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THE RETURNS ON RARE DIAMONDS AND GEMS

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Hard Assets:
The Returns on Rare Diamonds and Gems

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Abstract: This paper examines the investment performance of diamonds and other gems (sapphires, rubies, and emeralds) over the period 1999-2010, using a novel data set of auction transactions. Between 1999 and 2010, the annualized real USD returns for white and colored diamonds equaled 6.4% and 2.9%, respectively. Since 2003, the returns were 10.0%, 5.5%, and 6.8% for white diamonds, colored diamonds, and other gems, respectively. Both white and colored diamonds outperformed the stock market over our time frame. Nevertheless, gem returns are positively correlated with stock market returns, suggesting the existence of stock market wealth effects.

JEL classification: G11; G12; Q3; Z11.

Keywords: Auctions; Diamonds; Gems; Hedonic regressions; Alternative investments.

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1. Introduction

In the recent past, impressive sums of money have been spent on diamonds and other gems. In December 2008, a British jewelry dealer paid more than 24 million U.S. dollar (USD) for the 35.56 carat grayish-blue Wittelsbach Diamond at a Christie's auction in London. On 16 November 2010, a rectangular 24.78 carat pink diamond was sold in the auction rooms of Sotheby's Geneva for the record price of 45.75 million USD. In private transactions, the figures have even been higher (Bloomberg, 2008). According to some jewelry experts, the recent financial crisis is partially responsible for the elevated price levels: "nobody knows what they are buying with stocks, but here they are buying something solid and tangible" (Reuters, 2010).

Also in the late 1970s and the early 1980s – when the economic climate was arguably even more uncertain than today – there was an increased investor attention for tangible but easily storable assets, such as gold (Ibottson and Brinson, 1993), stamps (Dimson and Spaenjers, 2011), and gemstones. Two interesting examples of diamond investor manuals that were published around that time were Sutton (1979) and Dohrmann (1981). Both studies elaborated extensively on the advantages of investing in diamonds; the latter publication even claimed in its preface that "diamonds have a track record of thousands of years of value with steady, stable appreciation".

The production side of the gem industry has been dominated by the De Beers cartel since the 1870s. By stockpiling the excess supply of rough diamonds and creating an illusion of scarcity, but also by curbing attempts of speculation, the company cartel has managed to create an "orderly" primary market with prices that have been steadily increasing over time (Spar, 2006). Over the next few years, worldwide jewelry sales are expected to grow strongly, especially in emerging markets (KPMG, 2010).[1]

There are two interesting aspects to the consumer demand for diamonds. First, diamonds may constitute a market for social status (Scott and Yelowitz, 2010).[2] Second, and more relevant

[1] KPMG (2010) foresees a growth in total revenues from 185 billion USD in 2010 to 230 billion USD in 2015. The Indian and Chinese market for gems will have surpassed the U.S. market in size by 2015.

[2] Scott and Yelowitz (2010) show that the (online) supply of diamonds has distinct discontinuities in the frequency distributions by size. Also, a diamond's price is significantly lower when its size is just below a round carat weight, such as one or two carat. This may be due to a behavioral whole numbers effect or – in the context

when looking at price trends, diamonds are appreciated not only because of their intrinsic consumption effects, but also because they are costly and are a store of value. This may have become even more important since the recent financial crisis. A recent Capgemini (2010) study on passion investments indeed stressed that high-net-worth individuals seek out “more tangible assets expected to hold their long-term value”. As a result, ‘jewelry, gems, and watches’ overtook ‘art’ as the second most important category of passion investments globally in 2009.

Unfortunately, however, apart from anecdotal press reports and fragmentary data in outdated investor guidebooks, no information is available on the historical investment performance of gems. This study constitutes a first step towards filling this gap in the literature. We estimate the returns on diamonds and other gems in the secondary market over the period 1999-2010, using a novel data set of auction transactions. We concentrate only on the upper end of the market: high-quality “white” (colorless or near-colorless) and colored diamonds, and other types of precious gemstones (sapphires, rubies, and emeralds). We also compare and relate the price trends in the secondary market for investment-grade gems to the returns on more traditional asset categories.

We find that the average annual real (i.e., deflated) USD returns for white and colored diamonds equaled 6.4% and 2.9%, respectively, between 1999 and 2010. Since 2003, the annualized real returns were 10.0%, 5.5%, and 6.8% for white diamonds, colored diamonds, and other gems, respectively. Although the diamond returns since 1999 have been below those on gold, both white and colored diamonds have significantly outperformed the stock market. The reward-to-volatility of white diamonds has been similar to that of government bonds. Gem returns are positively correlated with stock market returns, suggesting the existence of stock market wealth effects. Therefore, even if financial crises turn the attention towards tangible assets, the drop in wealth that they cause can also adversely impact the prices of those goods. Overall, returns may on average be slightly higher for higher-quality objects.

This paper proceeds as follows. Section 2 presents the data and methodology. Section 3 illustrates the importance of time-invariant price-determining variables such as carat, color, and clarity. Section 4 outlines our price indices. Section 5 compares the performance of

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of engagement and wedding rings – be evidence of conspicuous consumption. We do not study this (retail) segment of the diamonds market.

diamonds with that of other assets. Section 6 briefly examines whether higher-quality objects are also better investments. Section 7 concludes and discusses the need for a longer-term perspective.

2. Data and methodology

The data used in this study were provided by Rocks International, a team of international diamond industry experts. The original database includes information on auction sales of gems at offices of Sotheby's and Christie's worldwide. Although a limited number of transactions are included for the early- and mid-1990s, we start our analysis in 1999, the first year for which there is representative coverage. In total, the database contains information on 3,952 sales. Table 1 shows the distribution of sales per half-year over the three types of stones included in the database: white diamonds, colored diamonds, and other gems. The different sorts of non-diamond gems considered are emeralds from Colombia, rubies from Burma (Myanmar), and sapphires from Burma, Ceylon (Sri Lanka), and Kashmir. (Ten transactions that concern stones from other regions were deleted from the database.) The panel shows that a small majority of the transacted gems are white diamonds (2,034 sales). The number of observations for colored diamonds (1,086) is slightly above that for other gems (832).

