreement

The above case has a particular significance for the diamond industry as it is a rare moment of victory for consumers after centuries of pricing abuse imposed by De Beers. As part of the agreement, De Beers had to gradually shift out of the supply agreement with Alrosa in order to ensure a fair market for the competitors and the consumers. However, experts found that the parties might have engaged in price collusion even after the closure of the above antitrust case.

A pro-collusive environment within the diamond industry is given by two elements:

1) A comprehensive index of present retail prices classified by diamond type from a third party – i.e. the Rapaport retail price index.
2) Price commitment in the oligopoly without the possibility of defection.

The journey of rough diamonds to retail is lengthy, so the effect of price collusion taking place on the upstream level may seem less obvious across the supply chain. In order to understand how miners impact retail pricing, it is essential to understand each player's role throughout the value chain and draw a clear distinction between rough and polished diamond costs. The below figure clearly illustrates the distinct stages of the value chain:

Figure 3. The Value Chain of Diamond. From Diamond Foundry. Retrieved from https://diamondfoundry.com/blogs/the-foundry-journal/how-price-collusion-works-in-the-diamond-mining-industry

Costs and prices may be established with more ease for firms at the downstream level of the supply chain due to market features such as a higher degree of pricing transparency and competition. Indeed, the value of a polished diamond is commonly determined by the 4Cs: cut, color, clarity and carat weight. Instead, prices for rough diamonds depend on volatile features such as the production capacity of a determined year or the rarity of the stone. So, what is the logic behind the wholesale prices established on the upstream level? Assume that the costs for intermediary services are known and account for a fixed price of $50 per rough carat. The fixed return to polish a diamond is 30%. These cost assumptions are made upon predictability for intermediary prices. The secrecy of the price actually relies almost entirely on the mining level as the downstream prices are either known or predictable. Hence, the wholesale price from miners to retailers could be represented by the following equation:

$$Diamond\ Wholesale\ Price \geq \frac{rough\ diamond\ price\ per\ carat + \$50}{30\%} \qquad \textbf{Equation (1)}$$

However, competitive concerns arise when the rough suppliers collude and set the following pricing scheme:

$$Diamond\ Wholesale\ Price \geq \frac{rough\ diamond\ price\ per\ carat + \$50}{30\%} \qquad \textbf{Equation (2)}$$

In an oligopoly, price coordination take place easily due to the low concentration of firms. In this case, it only takes De Beers and Alrosa to apply this pricing scheme given the high market power owned by each firm and there is evidence in their corporate policy that they follow this strategy. This is price collusion as its best and, as long as no detection occurs, following the strategy yields benefits to both parties (Diamond Foundry, 2020).

Collusion is easily sustained also by symmetry and product homogeneity. Detection is not a profitable solution as the decision to lower prices by one firm could harm the whole industry. This could compromise the perception of the diamonds since price is not the primary concern during a diamond jewelry purchase. The intrinsic value or utility of a diamond do not drive demand; rather, diamonds are purchased for their emotional appeal. At the end, it all returns to the grand marketing slogan of De Beers: "A Diamond is Forever" (Bracking & Sharife , 2014).

3. The Rough Diamond Industry Today: Competition Overview and Prospects

A Diamond may be forever but a cartel's power will eventually fade due to the changes within the market and the intervention of antitrust law. As briefly mentioned before (see Chapter 1, Section 1.1), the discoveries of new mines in other countries (e.g. Canada, Russia etc.) threatened De Beers' dominance and thus it had to come up with new strategies to maintain its position.

The industry of rough diamonds constitutes high barriers to entry given that access is constrained by the discoveries of mines which is very costly and complicated. Historically, diamonds were considered an extremely rare resource, even carrying a divine and noble conception. The modern history of the diamonds begins with the discoveries of mines in Kimberly, South Africa. In fact, there is a widespread misconception that diamonds are only found in South Africa. In reality, diamonds are a global resource. Already in the 16th century, important diamond deposits were discovered in Brazil, followed by the mass discoveries of South African mines which De Beers was able to exploit. Other operators joined the industry when other mines were discovered (Kohn, 2002).

By the end of the 20th century, after the Soviet Union joined the world diamond production, Russian diamonds constituted an important threat to the existing market given their notorious quality. Meanwhile, Zaire (today knowns as the Democratic Republic of Congo) joined the world production with lower quality stones. While South Africa and Russia maintained a constant supply, Zaire's mass produced inferior-quality diamonds, flooding the market with cheaper stones, potentially undermining the reputation of diamonds.

In 1980s, Botswana entered the industry after the discovery of a new mine: the Jwaneng. The latter was so productive that the country became the third producer of diamonds in volume and second in the value. Botswana distinguished itself from providing superior class diamonds that were highly demanded in the market. To secure its dominance, De Beers entered into a joint venture with the government of Botswana to create "Debswana", a mining company which ownership belongs equally to both parties, an agreement which impact is not indifferent on the industry.

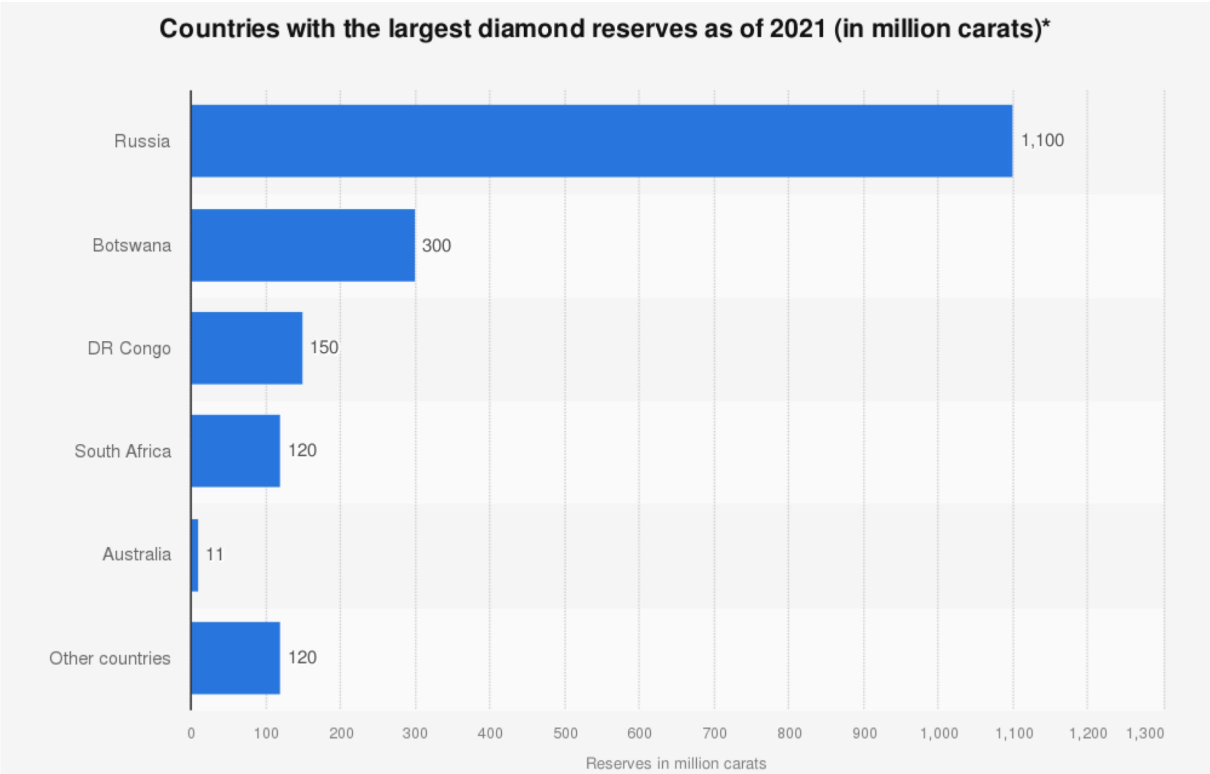


Figure 4. Countries with the largest diamond reserves as of 2021 (in million carats. From Statista. Retrieved from https://bit.ly/3NkpVz5

Another wave of discoveries occurred in 1985 with the entrance of Australian diamonds and in 2000 when diamonds were discovered in Canada (Gemological Institute of America, 2016).

Figure 4 reproduces the largest reserves in 2021, measured in volume of production in million carats. As it may be observed, Russia owns the most productive mines, reaching 1.1 billion carats in 2021. The second biggest producer is Botswana which supply is estimated for 300 million carats. Also, Congo is a big supplier given production reach approximately to 150 million carats. Of course, South Africa has been historically one of the main producers, supplying roughly 120 million carats in 2021. Finally, the other major producer country is Australia, ranging to 11 million carats of diamonds. Other countries (e.g. Namibia, India, Indonesia, United States etc.), contributed 120 million carats in 2021 (Garside M. , 2022).