[Insert Table 1 about here]

Table 1 also shows the average transaction price in USD, and the average price per carat, for each period for each type of gem. The results indicate that the average transaction value is highest for colored diamonds (530,349 USD), followed by white diamonds (440,583 USD) and other gems (272,921 USD). Also the average price paid per carat is highest for colored diamonds – at 78,306 USD. However, there is substantial time-series variation in average prices. For example, the average transaction value for white diamonds was 212,887 USD in the second half of 2002, but 817,855 USD in the first half of 2008.

The increase in the price per carat since the early years of our time frame is further illustrated in Figure 1, which shows the evolution of the average price per carat in USD for white diamonds, colored diamonds, and other gems. For both white and colored diamonds, the average price level per carat has roughly multiplied threefold.

[Insert Figure 1 about here]

Calculating average prices is only an initial step, since a price index should also take into account variation in the average quality of the items sold. Indeed, average prices can go up both because of a true increase in the overall price level, or because of a shift in the sales composition towards higher-quality objects. Dohrmann (1981) claims that the uniqueness of each piece implies that constructing a price index for diamonds is like "trying to have an index for snowflakes". Such a statement is incorrect: building a price index for heterogeneous goods is far from impossible, provided that enough transactions are observed and that detailed sales information is available. Index construction may even be less complicated for diamonds than for other collectible goods, since a relatively limited number of easily quantifiable characteristics capture a lot of the appeal – and hence the price – of each stone.

In this study, we estimate the returns on gems by applying a hedonic regression to our database. The hedonic methodology has previously been used to estimate the returns on other heterogeneous and infrequently traded assets, such as real estate (e.g., Meese and Wallace, 1997), wine (e.g., Combris et al, 1997), and art (e.g., Renneboog and Spaenjers, 2010). The idea is to relate the prices of individual sales to a number of price-determining characteristics (e.g., the number of rooms in a house, the region of production of a bottle of wine, or the size of a painting) and a range of time dummies (e.g., years). Under the assumption that the hedonic characteristics capture the quality of the item, the regression coefficients on the time dummies will proxy for the price level in each period. More formally, a hedonic regression model can be represented as in Equation (1):

$$\ln p_{kt} = \alpha + \sum_{m=1}^{M} \beta_m x_{mkt} + \sum_{t=1}^{T} \gamma_t d_{kt} + \varepsilon_{kt} \ , \qquad (1)$$

where p_{kt} represents the price of good k at time t, x_{mkt} is the value of characteristic m of object k at time t, and d_{kt} is a time dummy variable which takes a value of one if good k is sold in period t (and zero otherwise). The coefficients β_m reflect the attribution of a shadow price to each of the M characteristics, while the changes in the antilogs of the coefficients γ_t are used to calculate returns over T time periods.

The choice of the hedonic characteristics is of key importance, since these variables should capture as precisely as possible the time-invariant quality or appeal of each item. Our database contains information on many of the characteristics that can be expected to impact gem prices. We first focus on 'the four Cs', which are assumed to be the most important factors in setting the value of diamonds (and, to some extent, other gems): carat, color, clarity, and cut. The variable *Ln(carat)* measures the natural log of the carat weight. We have different categories of color for each type of diamonds, indicating different color spectra of light emitted. For white diamonds, our dummy categories are based on the traditional scale which goes from D to Z.[3] Colorless or nearly colorless diamonds have greater brilliance. For colored diamonds, we include separate variables for blue, brown, green, pink, and yellow stones (which are the most frequently observed colors). With respect to the other gems, we create separate variables for emeralds, rubies, and for sapphires from Burma, Ceylon, and Kashmir. For the diamonds in our database, we also consider the clarity of each stone, going from flawless (*FL*), over internally flawless (*IF*), very very small inclusions (*VVS*), very small inclusions (*VS*), and small inclusions (*SI*), to inclusions or unspecified clarity (*Other / unknown*).[4] The inclusions are scratches, minerals, or other imperfections that have an impact on the diamond's clarity. Diamonds that are completely free from internal flaws are extremely rare. While the color and clarity of a diamond are predetermined by nature, the cut, which affects the brilliance and sparkle, is influenced by human intervention. Our database does not include detailed information on each object's proportions and finish. However, we take into account the shape of each diamond, by including a variable *Round*, which equals one if the diamond has the popular round cut. Dundek (2009) argues that "round brilliant diamonds are the only shape to have the perfect proportions defined. This shape has set the standard for all other diamond shapes." (Common non-round shapes are princess, emerald, radiant, oval, pear, asscher, marquise, and heart.)

Next, in most cases, we observe the location of sale, which can be Geneva, Hong Kong, Los Angeles, London, St. Moritz, or New York. If there are less than 20 sales in a location, the relevant sales are pooled with the *Other / unknown* category. Finally, we also include some additional information. *Christie's* equals one if the stone is sold at that auction house, and thus not at Sotheby's. *Brand* equals one if the jewel is from a premium brand, such as Bulgari, Cartier, Graff, or Tiffany. *Certificate* equals one when the database indicates that an authenticity certificate, often issued by one of the specialized laboratories, accompanies the stone. For white diamonds, a dummy variable *Potential* indicates whether the diamond could be upgraded by recutting or polishing. We only use these additional variables if there are at

[3] If a diamond is indicated to belong to two adjacent categories, we use the greatest letter.

[4] Only one colored diamond is of the "flawless" category; we pool it with the "internally flawless" stones.

least 20 observations that take the least frequent of the two possible values. (For example, all but one of the emeralds, rubies, and sapphires in our sample have a certificate, which makes the presence of a certificate not very informative.)