3.1 The Main Competitors of the Industry

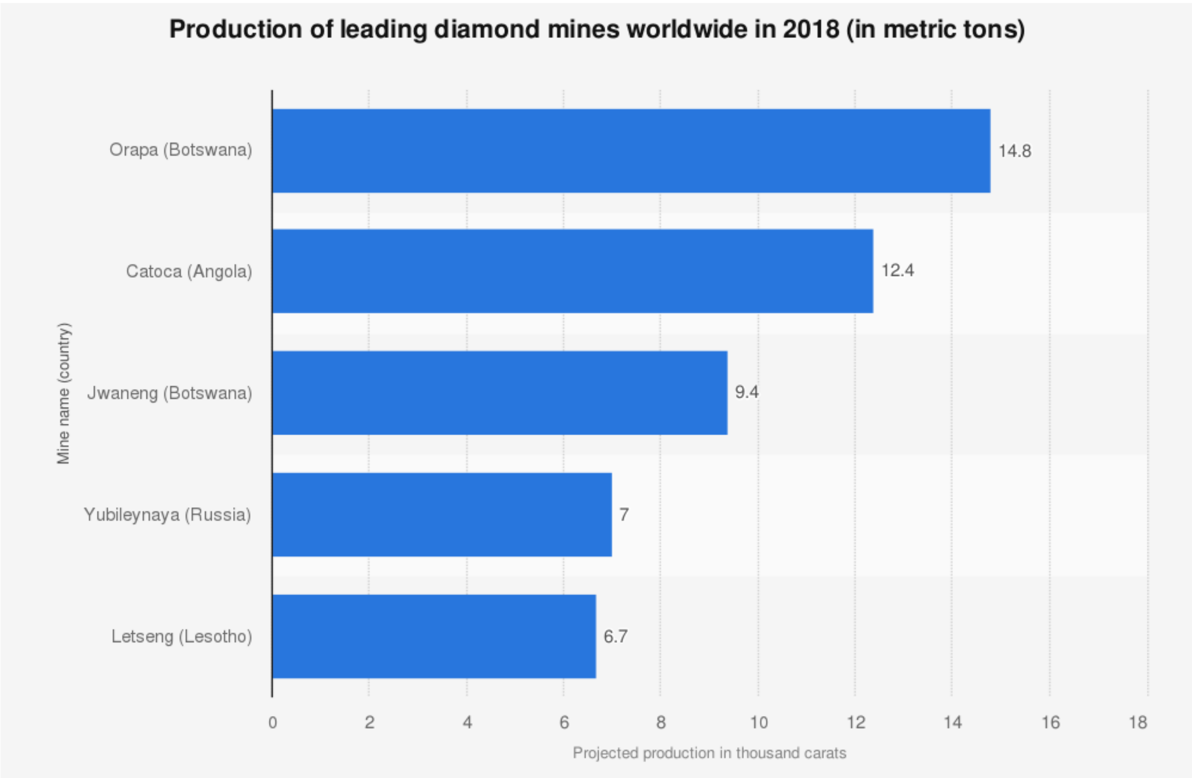


Figure 5. Production of leading diamond mines worldwide in 2018 (in metric tons). From Statista. Retrieved from https://www.statista.com/statistics/585297/projected-diamond-production-worldwide-by-leading-mines/

An interesting fact is where do the major mining companies operate to evaluate how much supply they control. As observed in Figure 4 and 5, the four countries with the largest diamond reserves in 2021 are in Russia, Botswana, Congo and South Africa. Now, one question arises: who are the operators in these countries?

As the market changed dramatically due to the entrance of new producers, De Beers had to adopt new strategies to defend itself from the new competitive fringe. De Beers is still one of the main players of the industry, but diamond supply no longer belongs just to one firm but instead diamonds flow into the market from multiple channels today. Although, the underlying structure of distribution did not alter much. Diamonds still flow from mines through cutting centers, and ultimately to retail customers as shown in Figure 3.

Today, the rough mining industry is no longer a monopoly, but it is indeed an oligopoly of few firms owning a certain degree of market share in the industry. In the following sections, the major diamond producers will be analyzed according to where they operate and how much supply they control in each country. The following figure gives an idea of the market shared by the firms in the industry today:

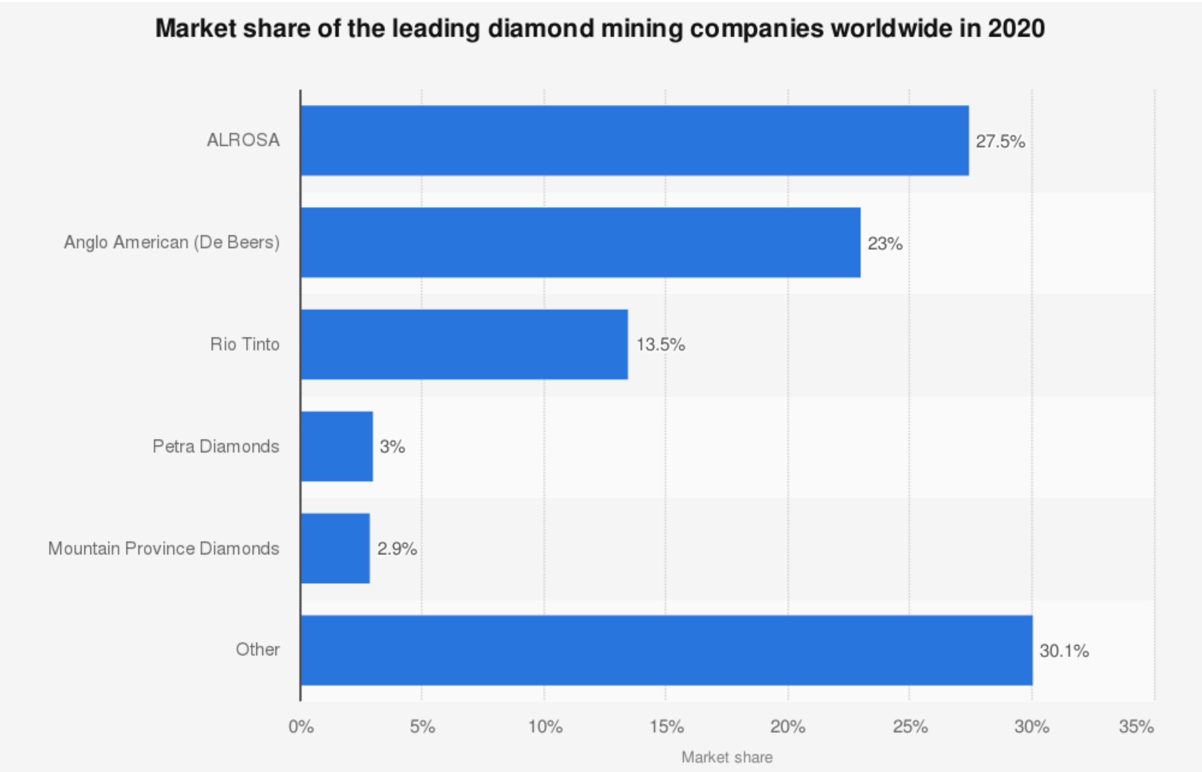


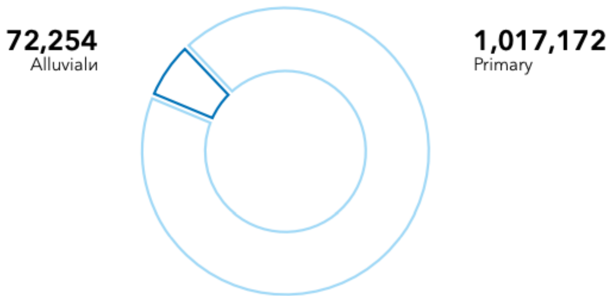
Figure 6. Figure 6. Market share of the leading diamond mining companies worldwide in 2020. From Statista. Retrieved from https://www.statista.com/statistics/585450/market-share-of-diamond-supply-worldwide-by-producer/

2.1.1 Alrosa Group

Alrosa is the leading mining company of Russia (see Figure 6), as well as the largest public owned company, having its public float of 34%, with 66% owned by the Russian Federation, the Republic of Sakha (Yakutia) and the municipal agencies of the Republic of Sakha (Yakutia).

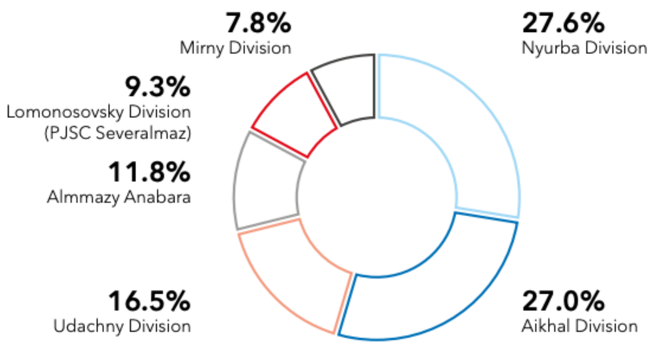
What contributes to the creation of the sizeable market share is the fact that the largest mining reserves are in Russia (estimated to 1.1 billion carats) and Alrosa accounts for 95% share in Russia's diamond production . The company operates in two regions of Russia – the Republic of Sakha (Yakutia) and the Arkhangelsk Region – and in Africa (Alrosa, 2018).

Alrosa Group (2022) identifies that "As of 1 January 2021, using the standards of Russian National Reserves Committee, the diamond reserves on the Group's balance sheet totaled 1,089,425.7 thousand carats.". 93% of the diamonds originate from "primary mines" while only 6% come from "alluvial mines" (see Figure 7 below).



Indicator	thousand carats
Primary	1,017,172
Alluvial	72,254

Figure 7. Figure 7. Diamond reserves as of 1 Jan 2021, thousand carats. From "ALROSA Annual Report 2020" (page 52) by ALROSA Group, 2021. Retrieved from http://www.alrosa.ru/wp-content/uploads/2021/06/ALROSA-Annual-Report-2020.pdf



Indicator	%
Nyurba Division	27.6
Aikhal Division	27.0
Udachny Division	16.5
Almazy Anabara	11.8
Lomonosovsky Division	9.3
Mirny Division	7.8

Figure 8. Structure of diamond production by the mining divisions of the ALROSA Group in 2020. From "ALROSA Annual Report 2020" (page 56) by ALROSA Group, 2021. Retrieved from http://www.alrosa.ru/wp-content/uploads/2021/06/ALROSA-Annual-Report-2020.pdf

Figure 8 displays the six mining divisions of Alrosa engaged in field development, extraction, and processing of rough diamonds. Under four of the six divisions – namely Nyurba, Aikhal, Udachy, Almmazy, Lomonosovsky and Mirny – some of the most productive mines on earth can be found. The youngest division, Nyurba Division, controls the production of the Nyurba open-pit mine located in Nyurba, Russia, which contain an estimated 132.75Mct of proven and probable reserves as of July 2018. As for the Aikhal Division, mining takes place in the largest diamond mine in the world (Alrosa, Annual Report 2020, 2021).