Table 2 shows the descriptive statistics for all variables in our set-up. For all dummy variables, we show the frequencies of zeros and ones. For the variable *Ln(carat)*, we show the average value. The mean weight is highest in the category of non-diamond gems (2.63 carat vs. 2.19 for white diamonds – compare Panels A and C). In the category of white diamonds (Panel A), we see that the 'colorless' diamonds with color grading D are traded most often at the included auctions (with 42.6% of the trades). For colored diamonds (Panel B), the most frequently observed color is yellow (57.0%), followed by pink (17.6%) and blue (11.5%). In both diamond categories (Panels A-B), we observe variation with respect to clarity, but stones with very small inclusions are the largest category. Truly flawless diamonds are very rare, even in the top segment of auctioned gems. Over the time period 1999-2010, only 91 flawless white diamonds were auctioned in addition to 484 internally flawless white diamonds (Panel A) and 151 internally flawless colored ones (Panel B). About one in five of the white diamonds, and one in eight of the colored diamonds have a round shape (Panels A-B). Panel C shows that sapphires are more frequently traded than both emeralds and rubies, but there is some variation in their countries of origin. For all three types of gems, a majority of the sales included took place at Christie's. Only a small minority is from a renowned premium brand. The proportion of white diamonds (Panel A) that has the potential to be upgraded by means of recutting or polishing is relatively small. Finally, we see that virtually all diamonds' origin and quality are well-documented and certified (Panels A-B).

[Insert Table 2 about here]

3. The price determinants of gems

The shadow prices of the hedonic characteristics – represented by the vector of coefficients β in Equation (1) – are assumed to stay constant over time. This is a fair assumption given that our estimation time frame is relatively short. Therefore, we deflate all prices to real USD, using the U.S. Consumer Price Index. We then estimate Equation (1) for each of the three types of stones, using ordinary least squares (OLS). Before examining the estimated returns, we focus on the results on the hedonic variables, which are shown in Table 3. To avoid multicollinearity, we have to leave out one dummy variable for some groups of variables. For the included dummies, we do not only report the coefficient, the standard deviation, and the t-statistic, but also the percentage price impact of the variable, which can be calculated as one minus the exponent of the coefficient. This enables us to focus on the economic significance of the hedonic variables.

[Insert Table 3 about here]

Table 3 shows that many of our hedonic variables have a substantial impact on prices. The impact of caratage differs between the different types of stones, but in general there is a very strong relationship between weight and price (Panels A-C). If we omit the squared term from the three models, the coefficients on *Ln(carat)* are all above one, indicating that in general prices increase more than proportionately with carat value (not reported). For white diamonds (Panel A), we see that prices move with the color and clarity scales. For example, a diamond of color category *E* sells on average at an 18.7% discount compared to an otherwise similar diamond of color category *D* (the left-out category); this discount increases to more than 80% for lower-quality stones. The average premium for a flawless diamond over an internally flawless (*FL*) diamond is 17.9%. Relative to an internally flawless white diamond, a white diamond with very very small inclusions (*VVS*) still incurs a discount of 27.2%. Also for colored diamonds (Panel B), color and clarity play important roles. The most expensive colored diamonds are blue; they cost in general more than twice as much as green diamonds, more than three times as much as pink ones, about eight times the value of yellow diamonds and more than sixteen times the value of brown diamonds. We also see that there is a significant premium of more than 20% for a round shape in the case of white diamonds (Panel A), but not for colored diamonds (Panel B). With respect to the other gem stone types (Panel C), we observe that rubies are clearly more expensive than the other types of stones. Rubies are twice as expensive as emeralds. There is a strong difference in price between the different types of sapphires: the ones coming from Kashmir are significantly more expensive than the ones from Burma or Ceylon. White diamonds (Panel A) sell at slightly higher prices in London and Hong Kong than in Geneva, New York, or Sankt Moritz. Other types of gems (Panel C) are especially expensive in Hong Kong. However, it is important to note that the pricing differences between locations may reflect otherwise unobservable differences in average quality, rather than violations of the law of one price. (Moreover, the pricing differences between locations are relatively small such that arbitrage opportunities between locations would not be exploitable.) We find no significant difference in prices that the different auction houses (Christie's and Sotheby's) obtain (Panels A-C). There are only relatively small premia for jewels created by renowned designer houses: 5.3% for white diamonds (Panel A), 2.3% for colored diamonds (Panel B) and 24.0% for other gems (Panel C). Substantially lower prices are paid for the few colored stones that do not seem to have a certificate (Panel B). Finally, we see a premium of more than 20% for white stones that have the potential to be recut and upgraded (Panel A).

At the bottom of each panel, we show the R-squared of each model. We find that our time dummies and hedonic characteristics together explain almost 95% of the variation in prices of white diamonds (Panel A). The explanatory power is somewhat lower for colored diamonds and for other gems, although still 50% or more.

In Figure 2, we graphically illustrate the importance of color and clarity for white diamonds. Panel A shows the relative pricing differences between D-grade diamonds and other color grades, all else equal. Panel B shows the premium or discount for different types of clarity in comparison to an otherwise identical internally flawless (*IF*) diamond.

[Insert Figure 2 about here]

4. The returns on gems

In Table 4, we show the returns for each type of gem, in deflated USD. These real returns are calculated as the exponent of the difference between the coefficients γ on the time dummy variables in two subsequent periods, minus one. For the non-diamond stones, we exclude the periods for which there are less than 20 observations, because we want to avoid reporting non-representative returns. We also construct a price index for each category, with the relative deflated price level in the first semester of 1999 (or the second half of 2003, in the case of other gems) set equal to 100.

[Insert Table 4 about here]

For white diamonds, we observe an annualized deflated USD return of 6.4% between the first half of 1999 and the end of 2010. Negative real returns were recorded in a number of time periods following the dot-com bust in early 2000 and during the middle of the recent financial crisis. These negative returns were more than compensated, however, by solid price rises subsequent to the crisis periods, namely between end-2003 and early-2008 and since late-2009, when also equity markets performed well. The results suggest that changes in the equity market impact the funds available for investment in collectibles markets; we will examine the relationship between equity and diamond prices more thoroughly in the next section. Despite the financial crisis of 2007-2008, the annualized return after inflation on white diamonds since the second half of 2003 still equals 10.0%.

The performance of colored diamonds is lower. The average deflated returns equal 2.9% since 1999 and 5.5% since 2003.[5] The index for other gem stones is only available over a shorter time period, and is relatively volatile. Nevertheless, the returns beat inflation by an annualized 6.8% between end-2003 and end-2010.

The nominal USD equivalents of the reported deflated returns since the second semester of 2003 are 12.6% for white diamonds, 8.0% for colored diamonds, and 9.5% for other gems (not reported).