Mining also takes place Africa at the Catoca (Angola) which is a joint venture of Angola's state-owned diamond company Endiama, Alrosa, and China-based company Lev Leviev International (Carmen, 2021).

2.1.2 De Beers Group

De Beers is no longer the industry's sole operator due to the entry of new competitors which shifted the competitive landscape, but it still remains a major producer. Its market share in 2020 reaches 23%, 4.5 percent lower than the leader Alrosa (see Figure 6). Nonetheless, De Beers'

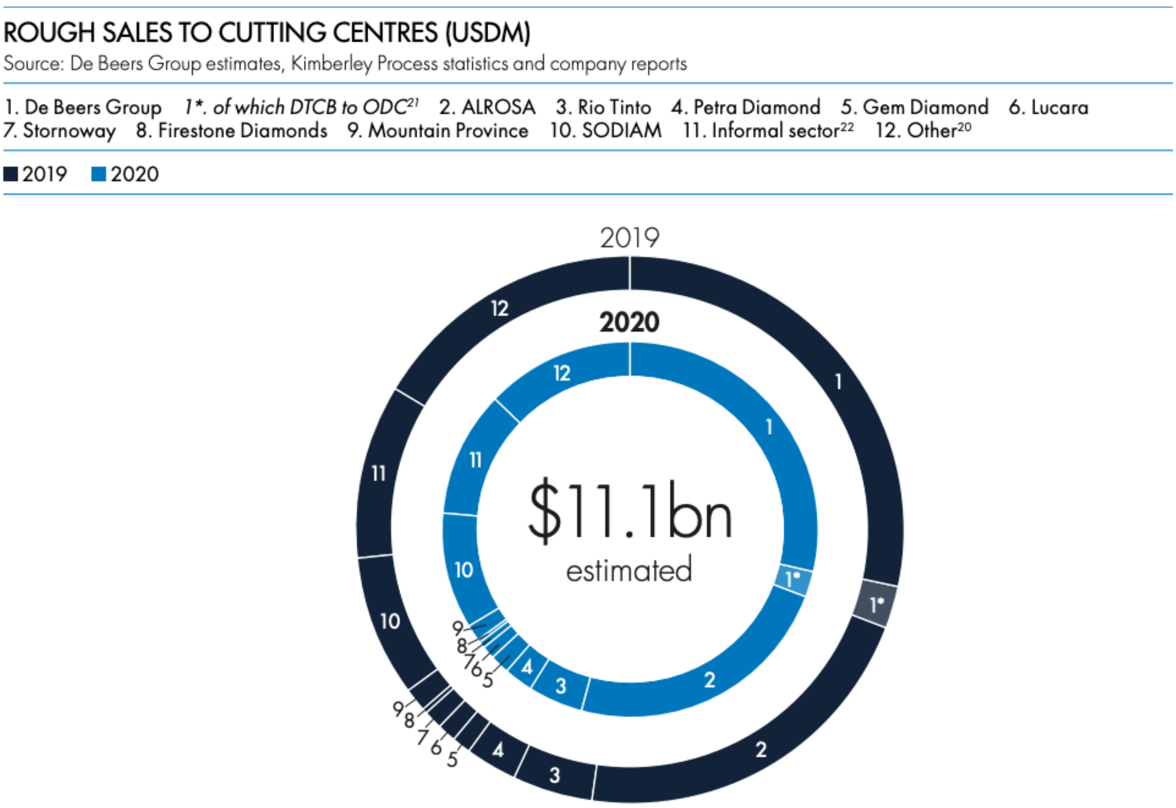


Figure 9. "Rough Sales To Cutting Centres (Usdm)". From "Diamond Insight Report 2021" (page 15) by De Beers Group 2022. Retrieved from https://bit.ly/3xagiMd

sales to cutting centers outnumber Alrosa's (see Figure 9) given that De Beers operates in both B2B and B2C markets, whereas Alrosa primarily focuses on B2B while also serving the industrial diamond market. This makes De Beers the leader in terms of diamond value on the market rather than production volume (De Beers Group, 2022).

De Beers' historic dominance undoubtedly gives the company market power to act and close deals with the world's most important countries. The company operates in four countries: Botswana, Namibia, South Africa and Canada. Its best asset is the joint venture with Botswana that permits it to operate in the country's three main mines: Jwaneng, Orapa, and Letlhakane. Figure 5 displays the diamond production in metric tons of the leading diamond mines worldwide in 2018. The Orapa open-pit mine produced 14.8 metric tons of diamonds in 2018 and the Jwaneng diamond mine in Botswana produced 9.4 metric tons (Garside, 2019).

Interesting enough, De Beers also operates in Canada, controlling fly-in-fly-out remote mine sites: Gahcho Kué and Snap Lake.

2.1.3 Rio Tinto

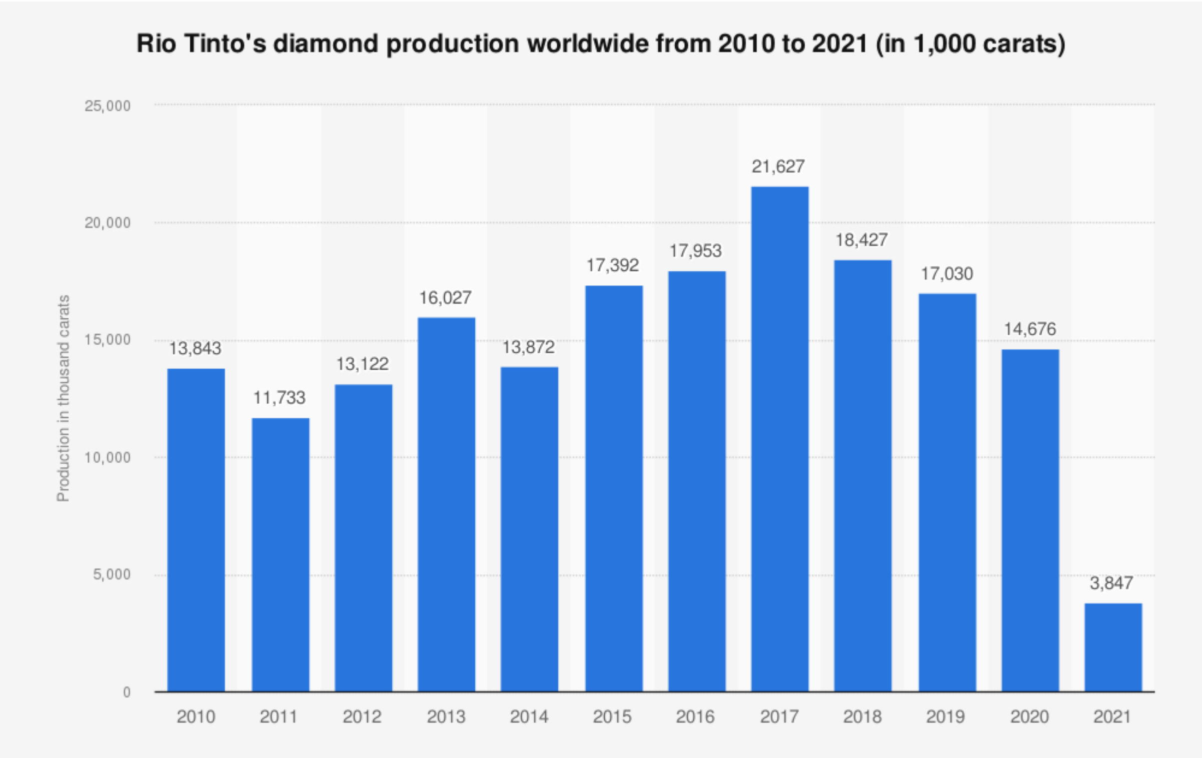


Figure 10. Rio Tinto's diamond production worldwide from 2010 to 2021 (in 1,000 carats). From "Statista" by M. Garside. Retrieved from https://bit.ly/3NC0c5n

The third largest mining company by market share is Rio Tinto, owning 13.3% of the world's rough diamond market. The Anglo-Australian multinational company operates in the metals and mining industry, having 100% share in both Argyle Diamond Mine in Western Australia and Diavik Diamond Mine in the Northwest Territories of Canada, and the Murowa Diamond Mine located in Zimbabwe (78% ownership) (Rio Tinto, 2021).

However, on 3 November 2020, Argyle Diamond Mine closed down due to exhausted supply. As a result, in Rio Tinto's Annual Report of 2021, only production of Diavik is reported. Figure 10 marks a nearly 74% decrease from the previous year, and the company's lowest diamond production in the period of consideration Rio Tinto also announced the closure of Diavik which "[…] will cease production (at Diavik) in 2025, at which time there will no diamonds left to economically mine" (Rio Tinto, 2022). Following this big change of the production, the market positioning as displayed in Figure 6 will probably reshuffle for 2021 and 2022. As Rio Tinto back down the diamond market, the incumbents that are actively producing will probably witness an increase in the market share. Eventually, only those that are already establieshed and have suffient financial means to explore new mining sites will survive in the industry. A big modern issue of the diamond industry is the decay of the diamond deposits.

2.1.4 Petra Diamonds

Petra Diamonds Ltd is a diamond mining company based in Jersey. Its operation is located at eight mines in South Africa and Tanzania, holding also additional exploration programs in Botswana. As in 2020, the company is fourth for market share, owning 3% of world's total (see Figure 2020). Petra Diamonds is renowned for owning world's most productive mines and for turning De Beers' unprofitable mines into productive one. The Cullinan Mine in South Africa is famous for refusing to join De Beers' distribution system in the eighteenth century, but it finally bowed to the cartel in 1905 (see Chapter 1, section 1). When De Beers' decided to sell the mine that once produced the huge stones worthy of Queen Elizabeth's crown, Petra Diamonds quickly jumped on the sale. The English Company was able to restore the mine's production when De Beers gave up (Petra Diamonds, 2017).

However, Petra Diamonds is also impacted by the constrained life of its diamond mines. The company will potentially forgo part of its market share by giving up the Koffiefontein mine (South Africa) either by selling or producing until it reaches the end of its productive life (Daniel, 2022).

3.2 Current Challenges of the Diamond Industry

A diamond takes billions of years to create, and at present consumption rates, supplies will run out one day. A mine can be productive for a decades but eventually it will turn out to be unprofitable to keep the production running. as, to find diamonds, excavation needs to go further and further. At the same time, discovering new mines requires much time effort and monetary investment so it not an affordable activity for all companies. Take Rio Tinto for instance, the company decided to exit the market for sustainability reasons, but the truth is that its mines were no longer productive and they were simply too costly to continue operating. This change in the game might be viewed as both an opportunity and a threat. It might be advantageous for the incumbents because a significant chunk of Rio Tinto's market share is now foregone, reducing competition. On the other hand, some new operators may try to find their way to enter the market. This could be prevented by the high barriers to entry imposed by the industry given that diamonds are natural resources for which mining companies spend billions on exploration and extraction before they can start to make profits. This move by Rio Tinto could also be detrimental for the industry as it creates some sort of uncertainty that could negatively influence the industry. Argyle mine was famous for its pink diamonds, a stone of particular rarity. As a fact, 90% of pink diamonds was mined by Rio Tinto in the Argyle mine. Within the latter mine itself, pink diamonds were also incredibly rare, representing less than 1% of the total diamonds mined, as the next table highlights:

Table 1

Types of diamonds mined in the Argyle mine by colors (in production % and in volume per carats)

Colour	Brown	Near-Colourless	Pink
Est. Production %	72%	27%	< 1%
Est. Production Volume (carats)	9.4 million	3.5 million	< 0.1 million

Note. From Australian Diamond Portfolio. Retrieved from https://bit.ly/3xiu9kW

The closedown of the mine gives rise to a shortage of such diamonds which could imply shifting of demand and supply. Stability is one of the ingredients to the success of the rough diamond industry as already observed in the paraphs above (see Chapter 1, Sections 1.1 and 1.2) (Australian Diamond Portfolio, 2021).

As the natural diamond industry begins to show some fragility due to the limited supply and demand surge, another potential threat is on the way to disrupt the market: the introduction of lab-grown diamonds.

CHAPTER II: Lab-Grown Diamonds

Introduction

It is important to understand that lab-grown diamonds are not similar to natural diamonds, but their composition makes them per se the same as those found in nature. Hence, the actual difference between the two is determined by the origin and the perception of consumers. The natural question that arises now is whether lab-grown diamonds constitute a threat to the existing market. The diamond business has followed an atypical course in recent times as a result of new obstacles, especially due to the influence of Covid-19 and the Russia-Ukraine War. Under these circumstances, lab diamonds may seize the opportunity to squeeze into the industry and take part of the natural diamond market share. Furthermore, the reputation of mined diamonds is not immaculate; the brilliance of diamonds is a mask that conceals the darkness behind the manufacturing of such stones, which is sometimes associated with wars and corruption. The so called "Blood diamonds" are those gems that were traded by militia groups in war-torn countries such as Sierra Leone to fund brutal civil wars. As a remedy, the Kimberly Process is a certification process that proves the origins of diamonds that was created to clean up the supply chain of conflict diamonds.

Despite diamonds' poor reputation, five decades after the notorious campaign "A Diamond is Forever", 80% of the brides married off with a diamond on the finger. The message was clear, if you loved someone, only a diamond will due. Today, diamonds are still perceived as an amulet of love, but consumers needs are changing. The legacy of forced labor and conflicts that surrounds mined diamonds does not help to capture the demand from the younger generation that care about the ethics behind their purchase. Now, consumers may buy their favorite jewelries for a fraction of the price, contributing to sustainability and technology growth by choosing lab-grown diamond jewelries.

Furthermore, diamonds do not only have ornamental purposes but their use in the industrial sector make them an important resource. They are still used for cutting and polishing tools but not many people are aware that they are the best conductors on earth, much better than silicon that is widely used in electronic devices. Using natural diamonds for such purpose is not an efficient choice for obvious reasons so the innovation of lab-grown diamonds could contribute to technology advancements in the fields of cloud-computing or electric mobility.

The following chapter will mainly focus on the current diamond market and how the presence of lab-grown diamonds impacts the existing industry, especially the jewelry market. Diamond jewelries remain popular today but as demand in the recent year rose substantially and is forecasted to rise in the near future, supply is diminishing due to the production break given by the decay of over-exploited mining sites and other issues related to the pandemic and the Russia-Ukraine war.

1. The Innovation of Lab-Grown Diamonds

The formation of a natural diamond takes place in the earth's mantle, where carbon is compressed under extremely high temperatures and pressures. This process takes about 1-3 billion years which is why diamonds are so expensive as of their long creation process makes them unique and durable (May, 2022).

In the 18th century, scientists discovered that diamonds are constituted of pure carbon. This discovery led to the spree to create synthetic diamonds in laboratories. The first successful attempt was made by General Electrics in 1954 under the projects called "Project Superpressure" using high-pressure (100,000 atm) and temperature (1,600º C) to dissolve graphite, a mineral made of pure carbon. The material obtained was indeed the first "synthetic" diamond that had the ability to break metals and, so, conformed with features of natural diamonds. However, it was not a gem-quality diamond so it was not suitable for ornamental purposes but only for industrial uses. The first lab-grown diamond that was remotely worthy to create jewelries was created by General Electric but it was too expensive and too cheap in quality to compete with the natural counterpart (HALL, 1959). This method is now called the HPHT which is usually adopted to achieve cost-efficiencies. At the end of 20th century, the Institute of Geology and Geophysical (Russia) invented the BARS apparatus that follows the logic that underlies in the HPHT method. Out of all diamond pressing methods, the BARS is deemed to be most efficient and high-quality process. To simplify, the devides imitates the natural process of diamond formation in the earth mantle by artificially reproducing the temperatures and pressures (Shigley, 2016).

The other way to create lab-grown diamonds is the CVD method which is based on the process of diamond growth through a hydrocarbon gas mixture. In such method, a small diamond seed is placed in a chamber with a carbon-rich gas. The chamber is then heated to around 800 degrees Celsius (1,472 degrees Fahrenheit) and a plasma is generated. The plasma breaks down the carbon atoms in the gas, which is then attached to the diamond seed, slowly growing it into a larger diamond. This method is more suitable for the creation of higher-quality diamonds given that scientist could manipulate the composition of the stones more effectively and thus creating larger gems, appropriate for ornamental purposes (Koizumi, Nebel, & Milos, 2008).

2. The Relevant Market of Lab-Grown Diamonds

If lab-grown diamonds and mined diamonds have the same chemical composition and are visually indistinguishable then they should be substitutes for one another. However, the two types of stones are somewhat differentiated, perhaps in terms of consumers' perception regarding their emotional appeal. The first step in evaluating if mined and lab-grown diamonds compete with each other is to observe whether they belong in the same relevant market. The latter is determined through the product and geographical dimension.

The geographical market comprises the area where the competitive conditions are closely comparable for the relevant products offered – in this case mined and lab diamonds. The relevant product market constitutes the substitutability of the products taken into consideration in terms of their characteristics, price, and function. One approach to assess this market analysis is the determination of product substitutability in terms of demand and supply (European Commission, 2020).

2.1 The Geographical and Product Dimension: Supply Substitutability

Supply substitutability refers to the extent to which consumers may switch to suppliers of a product. In this case, one way to determine supply substitutability between natural and lab-grown is to see whether the production below capacity by a mining company may increase the price of the natural diamonds. To determine whether natural diamond supply can be replaced by lab-grown diamond production, consider a scenario in which mining companies produce below capacity – thus raising prices – and observe whether lab-grown diamond companies can replace the forgone supply by the mining operators. As seen in the previous chapter, one tool the mining companies utilize to maintain their market power is supply control. De Beers had been purposely forgoing some profits by maintain its supply low, withholding stockpiles of diamonds to drive prices above the competitive level. This practice is still common in the industry with the only difference that today there is a specific necessary percentage of technical stockpile. Essentially, the general behavior of mining companies is similar as the ultimate goal of all of the players is to make diamonds a rare resource, even if that meant artificially manipulating supply. To analyze the supply substitutability, data about production of the diamond industry as a whole will be taken into account, differentiating from actual production and capacity of production, taking also the value of the inventory and the demand for diamonds in the market. To obtained unbiased results, the analysis will be assessed during the year 2018 as the production of the subsequent years are affected by the pandemic. The source of the data is the eleventh annual report over the diamond industry in 2021-2022 jointly prepared by Bain & Co and AWDC. With this information at hand, it will be possible to assume whether lab-grown diamonds can meet the portion of demand that is purposely forgone by the mining companies.