5. Comparison with other assets

Table 4 is instructive, but it is hard to evaluate the financial attractiveness of gems without a proper benchmark. Therefore, in Figure 3 we compare the index values of white and colored diamonds to the investment performance of global stocks, global government bonds, and gold. All additional data come from Global Financial Data.[6] As before, all index values capture returns in deflated USD, and each index is set equal to 100 for the first half of 1999.

[Insert Figure 3 about here]

Figure 3 shows that white diamonds outperformed financial assets between early-1999 and late-2010. Colored diamonds performed better than stocks and approximately as well as bonds. Figure 3 also shows, however, that gold appreciated still faster than investment-grade

[5] Interestingly, the returns seem to anticipate somewhat the movement in the white diamond market: there is a positive correlation between the returns on white diamonds and the lagged returns on colored diamonds. The reason for this is unclear; maybe the timing of the sales plays a role.

[6] A methodological issue is the appropriate timing of the stock, bond, and gold returns, since the diamond price indices aggregate information per semester. The time series in Figure 3 and Table 5 are based on the underlying index values at the end of March and the end of September in each year.

gems. Of course, gold has increased its status of a safe haven since the deep financial crisis that started in 2007.

Figure 3 also further illustrates that shocks in the equity market often precede changes in the gem market. For example, the financial crisis struck in the second half of 2007, but only translated into lower diamond prices in the second semester of 2008.

In Table 5, we more formally compare the performance of white and colored diamonds with that of financial assets and gold since the first half of 1999. We show the annualized returns, the annualized standard deviation,[7] and an estimate of the Sharpe ratio (i.e., the return in excess of the risk free rate by unit of risk) for each asset.[8] Moreover, we include the correlation of each asset with same-period and previous-period global stock returns.

[Insert Table 5 about here]

White diamonds appreciated by an annualized 6.4% in real USD between 1999 and 2010, whereas stocks and bonds recorded average returns of -0.1% and 3.3% over the same period. (For gold, the average annual appreciation since the first half of 1999 is equal to 11.6%.) The dismal performance of stocks is of course influenced by the bursting of the high-tech bubble in 2000 and by the financial crisis that commenced in 2007. When combining return and risk into a Sharpe ratio, we learn that white diamonds have substantially outperformed stocks since 1999, while their reward-to-variability has been comparable to that of bonds.[9]

Table 5 also shows that the price changes of diamonds are positively correlated with contemporaneous and lagged global equity market returns. This confirms the existence of a stock market wealth effect: the acquisition of diamonds is impacted by the evolution of equity wealth. (A similar observation that equity markets have wealth effects on collectibles prices is made by Goetzmann et al. (2011) in the context of the art market.) Our results thus shed doubt on the statement of an auction house jewelry specialist in July 2008 that "when stock markets go down, it's always good for us" (Bloomberg, 2008), which would suggest a

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[7] The annualized standard deviation is calculated by multiplying the standard deviation over the half-yearly returns by the square root of two.

[8] We consider returns before transaction costs; these costs are of course higher for gems than for financial assets.

[9] It is important to note that the raw standard deviations may slightly underestimate the true riskiness of diamond investments, due to the time aggregation of data. We do not go deeper into this issue here, but refer to Renneboog and Spaenjers (2010).

negative correlation between the diamond and equity markets. Table 4 already showed that white diamond prices dropped substantially during the second half of 2008 and the first half of 2009 – even if somewhat less than the overall equity market.

6. The "masterpiece effect"

An interesting question is whether the highest-end objects appreciate faster in value than the market as a whole. We therefore repeat the estimation of our hedonic model, first using all white diamonds of color categories D, E, and F, and second using all of those diamonds that weigh at least 10 carat. We illustrate the findings in Figure 4.

[Insert Figure 4 about here]

There seems to be a small return premium for top-quality objects. Over our time frame, we find an annualized return of 7.6% for the larger white diamonds of categories D, E, and F (not reported), compared to 6.4% for our baseline series. This backs up previous evidence on the art market that higher returns can be realized on "masterpieces" (Renneboog and Spaenjers, 2010). Yet, just like high-quality art works, top-end diamonds have slightly more volatile price paths.

7. Conclusion and discussion

In this paper, we study the market for investment-grade gems between 1999 and 2010. Applying a hedonic regression to a unique data set of auction transactions, we confirm that 'the four Cs' indeed play an important role in setting white diamond prices; overall, we are able to explain about 95% of their price variation. Our model also performs well for colored diamonds and other gems (sapphires, rubies, and emeralds).

Over the past twelve years, the annual USD returns for white and colored diamonds amount to 6.4% and 2.9%, over and above inflation. Since 2003, we are also able to calculate returns for other gem types. The annualized real returns are then 10.0%, 5.5%, and 6.8% for white diamonds, colored diamonds, and other gems, respectively; the nominal equivalents are 12.6%, 8.0%, and 9.5%.

Although the diamond returns since 1999 have been below those on gold (a much-used safe haven in the recent financial crisis), both white and colored diamonds have significantly outperformed the stock market. The reward-to-risk of white diamonds has been very close to that of government bonds. The returns on gems are positively correlated with stock market returns: an increase (decrease) in equity prices is often followed by an increase (decrease) in diamond prices. There is evidence of a positive “masterpiece effect”: returns may be higher for higher-quality objects.

One important issue to keep in mind is the low performance and high volatility of financial markets in the period examined in this paper. Ideally, we would like to compare the price trends of diamonds with that of financial assets over longer periods. Under the influence of De Beers, the market price of rough diamonds in the primary market has gone up over many decades, but it is unclear whether this represents a realizable return for investors. It is well-known that the aim of De Beers is to have a steady upwards price path in the primary market, and as little activity as possible in the secondary market. Furthermore, the crash in the price level of retail diamonds in the early 1980s (National Gemstone, 2010) hints at the existence of risks not captured by our study. More research is needed to get a truly long-term picture of the realizable investment performance of gems.

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Table 1: Numbers of observations and average price levels

Table 1 displays the number of observed sales, the average price in nominal USD, and the average price per carat in nominal USD of white diamonds, colored diamonds, and other gems for each semester over the period 1999-2010. It also shows the total number of observations and the overall average prices for each type.