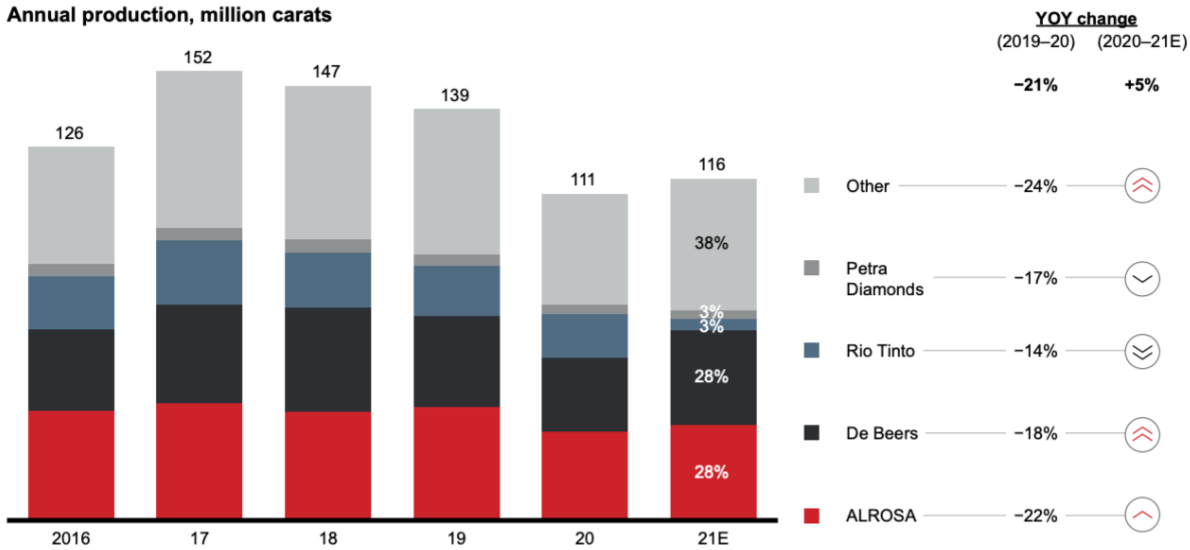


Figure 11. Annual production of mined diamonds in million carats. From "The Global Diamond Industry 2021-22" by Bain & Co (page.12). Retrieved from https://bit.ly/3zjrj0s

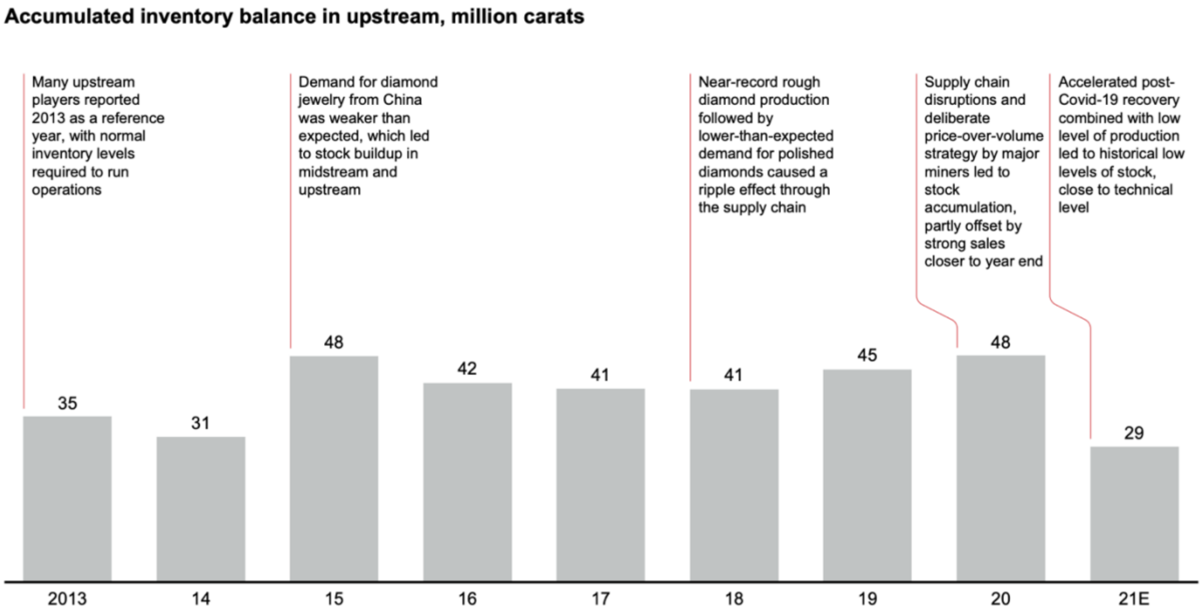


Figure 12. Accumulated inventory balance in upstream in million carats. From "A Brilliant Recovery Shapes Up" (2022) by Bain & Co. Retrieved from https://bit.ly/3zjrj0s

According to the report mentioned above, actual production of the upstream level for natural diamonds in 2018 reached to 147 million carats (see Figure 11).

On the other hand, the companies totaled 41 million carats in their inventories (see Figure 12). As a result, the capacity of production of the mining industry in 2018 was 188 million carats (147 million of actual production + 41 million stockpiled). Hence, in 2018 the companies produced up to 78% of the total capacity and retained 22% as inventory. These diamonds were purposely not released as part of their "price-over-volume" strategy with the ultimate purpose to maintain the prices. On the other hand, the demand is assumed to reach 147 million carats (valued $15 billions). Note that there is no information available on actual demand so this data is estimated using total sales of natural diamonds in 2018 provided by the above report (Linde, Kravchenko, Epstein, & Rentmeesters, The Global Diamond Industry 2021–22, 2022). On the other hand, the world actual demand for diamonds amounts to 147 carats (valued $15 billions). So, the demand for diamonds that is not covered in 2018 amounts to 1 million carats on the market (approximately 0.6% of the demand). The central question is whether these 1 million carats demanded could have been satisfied by the lab-grown industry. According to independent industry analysts Golan and Ziminsky, up until 2018, lab-grown diamonds represented less than 1% of total diamonds sales (Kavilanz, 2022). So, it can be assumed that the production of lab-grown diamonds is aimed at grabbing the part of demand given up by the mining industry or at least its supply is pegged on the behavior of the mining firms. In any case, the market grabbed by the lab-grown industry is not as relevant in 2018 relative to that of mined diamonds. As a result of this supply analysis, it is possible to conclude that the two types of diamonds do not exactly belong to the same relevant market, as mined diamonds continue to serve most of the demand in 2018, and thus the mining companies still hold an extensive part of the market.

As for the geographical relevant market, the analysis may be carried out in a logical manner. The demand for both types diamonds basically come from the same countries, where competitive conditions from one country to another are not particularly different or detrimental for each type of diamonds. Therefore, based on the geographical dimension, it may be concluded that the two varieties of diamonds belong to the same relevant market.

2.2 The Product Dimension: Analysing Demand Substitutability

Demand substitutability for natural diamonds is determined by the extent to which lab-grown diamonds can serve as acceptable substitutes. This is also related to the differentiation between the two types of gems: if they are sufficiently distinct, they may not be perceived as close substitutes, and consumers will not switch from one to the other if the price rises above the marginal cost. The cross price elasticity could be used to determine the degree of substitutability of the two types of diamonds:

$$\varepsilon_{ij} = \frac{\%\Delta q_i}{\%\Delta p_j} \qquad \textbf{Equation (3)}$$

Cross-price elasticity (ε_{ij}) is the percentage change in the quantity demanded for product i ($\%\Delta q_i$) for a percentage change in the price of product j ($\%\Delta p_j$). Considering that "i" represents lab-grown diamonds and "j" natural ones, the equation identifies whether price changes of natural diamonds could affect the demand for lab-grown diamonds. If cross price elasticity is low, it indicates that the lab-grown diamond industry is not significantly affected by the price changes of the natural diamonds.

The diamond industry experienced a strong recovery in sales in 2021 as a result of the Covid-19 crisis that occurred in 2019 and 2020. The pandemic had a general negative impact on the economy, particularly on the manufacturing sector. The diamond industry was not immune to its effects given that it was strongly influenced by the effects of the lockdown that decreased the rate of engagements and weddings. This resulted in a fall of sales of 11% during the period 2019-2020, adding to the decrease of 7% for the period 2018-2019. So, in two years the sale of diamonds decreased on average by 9% (see Figure 13).

Figure 13. Rough Diamond Price Index and Polished Diamond Price Index, 2004 price=100. From "The Global Diamond Industry 2021-22" (2022) by Bain & Co. Retrieved from https://bit.ly/3zjrj0s

The demand growth for natural diamonds is forecasted in Figure 14. Optimistically speaking, the demand for mined diamonds increases roughly 15%-16% in the short run (2020-2023) and slows down to 2%-3% in the long-run (2023-2030). A more realistic view forecasts an increase of 10%-11% in the short-term to then decrease to 1%-2% in the long-term (Linde, Kravchenko, Epstein , & Rentmeesters, 2021).

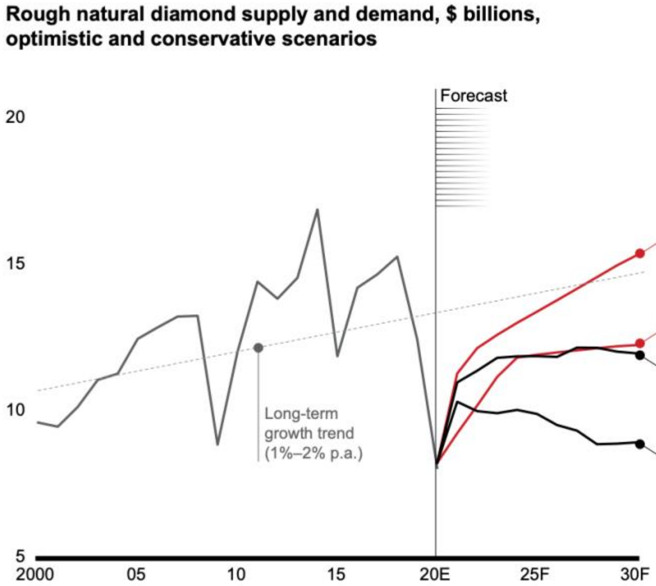


Figure 15. Rough Natural Diamond Supply and Demand, $ billions, optimistic and conservative scenario. From "The Global Diamond Industry 2020-21" (page 52) by Bain & Co (2021). Retrieved from https://bit.ly/3PZrBQ6

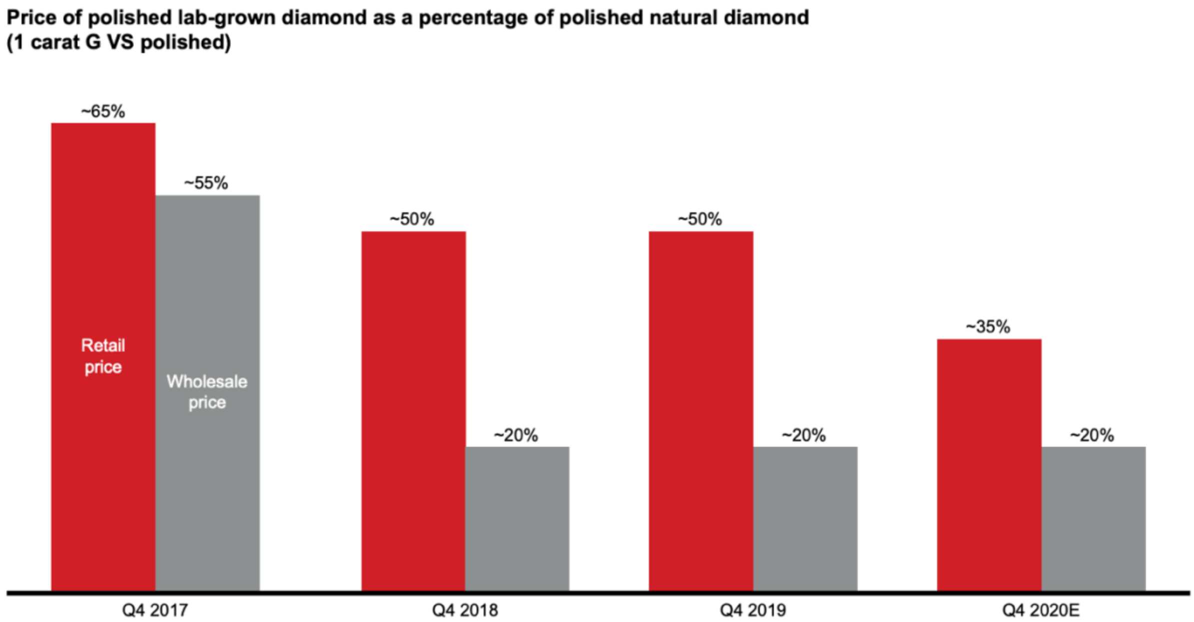


Figure 14. Price of polished lab-grown diamond as a percentage of polished natural diamond (1 carat G VS polished). From "The Global Diamond Industry 2020-21" (page 52) by Bain & Co (2021). Retrieved from https://bit.ly/3PZrBQ6

At the same time, also lab-grown diamonds saw their demand increasing as their prices relative to their natural counterpart fell. In 2020, the average polished lab-grown retail price was 30% and the average wholesale price was 14% of natural prices (see Figure 15). In the report for the period 2021-2022, Bain & Co estimates that the prices of lab grown diamonds as share of natural prices increased to 35% and 20% ("The Global Diamond Industry 2021-22" (page 6) by Bain & Co, 2022). So, the price of lab-grown diamonds is decreasing year by year and at the same time its demand is also projected to rise. In 2020, the market size of lab-grown diamonds amounts to $19.3 billion with an expected annual growth rate of 9.4%. So, the market size is expected to reach $49.9 billion by 2030.

To calculate the price elasticity between the two types of diamond in the year 2021, consider "i" as the lab grown diamonds and "j" as the natural diamonds. Assume that the annual demand growth for lab-grown diamonds amounts to 9.4% ($\%\Delta q_i$) – forecast of lab-grown market size growth – and that the percentage growth of price for polished natural diamonds during the period 2020-2021 is 9% ($\%\Delta p_j$). Hence, the cross-price elasticity of demand will be calculated in the following way:

$$\varepsilon_{ij} = \frac{\%\Delta q_i}{\%\Delta p_j} = \frac{9.4\%}{9\%} \cong 1.04$$ **Equation (4)**

This result indicates that the two types of diamonds are, to some extent, substitutable. If the price of natural diamonds increases (ceteris paribus), it will encourage some consumers to switch to lab-grown diamonds. Therefore, the buyer is influenced both by its preferences and the price.

CHAPTER III: The Future of the Diamond Industry

Introduction

Essentially, lab-grown diamonds continue to diverge into a separate, more affordable jewelry category. Just as price, the perception for lab-grown diamonds is relevant. The romance surrounding natural diamonds remains strong, but given the current market challenges, the diamond industry may mutate in the future. Indeed, prices are likely to rise as the Russia-Ukraine war has tightened the supply chain for natural raw diamonds. Western sanctions against Russia directly affect Alrosa as it is partially owned by the state. This means that Russian diamonds will stop flowing into the market and, with demand for diamonds rising, this is not exactly an ideal situation for the market equilibrium. The prices may increase substantially up to a point that consumers will switch to cheaper alternatives, either other types of stones or lab-grown diamonds (Kavilanz, 2022).

The future of the mining industry is also compromised by the availability of diamonds in nature given that some of the largest mines are closing off for unproductivity. Take the closure of the Argyle mine owned by Rio Tinto, the largest supplier of pink diamonds on the market, which will provoke a shortage of supply of these types of diamonds. Occasionally, Alrosa finds exceptional high-quality pink diamonds in its mines in Yakutia but the firm can only satisfy the demand to a limited extent. Hence, the experts of the industry predict an enormous increase in the price of pink diamonds which could have some undesirable effect for market stability (Gomelsky, 2020).

This is where the lab-grown diamonds could potentially penetrate to capture the unsatisfied demand for natural diamonds. What must be highlighted is also that the lab-grown industry does not entirely pose as alternative to consumer with budget constraint, but it also owns genuine demand given the increasing consumer awareness over sustainability and human rights. What partially disrupts the mining industry is the stigma for forced labor and exploitation of natural resources while lab-grown diamonds appear to be a cheaper and more sustainable option. Lab-grown diamonds are getting more popular than ever, and their market value is expected to increase to 29.2 billion by 2025; by 2030, the share of global diamond market will rise to 10% (Garside M. , 2019).

Given the outcome of equation 4, the natural diamond sector should be reacting to the behavior of the lab-grown industry, since price increases of mined diamonds are causing some buyers to migrate to the less expensive choice, lab-grown diamonds. In order to increase the supply and curb the increasing prices, the mining companies could rise production and intensify the exploration for new mining sites. This is not an easy task to achieve as the existing mines could one day deteriorate and exploration is a complicated activity. Perhaps, in the short-run the mining industry could still sustain the market regardless of the rising prices, but it should take into account the long-run effects: if the prices continue to climb, consumers will eventually be affected in their choices and start switching to other substitutes. So, hypothetically speaking, brides could permanently shift to lab-grown diamond ring to compensate the over-priced jewelries made with natural diamonds over the long-run.

Furthermore, the natural diamond business should be concerned about new entrants. Growing a diamond in a lab is substantially cheaper and time efficient. It only takes a few weeks – if not days – to produce a diamond and costs has lowered to $300-$500, about 10 times less than a decade ago (Bain & Co, AWDC, 2020). On the other hand, production cost for natural diamonds is costly and labor-intensive, but most importantly supply is limited. At the same time, the latter feature is what makes diamonds so special and rare. The romantic thought of a bride wearing a diamond ring that took billions of years to form is what drives the value up. By contrast, lab-grown diamonds lack uniqueness because their supply is limitless and their characteristics such as color and carat may be chosen during the production. Moreover, given the high rate of innovation within the lab-grown industry, the cost producing costs may fall further while quality rises, posing actual threat to the century old diamond industry (Church & Ware, 2000).

1. Defensive Measures Against Lab-Grown Diamonds

In the wake of the challenges mentioned above, the natural diamond industry has already started to react against the threat imposed by lab-grown diamonds. The technology advancement of lab-grown diamonds is reducing the divergence between the two types of diamonds and raising acceptance along the value chain. The difficult part of gaining acceptance among consumers is also affected by the willingness of jewelers to sell lab-grown diamonds. Yet, wholesale prices were knocked down by the decreasing production costs as a result of technology innovation; this attracted some mid-stream jewelry sellers who were compelled to rise their margins and, as price gaps between lab-grown and natural diamonds expand, more jewelers are starting to propose the more convenient alternative. For instance, some major jewelry retailers like Pandora are already embracing lab-grown diamonds (Townsend, 2021).