	Number of observations			**Average price in nominal USD**			**Average price / carat in nominal USD**		
Semester	White	Colored	Other gems	White	Colored	Other gems	White	Colored	Other gems
1999 (1)	42	23	10	247,046	259,096	248,738	18,290	38,311	20,302
1999 (2)	75	51	34	347,237	435,426	129,036	23,968	65,195	12,051
2000 (1)	87	38	49	376,442	358,030	200,715	23,135	56,965	14,632
2000 (2)	71	36	37	254,645	425,774	239,704	19,717	61,115	15,660
2001 (1)	89	43	28	321,323	228,779	220,736	21,787	46,633	11,638
2001 (2)	121	44	36	244,371	232,824	276,043	20,964	42,517	20,013
2002 (1)	72	49	27	267,138	228,782	156,929	19,666	38,609	14,622
2002 (2)	70	46	19	212,887	271,755	140,445	22,697	50,074	14,297
2003 (1)	49	27	18	308,444	237,116	145,530	20,519	20,402	12,935
2003 (2)	71	33	22	349,074	324,789	353,246	26,485	68,226	21,915
2004 (1)	88	57	30	375,120	434,952	220,680	27,891	64,022	20,484
2004 (2)	53	27	23	350,790	440,614	332,264	26,971	80,221	31,621
2005 (1)	113	42	48	370,545	404,504	320,667	25,588	79,268	27,256
2005 (2)	43	22	34	322,655	910,639	179,389	24,224	102,130	12,393
2006 (1)	101	65	71	371,682	547,782	291,371	32,889	64,549	24,211
2006 (2)	96	53	48	507,463	416,943	217,985	37,841	52,515	21,440
2007 (1)	92	60	42	415,626	683,877	344,331	36,585	76,489	22,288
2007 (2)	133	57	55	638,049	696,880	356,401	46,477	115,874	24,553
2008 (1)	86	51	41	817,855	778,011	316,885	58,728	86,682	25,316
2008 (2)	91	49	29	670,503	920,661	308,912	52,488	65,426	15,262
2009 (1)	111	36	37	465,515	676,261	175,948	40,659	92,984	16,103
2009 (2)	119	75	34	689,957	767,280	415,065	49,572	148,409	33,079
2010 (1)	118	75	49	653,831	775,850	434,993	53,040	145,689	38,489
2010 (2)	43	27	11	411,951	774,281	292,786	57,089	111,094	34,191
Total	2,034	1,086	832	440,583	530,349	272,921	34,226	78,306	21,430

Table 2: Descriptive statistics of hedonic variables

Table 2 shows the descriptive statistics of the hedonic variables included in this research. All hedonic characteristics are defined in Section 2 of this paper. For the dummy variables, we present the number of sales for which the variable takes the values of zero (0) and one (1), and the proportion of ones (% 1). For the caratage, we show the median carat weight. Panels A, B, and C show the statistics for white diamonds, colored diamonds, and other gems, respectively.

Panel A: White diamonds

Variable	0	1	% 1
Carat			
Ln(carat)	[median = 7.755 carat]		
Color			
D	1,167	867	42.6%
E	1,864	170	8.4%
F	1,826	208	10.2%
G	1,855	179	8.8%
H	1,862	172	8.5%
I-J	1,818	216	10.6%
K-L	1,945	89	4.4%
M-Z	1,915	119	5.9%
Other / unknown	2,020	14	0.7%
Clarity			
FL	1,943	91	4.5%
IF	1,550	484	23.8%
VVS	1,548	486	23.9%
VS	1,300	734	36.1%
SI	1,813	221	10.9%
Other / unknown	2,016	18	0.9%
Cut			
Round	1,628	406	20.0%
Location			
Geneva	1,384	650	32.0%
Hong Kong	1,562	472	23.2%
L.A.	2,013	21	1.0%
London	2,001	33	1.6%
St. Moritz	1,882	152	7.5%
New York	1,351	683	33.6%
Other / unknown	2,011	23	1.1%
Additional information			
Christie's	803	1,231	60.5%
Brand	1,772	262	12.9%
Certificate	136	1,898	93.3%
Potential	1,876	158	7.8%

Panel B: Colored diamonds

Variable	0	1	% 1
Carat			
Ln(carat)	[median = 7.175 carat]		
Color			
Blue	961	125	11.5%
Brown	1,004	82	7.6%
Green	1,057	29	2.7%
Pink	895	191	17.6%
Yellow	467	619	57.0%
Other / unknown	1,046	40	3.7%
Clarity			
IF	935	151	13.9%
VVS	862	224	20.6%
VS	624	462	42.5%
SI	944	142	13.1%
Other / unknown	979	107	9.9%
Cut			
Round	964	122	11.2%
Location			
Geneva	736	350	32.2%
Hong Kong	792	294	27.1%
St. Moritz	1,012	74	6.8%
New York	769	317	29.2%
Other / unknown	1,035	51	4.7%
Additional information			
Christie's	478	608	56.0%
Brand	998	88	8.1%
Certificate	43	1,043	96.0%

Panel C: Other gems

Variable	0	1	% 1
Carat			
Ln(carat)	[median = 12.885 carat]		
Color			
Emerald	656	176	21.2%
Ruby	692	140	16.8%
Sapphire Burma	618	214	25.7%
Sapphire Ceylon	686	146	17.5%
Sapphire Kashmir	676	156	18.8%
Location			
Geneva	482	350	42.1%
Hong Kong	690	142	17.1%
St. Moritz	763	69	8.3%
New York	588	244	29.3%
Other / unknown	805	27	3.2%
Additional information			
Christie's	346	486	58.4%
Brand	647	185	22.2%

Table 3: Regression results hedonic variables

Table 3 shows the results (coefficients, standard deviations, and t-statistics) of the OLS estimation of hedonic regression equation (1). All hedonic characteristics are defined in Section 2 of this paper. For the dummy variables, we also report the price impact, calculated as one minus the exponent of the coefficient. Panels A, B, and C show the results for white diamonds, colored diamonds, and other gems, respectively.

Panel A: White diamonds

Variable	Coeff.	S.D.	*t*-stat.	Impact
Time dummies		[cf. Table 4]		
Carat				
Ln(carat)	1.8696	0.0578	32.33	
Ln(carat)^2	-0.0949	0.0115	-8.27	
Color				
D		[left out]		
E	-0.2076	0.0221	-9.38	-18.7%
F	-0.3175	0.0211	-15.01	-27.2%
G	-0.5202	0.0223	-23.35	-40.6%
H	-0.6975	0.0228	-30.60	-50.2%
I-J	-1.0083	0.0215	-46.84	-63.5%
K-L	-1.4045	0.0314	-44.74	-75.5%
M-Z	-1.7475	0.0302	-57.92	-82.6%
Other / unknown	-1.8066	0.0730	-24.76	-83.6%
Clarity				
FL	0.1649	0.0299	5.52	17.9%
IF		[left out]		
VVS	-0.3177	0.0185	-17.16	-27.2%
VS	-0.4320	0.0180	-24.02	-35.1%
SI	-0.7521	0.0230	-32.69	-52.9%
Other / unknown	-1.0507	0.0643	-16.34	-65.0%
Cut				
Round	0.2013	0.0148	13.62	22.3%
Location				
Geneva		[left out]		
Hong Kong	0.1343	0.0173	7.78	14.4%
L.A.	0.0445	0.0573	0.78	4.6%
London	0.1763	0.0465	3.80	19.3%
St. Moritz	-0.0061	0.0244	-0.25	-0.6%
New York	0.0012	0.0148	0.08	0.1%
Other / unknown	-0.0789	0.0541	-1.46	-7.6%
Additional information				
Christie's	0.0077	0.0121	0.63	0.8%
Brand	0.0514	0.0174	2.95	5.3%
Certificate	-0.0562	0.0271	-2.07	-5.5%
Potential	0.2095	0.0232	9.04	23.3%
N		2,034		
R-squared		94.7%		

Panel B: Colored diamonds

Variable	Coeff.	S.D.	*t*-stat.	Impact
Time dummies		[cf. Table 4]		
Carat				
Ln(carat)	0.6547	0.1008	6.49	
Ln(carat)^2	0.0560	0.0220	2.55	
Color				
Blue	2.2244	0.0878	25.32	824.8%
Brown	-0.6951	0.0968	-7.18	-50.1%
Green	1.5177	0.1568	9.68	356.2%
Pink	1.2405	0.0709	17.50	245.7%
Yellow		[left out]		
Other / unknown	0.8323	0.1346	6.18	129.9%
Clarity				
IF		[left out]		
VVS	-0.2773	0.0848	-3.27	-24.2%
VS	-0.3099	0.0769	-4.03	-26.7%
SI	-0.4905	0.0962	-5.10	-38.8%
Other / unknown	-0.5898	0.1066	-5.53	-44.6%
Cut				
Round	-0.0218	0.0783	-0.28	-2.2%
Location				
Geneva		[left out]		
Hong Kong	-0.1036	0.0697	-1.49	-9.8%
St. Moritz	-0.2580	0.1099	-2.35	-22.7%
New York	-0.1575	0.0661	-2.38	-14.6%
Other / unknown	0.3465	0.1243	2.79	41.4%
Additional information				
Christie's	-0.0210	0.0518	-0.40	-2.1%
Brand	0.0231	0.0895	0.26	2.3%
Certificate	0.4578	0.1311	3.49	58.1%
N		1,086		
R-squared		59.2%		

Panel C: Other gems

Variable	Coeff.	S.D.	*t*-stat.	Impact
Time dummies		[cf. Table 4]		
Carat				
Ln(carat)	1.2334	0.2058	5.99	
Ln(carat)^2	-0.0636	0.0353	-1.80	
Color				
Emerald		[left out]		
Ruby	0.7737	0.0819	9.45	116.8%
Sapphire Burma	-0.7254	0.0751	-9.67	-51.6%
Sapphire Ceylon	-1.3054	0.0886	-14.74	-72.9%
Sapphire Kashmir	0.3226	0.0785	4.11	38.1%
Location				
Geneva		[left out]		
Hong Kong	0.3564	0.0757	4.71	42.8%
St. Moritz	-0.2236	0.0994	-2.25	-20.0%
New York	0.0633	0.0618	1.02	6.5%
Other / unknown	-0.2035	0.1510	-1.35	-18.4%
Additional information				
Christie's	0.0439	0.0539	0.81	4.5%
Brand	0.2152	0.0604	3.56	24.0%
N		832		
R-squared		50.0%		

Table 4: Real returns and index values

Table 4 shows the returns in deflated USD, which follow from the OLS estimation of hedonic regression equation (1), for white diamonds, colored diamonds, and other gems for each semester over the period 1999-2010. It also shows index values, where the index is set equal to 100 in the first semester of 1999 for white and colored diamonds, and in the second half of 2003 for other gems.

	Real returns (in deflated USD)			Index values		
Period	White	Colored	Other gems	White	Colored	Other gems
1999 (1)				100.0	100.0	
1999 (2)	16.6%	7.5%		116.6	107.5	
2000 (1)	-1.2%	-35.4%	3.9%	115.2	69.4	
2000 (2)	-8.9%	43.8%	-10.5%	104.9	99.9	
2001 (1)	6.0%	-8.3%	5.1%	111.3	91.6	
2001 (2)	-5.0%	-22.9%	-1.2%	105.7	70.6	
2002 (1)	-1.1%	10.1%		104.6	77.7	
2002 (2)	-1.9%	-4.8%		102.6	74.0	
2003 (1)	-8.5%	-4.7%		93.9	70.5	
2003 (2)	12.2%	35.4%		105.3	95.4	100.0
2004 (1)	0.2%	-4.6%	1.3%	105.5	91.0	101.3
2004 (2)	10.2%	23.5%	-3.5%	116.3	112.4	97.7
2005 (1)	16.6%	10.5%	1.4%	135.6	124.3	99.0
2005 (2)	2.7%	2.3%	-19.3%	139.2	127.1	80.0
2006 (1)	10.8%	-5.4%	25.8%	154.3	120.3	100.6
2006 (2)	7.8%	-1.2%	-15.3%	166.3	118.8	85.2
2007 (1)	10.1%	8.0%	55.3%	183.2	128.4	132.3
2007 (2)	9.0%	14.5%	-12.5%	199.7	147.0	115.8
2008 (1)	36.0%	-14.6%	22.7%	271.6	125.6	142.1
2008 (2)	-23.3%	-15.9%	-33.6%	208.2	105.6	94.3
2009 (1)	-13.5%	0.8%	-7.1%	180.0	106.4	87.7
2009 (2)	4.9%	17.7%	58.7%	188.8	125.2	139.1
2010 (1)	10.4%	0.6%	10.4%	208.5	125.9	153.6
2010 (2)	-1.6%	10.0%		205.0	138.4	
Geometric average return since 1999 (1)				6.4%	2.9%	N.A.
Geometric average return since 2003 (2)				10.0%	5.5%	6.8%