Furthermore, while lab-grown prices was initially tied down to that of natural diamond’s, as the sector progresses, pricing is beginning to follow a "cost-plus model". The increasing acceptance of lab-grown diamonds is also shifting away the industry from the natural counterpart as the increasing acceptance and quality is helping the lab diamonds to construct a demand and supply of its own. Some experts optimistically believe that lab-grown diamonds will eventually diverge into mass-jewelry category and will have a different consumer target than that of natural consumers. Hence, the two types of diamonds will eventually belong to a differentiated relevant market. On the other hand, more conservative experts predict that lab-grown diamonds will indeed affect the natural diamond industry by reversing the effects of product differentiation and target both mass and premium audience (Linde, Kravchenko, Epstein , & Rentmeesters, The Global Diamond Industry 2020–21, 2021).

Indeed, the technology of lab-grown diamonds could be disruptive for the industry and, as already said, the last thing that the mining companies want are uncertainties in the market. Stability is what fosters the industry as price shocks could permanently shift consumers' sentiment for diamonds. Following the investigation for the relevant market in the previous paragraphs, lab-grown diamonds could indeed be perceived as substitutes to natural diamonds if the latter increases prices more and more. For such reason, some incumbents of the diamond industry are already taking defensive measures to preserve their market position.

1.1 De Beers' Lab-Grown Diamonds: Lightbox Jewelry

De Beers' responsive measure to protect its natural diamond market is quite intriguing. De Beers Group launched in 2018 "Lightbox Jewelry", a brand of lab-grown diamond jewelry. The conglomerate also owns Element Six, the laboratory from which the new jewelry brand sources its diamonds. Each stone features a permanent Lightbox logo, which serves as a quality assurance and is visible only under magnification. The Group invested $94 million to open up its Element Six facility in Oregon and partnered up with online retailer Blue Nile to sell the new line of jewelry. In reality, De Beers has been producing lab-grown diamonds for industrial uses for over 50 years, but it only expanded its scope to jewelry when it recognized the growing relevance of lab-created diamond jewelry (DeMarco, 2020).

The motivations behind De Beers' choice to enter the lab-grown industry are debatable. Initially, many in the industry were shocked when De Beers debuted Lightbox, believing that it would have been detrimental for the company's century old legacy and could have shattered the romantic image of natural diamonds. Next, its pricing decisions are quite arguable given that it aggressively ripped off the prices of the industry. Prices are transparently disclosed on Lightbox's website: 200$ per ¼ carat, $400 per ½ carat, $600 per ¾ carat, and $800 per carat.

The rarity and value of a mined polished diamond is driven by features like carat, color, cut and clarity – the so-called 4Cs – but in lab diamonds these characteristics are upon engineers' will. As a result, rarity is not a pricing factor and so diamonds can be priced in a linear way. On the website, the company affirms to have lower prices than competition, explicitly stating that other operators rise their prices as they reproduce the natural diamond pricing (Lightbox, 2019).

De Beers treats lab-grown diamonds as the “cheap” and “fun” alternative to natural diamonds, perfect as a piece of fashion jewelry but definitely not worthy of a bride's finger. In fact, Bruce Cleaver, chief executive of De Beers Group, declares that lab diamonds “may not be forever, but is perfect for right now” (Bhattarai, 2018, The Washington Post, paragraph 6). This move may be a double-edged sword. If Lightbox's effort to separate the two types of diamonds is worthless, the danger is that aligning a cheap alternative brand to the prestigious name of De Beers may raise the acceptance of lab-grown diamonds as a substitute, damaging the image of natural diamonds in the long run.

1.1.1 The Rationale Behind Lightbox

It seems like De Beers is attempting to rip-off the profitability of the lab-grown diamond industry by purposely setting prices below competitive levels. This aggressive post-entry behavior could deter entry by lowering entrants' profits and rising barriers to entry. In general, entering the diamond industry requires high sunk investments: exploration and excavation costs when it comes to mined diamonds and research and innovation related to lab-grown diamonds. Lightbox's price reduction does not necessarily mean that the company is pricing below its marginal costs, a practice condemned under antitrust regulations. However, its pricing decision could be a way to prevent the crowing of the lab-grown industry, strategy to protect its own position both in the natural and the lab-grown market.

What De Beers is trying to avoid is a situation that could be described under the Free-Entry Cournot Model. Entering the mining industry requires high sunk cost, taking into account that the global spending on exploration of diamond deposits in 2008 reached to $1 billion (Bain & Co and AWDC, 2012). On the other hand, sunk costs required to lauch lab-grown diamond production are high but supposely lower than starting a mining activity so barriers to entry are potentially lower. When a firm intend to enter the diamond industry, it has to forecast the nature of postentry competittion and its profits. Suppose firms compete in a free-entry Cournot setting, so they compete over quantities. There are N firms in the industry for lab-grown diamonds, the profit of the entrant will be $\pi^c(N)$ and its symmetric output equilibrium satisfies the following equality:

$$\frac{P^c - MC}{P^c} = \frac{1}{\varepsilon N} \qquad \textbf{Equation (5)}$$

Given that Lightbox lowered its prices, this practice will potentially lower the profits from entry, so entrants may be relunctant to enter the industry. Under the free-entry equilibrium, a firm expects negative profits post-entry given that the equilibrium number of firms is the amount of firms that yields negative expected profits for another firm. Hence, the equilibrium is defined by two conditions:

(i) Nash equilibrium in quantities: $MR(q^c) = MC(q^c)$.

(ii) Zero profits: $P^c = AC(q^c)$.

To simplify, Lightbox attempt to lower the prices may be part of its strategy to avoid a situation of free-entry equilibrium as lower barriers to entry that is not able to limit the number of firms could turn the industry in a perfect market. In theory, more competition and free-entry is more desirable on a social point of view as this increases the aggregate output and prices fall, resulting in a rise of total surplus and welfare. However, when economies of scale comes in the picture, an increase in competition may have some arguable effects. The production costs and time for lab-grown diamonds have significantly decreased in recent years as a result of innovation, underlying a certain degree of economies of scale. In this case an increase in competition may imply higher average costs as each lab-grown producer may be disicentivised to produce on a large scale. As a result, net total surplus and welfare is decresed (Church & Ware, 2000).

1.2 Promoting Natural Diamonds in China: The NDC's Latest Move

To offset the diamond the growth of the lab-grown industry, the Natural Diamond Council – the lobby group formed by the seven largest producers of natural diamonds, including Alrosa, De Beers Group, Dominion Diamonds, Lucara Diamond, Petra Diamonds, RZM Murowa, and Rio Tinto – signed a strategic alliance with Chow Tai Fook, a conglomerate company listed on the Hong Kong stock exchange with more than 4000 jewelry stores in mainland China. Promoting the sale of natural diamonds in China is the core objective of the partnership as the country represents the biggest market for diamonds after the US. By contrast, China is also the largest producer of lab-grown diamonds. Table 16 clearly displays that in

2020, China was estimated to produce 3 million carats, followed by India which production amounts to 1.5 million carats. These diamonds will mostly be retailed in the US.

To conquer the Chinese market, the partnership aims at restoring the value of natural

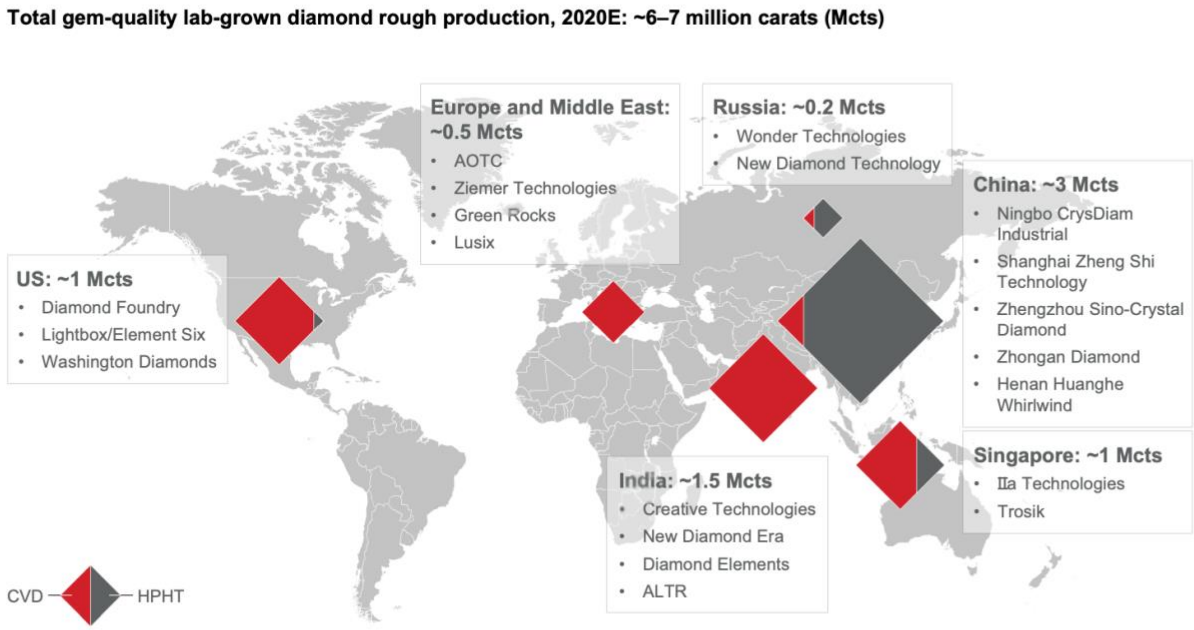


Figure 16. Total gem-quality lab-grown diamond rough production, 2020E: ~6–7 million carats (Mcts). From "The Global Diamond Industry 2020-21" by Bain & Co (2021). Retrieved from https://bit.ly/3PZrBQ6.

diamonds for Chinese consumers, accentuating the emotional component of the diamonds. The truth is that the choice of a diamond still relies in consumer perception rather than just price. Millennials and Gen Z's increasing environmental and humanitarian awareness lead the industry to shift towards a new strategy: sustainability. On one hand, lab-grown diamonds have been trying to push the image of sustainability and, on the other hand, mining companies have been trying to market themselves as community helpers in the countries where they operate. For example, retailer Pandora announced its conscious choice of selling lab-grown diamonds produced with renewable energy. This statement sparkled criticism from the NDC and other groups of the industry as they deemed it to be detrimental for the image of natural diamonds. The NDC filed a formal complaint to the US National Advertising Division against lab-grown producer Diamond Foundry. The competent authority warned lab-grown diamond companies not to exploit the image of sustainability if unfounded. At the same time, the Division backfired at the NDC by warning them about their anticompetitive advertising of constantly comparing the two types of diamonds, especially their unfounded claim that mining activities produce lower carbon footprint (Sanderson, 2021).