Table 5: Return distributions and correlations with stock returns

Table 5 provides information on the distribution of returns in deflated USD for white diamonds, colored diamonds, stocks, bonds, and gold, based on half-yearly returns over the period 1999-2010. The returns for white and colored diamonds are shown in Table 4. Data on the returns of global stocks, global government bonds, and gold were downloaded from Global Financial data.

	Annualized average return	**Annualized standard deviation**	**Sharpe ratio**	**Correlation with stock returns**	**Correlation with lagged stock returns**
White	6.4%	16.7%	0.440	0.310	0.370
Colored	2.9%	24.5%	0.228	0.270	0.176
Stocks	-0.1%	22.5%	0.098	1.000	0.043
Bonds	3.3%	6.9%	0.438	0.165	-0.004
Gold	11.6%	11.9%	0.979	0.155	0.130

Figure 1: Average price / carat in nominal USD

Figure 1 shows the average price per carat in nominal USD of white diamonds, colored diamonds, and other gems for each semester over the period 1999-2010.

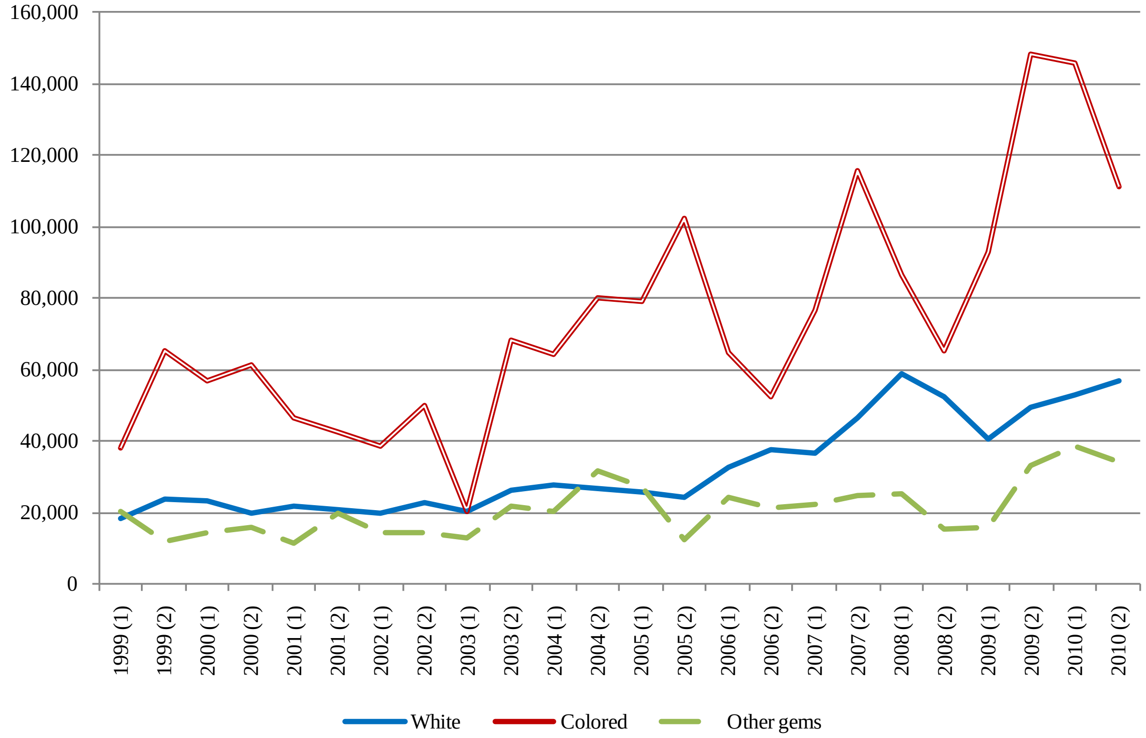
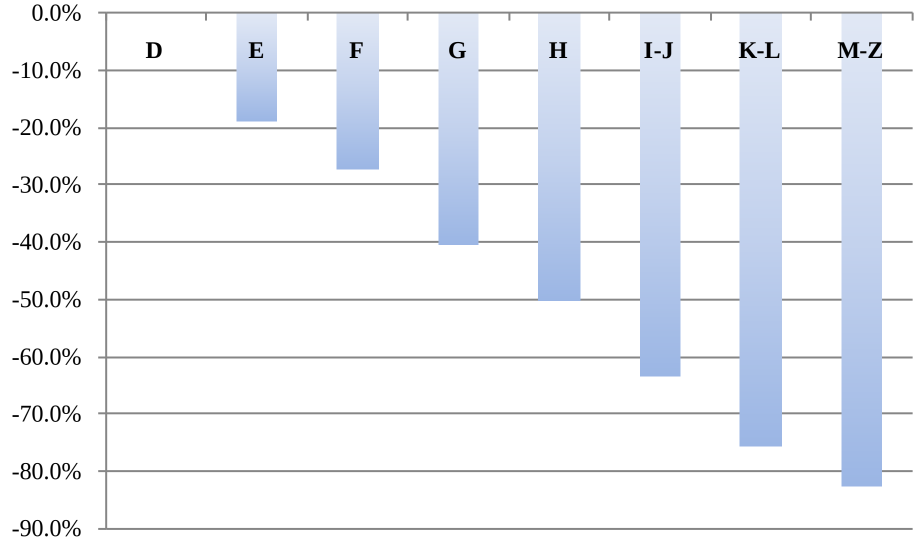


Figure 2: Importance of color and clarity for white diamonds

Figure 2 shows the relative pricing differences between white diamonds of different color grades (in Panel A) and clarity types (Panel B). The percentage premiums or discounts relative to the base categories (color grade *D* in Panel A and clarity type *IF* in Panel B) come from the hedonic regression output shown in Table 3.

Panel A: Color



Panel B: Clarity

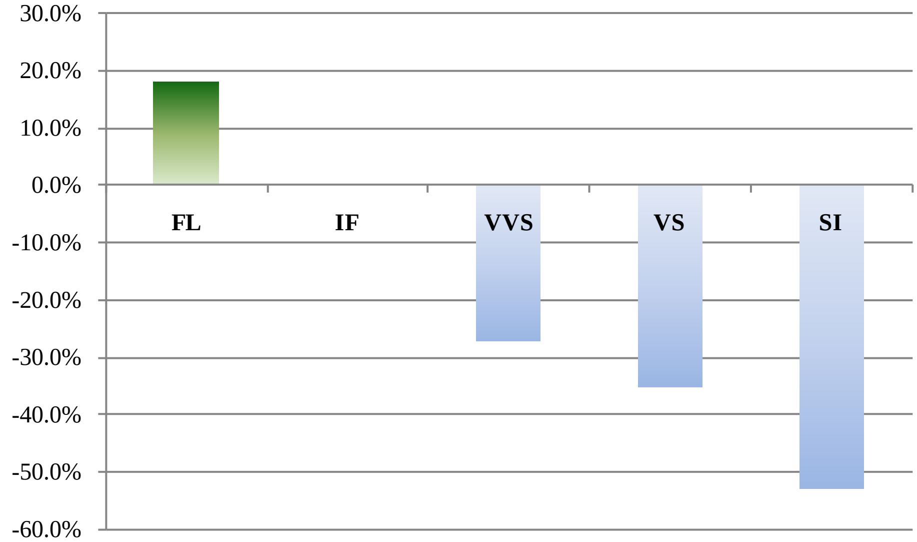


Figure 3: Real index values

Figure 3 shows the index values in deflated USD for white diamonds, colored diamonds, stocks, bonds, and gold, for each semester over the period 1999-2010. The returns for white and colored diamonds are shown in Table 4. Data on the returns of global stocks, global government bonds, and gold were downloaded from Global Financial data. In all cases, the index is set equal to 100 in the first semester of 1999.

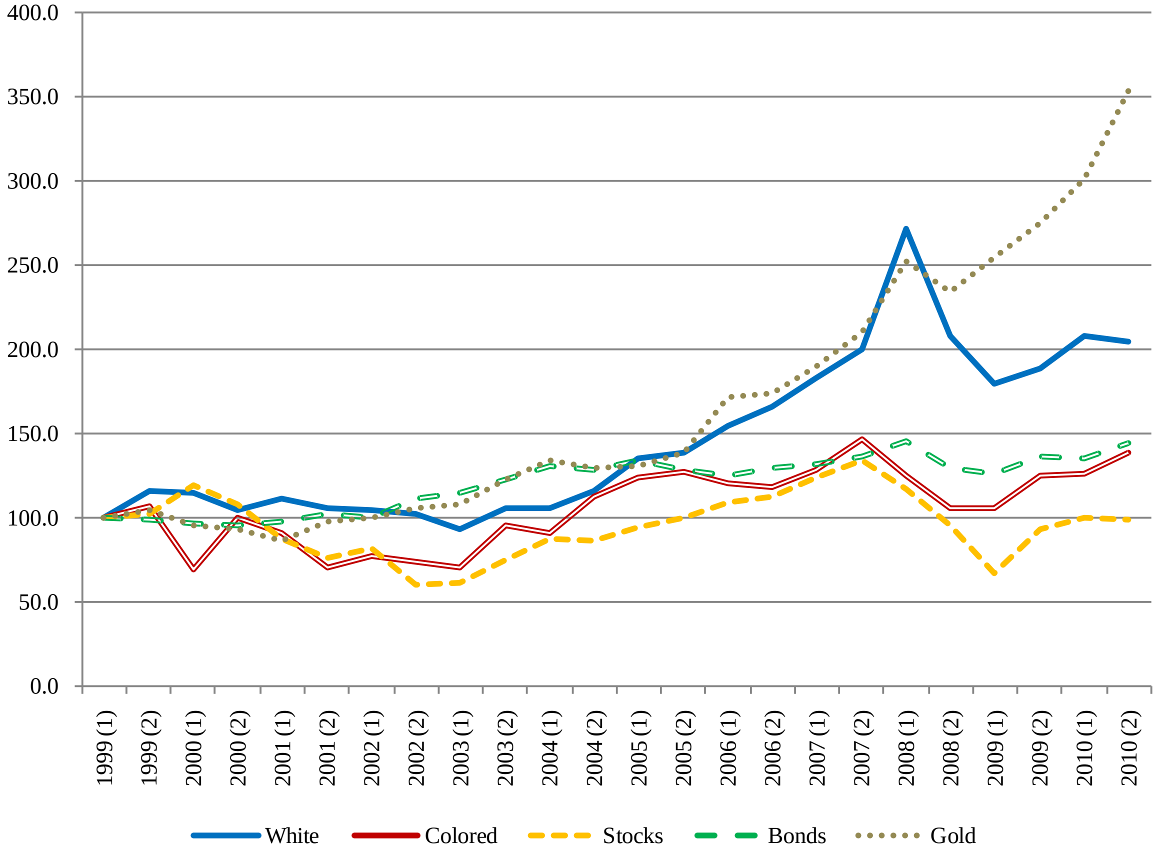


Figure 4: The "masterpiece effect"

Figure 4 shows the index values in deflated USD for white diamonds, white diamonds of color categories D, E, and F, and white diamonds of color categories D, E, and F of at least 10 carat, for each semester over the period 1999-2010. The baseline returns for white diamonds are shown in Table 4. The other returns follow from a re-estimation of hedonic regression equation (1). In all cases, the index is set equal to 100 in the first semester of 1999.