Marketing activity is intense on both sides, as securing demand is a top priority. However, the diamond industry's conservative view of rejecting the concept of lab-grown diamonds may be harmful. Lab-grown diamonds are here to stay, so incumbents should adapt to the new challenges rather than condemning the existence of the new entrants. This approach has the potential to mitigate the disruptive force that technology innovation frequently brings to the market (Polnauer, 2018).

2. Technology and Zero-Sum Game: The Disruptive Force of Lab-Grown Diamonds

Technology is often perceived as a disruptive force on the market, compromising the positioning of established products. Some experts believe that technology yields zero-sum game under determined circumstances, but others argue that it does not necessarily have to be so disruptive. For instance, zero-sum games may be observed in the tech-industry, given the high degree of innovation combined with strong network effects. Take Windows and MacOs – the two major operative systems in the market – installing Windows on a computer automatically yields zero profit for MacOs, and vice-versa. Hence, the net utility of the two participants is exactly balanced. Subtracting the total loss of one firm from the total gain of the other participant, the result is zero. This example could potentially be applied to the diamond industry. Consider the purchase of a diamond engagement ring; A consumer that chooses the natural diamond ring, automatically discards the lab diamond ring – it is extremely unlikely that it will choose both. Hence, this is a zero-sum game. In this type of setting, for natural diamonds to win, lab-grown must lose – and vice-versa (Karbasfrooshan, 2012).

By contrast, the innovation of lab-grown diamonds does not have to be a zero-sum game as there is the possibility to avoid such scenario given that there is enough market space for both to co-exist. The natural diamond firms and lab-grown firms could simply focus on consumers' demand and do the possible to enhance the real value of the gemstones. Not long ago, the consumer either had to accept the price proposed or choose a cheaper stone. Lab-grown most significant impact on the industry is enabling consumer choice. Hence, the best strategy for companies producing either type of diamonds is to innovate by offering better design and service to adapt to the changing demand of consumers (Shah, 2021). The constant comparison of lab-grown diamonds and natural diamonds in terms of value is limited to the emotions that rely within the piece of jewelry. Most of the times, diamonds are not bought as a financial investment but rather as an emotional amulet. Under these circumstances, it is better for the industry to collaborate and try to understand in the best way possible the consumer perspective.

More and more jewelers are proposing lab-grown alternatives to consumers either willingly or upon customer request. With increasing consumer awareness over lab-grown diamonds, the traditional industry cannot ignore the lab-grown diamond industry anymore.

According to a survey carried out in 2022 by THE MVEye – an independent industry research company which carries out jewelry consumer survey since 2004 – 72% of the survey respondents have heard about the lab-grown diamonds while a decade ago only 10% were aware. From this survey, also brand awareness has increased substantially, having Brilliant Earth as the best followed in fifth position by Lightbox owned by De Beers. However, the survey also found that most of the respondents choose lab diamonds as a fashion piece, as gifts for themselves or others and lastly as an engagement ring. Findings also include the importance for traceability and sustainability when purchasing a diamond of any kind. Lab-grown diamonds are especially popular among Millennials and Gen-Z as they are the group that are most price sensitive and concerned about the environmental impact (Hurwitz, 2022).

Finally, it is safe to say that finding a common interest to create a win-win situation may be a better strategy for the industry; perhaps finding a grey zone in the demand where operators of both types of diamonds can co-exist, turning the relationship into a non-zero sum game (Burrell, 2019). As previously stated, focusing on consumer demand in the sense of providing what buyers desire could be a winning strategy for both. As for now, most of consumers demand lab-grown diamonds jewelries for fashion pieces while some prefer a natural diamond for important gifts or events. Diamonds jewelries are also not a good investment as their price are subject to high mark-ups, eroding the resale value. The same is for lab-grown diamonds which resale value is not high given its low degree of rarity. Hence, isn't it better for the operators in the market to cooperate and split consumers' demand? Instead of competing fiercely with one another and ripping the image off of each other, simply targeting different groups of consumers could be a solution. On the one hand, De Beers can continue to promote the image of forever diamonds to brides, while Brilliant Earth may invest more in design and celebrity endorsements to attract a more fashionable clientele. As for now, this seems like a good compromise that could be a win-win situation for both operators of the industry. Perhaps, De Beers' strategy to abstain from producing engagement rings with Lightbox but only "fun and fashionable" jewelry pieces appears to be the ultimate move as it clearly attempts to fit the two types of jewelries in two different categories to separate consumers' demand for diamond.

Conclusion

A diamond may be forever but a cartelist' power will eventually fade away. Even the centenary monopoly of De Beers was terminated by the change of competitive conditions that transformed the market in an oligopoly. Recently, the growing popularity of lab-grown diamonds has posed a new challenge to the industry. On the other hand, a shortage of mined diamond supply as a result of COVID-19 and the Russia-Ukraine war, along with the natural degradation of some mines, may complicate the problem. Consequently, the insufficient production was not able to satisfy the brilliant recovery of demand after the pandemic, causing prices to increase considerably. Now, the natural question that arises is whether lab-grown diamonds could capture the mining industry's forgone demand as a consequence of the shortage and price surge. Bain & Co estimated that lab-grown diamond prices are 35% the price of natural diamonds in 2020. So, why isn't everyone purchasing lab-grown diamond jewelries if they are chemically and aesthetically identical to natural diamonds but considerably cheaper? The assessment of the relevant market comes handy to answer the questions. The purpose of the analysis is to identify whether the two types of diamonds belong to the same relevant market; in other words, whether they compete against each other. The product relevant market is analyzed through supply and demand substitutability, excluding the period of the pandemic to eliminate the bias in the study. Supply substitutability helps to understand whether the sacrificed part of mined diamonds' demand can be satisfied through the production of lab-grown diamonds. As for 2018, the production of natural diamonds reached to 78% of the total capacity, retaining 22% as inventory. Stockpiles are a typical instrument used by the mining industry to implement the "price-over-volume" strategy for price stability. In the model, demand is assumed to be 147 million carats, implying that 0.6% of demand remained unsatisfied in 2018. Given that lab-grown diamonds represented less than 1% of total diamond sales in 2018, it can be concluded that the supply of such diamonds was still pegged to its competitor's production, implying that the two products rely in different relevant market in terms of supply. On the other hand, the demand substitutability analysis suggests the opposite given the result of the cross-price elasticity of demand. The latter was calculated for the period of 2020-2021 to see the effects on the demand of lab-grown diamonds post price increase of mined diamonds. The ratio between the annual demand growth for lab-grown diamonds ($\%\Delta q_i = 9.4\%$) and the percentage growth of price for polished natural diamonds ($\%\Delta p_j =$

9%) gives a cross-price elasticity of 1.04 (ceteris paribus), suggesting that the two types of diamonds pose as substitutes for each other. Thus, they belong to the same relevant market.

Upon these evidence, the reccomended action for the natural diamond industry is to contain the inflation and take defensive measures to protect their position against the rising popularity of lab-grown diamond jewelries. As a consequence, the traditional industry needs to remodel its strategies to adapt to the changing market. The presence of lab-grown diamond jewelries, has already sparkled a response from the most relevant mining operators, namely De Beers and the NDC (the lobby group formed by the seven largest producers of natural diamonds). While the latter attempted to advertise and re-construct the image of natural diamonds in order to attract younger consumers and to capture the Chinese market, De Beers opted to enter the lab-grown diamond jewelry sector by launching the brand "Lightbox" in 2018. De Beers aggressively entered the industry by setting prices much below the competitive level perhaps to rip-off the industry's profitability which also rises barriers to entry. However, this strategy is a double-edged sword as aligning cheaper products to De Beers' name could potentially deter the image of its line of natural diamond jewelries. Choosing the right solution to the threat is not an easy task but there is one alternative that has not been quite considered by the market: the co-existance of the two products. Possibly, the best strategy could be simply to address all the efforts on consumers' demand instead of fiercly competing against each-other. Currently, it appears that lab-grown diamond jewelries are mostly desired as fashion accessories while natural diamond jewelries carry more intrinsic sentimental value. This existing fragmentation of the demand leaves ground for cooperation between firms in order to enhance the true value of diamonds to satify consumers' needs. The future competition framework is not entirely predictible as the increasing innovation of lab-grown diamonds could result in scenarios that are not even imaginable yet.

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