**RESULTS**

**HEDONIC REGRESSION**

We begin by fitting a hedonic regression model to our three datasets in order to construct a measure of artistic value for each piece. For Impressionist art (as in Beggs & Graddy (2009)), though, predictions are fit separately for observations in London and in New York due to currency differences, then recombined for the anchoring regressions. Tables 4-7 below show the results of the hedonic predictions.

Overall, hedonic characteristics such as the painting dimensions, the presence of a signature, medium, and artist and time effects (both omitted for brevity; both highly significant) have a significant impact on the sale price of the painting. It is surprising that a painting’s date of creation is generally not significant, which can be explained by the importance of artist variables. For Impressionist Art and Contemporary Art, much of the variation in price is explained by our regression model, indicated by generally high values. For our new dataset, however, the value is extremely low although variables are significant. This is to be expected: our dataset covers a very large variety of paintings, and so we should see very high variance across prices in our regression model (though far lower bias, as indicated by our highly significant hedonic variables). The F-statistic is extremely significant in all cases, which shows that our regression variables are relevant as a whole. In general, the most impactful variables are those for the art medium and the dimensions. This may be attributed to large pieces and pieces from specialized mediums selling for more, as indicated by large, significant coefficients for certain mediums and not for others. Despite a high value for Impressionist art, the intercept is highly significant. This suggests that non-hedonic factors likely play a large role in determining value for Impressionist pieces, which is understandable given the relatively more pronounced age and renown of those works. Additionally, the presence of a signature specifically, rather than other signs of authenticity such as a monogram, generally seems to be more important to determining hedonic value. We do observe that signature is more significant for Impressionist art auctioned in NYC, while medium is probably a more significant factor for that auctioned in London. As a further note, regressing on only artist and time dummies corresponds to a reduction in in the Impressionist and Contemporary datasets, as noted in Beggs & Graddy (regressions not included). Generally, it is clear that hedonic factors such as size and medium do play a large role in determine value for the works we examine.

**REPLICATION OF BEGGS & GRADDY (2009), “ANCHORING EFFECTS: EVIDENCE FROM ART AUCTIONS”**

Here, we attempt to replicate some of the work of Beggs & Graddy (2009), who analyze the same Impressionist and Contemporary datasets to test whether the first sale of a painting produces an anchoring effect on its later sales. In this research we only consider sale price, but they also run regressions for presale estimate and the probability of sale. As mentioned earlier, they identified resale observations by cross-checking against presale catalogs, so it is not possible for us to entirely replicate their work. We make the assumption that duplicate hedonic observations refer to multiple sales of the same item, and run our regressions for the full datasets each.

Tables <> to <> show our results, as well as the original tables of Beggs & Graddy. We were able to reproduce the discovery of highly significant anchoring effects in Impressionist art, and the more weakly significant effects in Contemporary art. However, our coefficients are not nearly as large, although significant. For Impressionist art, a 10% increase in the difference between past price and current hedonic prediction (anchoring) only corresponds to a 1.7% increase in the current sale price (original: 6.2-8.5%), while for Contemporary art this is only a 1.3% predicted increase (original: 5%). On the other hand, our regressions show that the residuals from past price (unobserved inputs into past price, such as the thrill of bidding) are much strong than anchoring in the case of Impressionist art (5% increase for Impressionist), which differs from the results of Beggs & Graddy. One explanation could be that the reputation of Impressionist pieces grows over time as these pieces trade ownership across collectors and museums, so that reputation effects tend to drive up buyer demand beyond hedonic value or even past price anchors. This suggests that bidders may not conduct serious hedonic analysis when considering related goods, or do not know how to properly appraise those substitutes. We do find a weaker impact of the past residuals on current price in the case of Contemporary art, a result which is shared by Beggs & Graddy. They attribute this to the heavy time-dependent variation in prices in this Contemporary art dataset (not shown here), which suggests past prices would not serve as meaningful anchors. We also replicated their discovery of relatively small time coefficients, particularly for Contemporary art. This indicates that the specific number of months between sales seems to not be a major influence in determining the current price of a work. Finally, our anchoring regressions also share the very high and adjusted values of Beggs & Graddy, indicating that much of the variation in hammer prices is explained by this model.

In addition to Impressionist and Contemporary art, we also ran their original anchoring regression on our new dataset of recent assorted painting sales (Table <>). Because our dataset does not seem to have identifiable multiple sales of the same item, we used an item’s average substitute (constructed as described in our methodology) instead of a past sale. This corresponds to running our regression for anchoring cross-effects without the measure of substitution, i.e. the control term. Despite this naïve approach that does not control for substitution, we can still discover some insight.

The value is much lower due to the very high variation in our data, but the F-statistic is extremely high indicating that our regression variables do seem to be relevant. We discovered strong and highly significant anchoring effects in this context (5.9% increase), although as in Contemporary art the residual from past price seemed to be relatively unimportant and less significant. This suggests that, although we have not properly controlled for substitution, anchoring is at work in this dataset. As in both the original results of Beggs & Graddy and our replication of their work, we found that time effects seemed to be relatively weak, though they are highly significant. Hence, our next regressions, designed to control for substitution, should yield more precise and accurate insight into anchoring effects. # CHECK THIS TO MAKE SURE DOESN’T CONFLICT WITH LATER INSIGHT, JUST USE THIS TO SHOW “GENERAL” RESULTS. OR, IF IT DOES ALL CONFLICT, YOU COULD USE THIS TO SHOW HOW NOT CONTROLLING FOR SUBSTITUTION REALLY IS PROBLEMATIC AND CAN LEAD YOU TO INACCURATE RESULTS.

< discuss why all variables are significant yet low R squared >

**ANCHORING CROSS-EFFECTS**

In this section, we describe our regression results that control for substitution. We employ our measures which describe how similar a current good is to its “average substitute,” a representative good constructed from all other identified substitutes. As discussed earlier, the measure represents the (log) second moment of hedonic prices of substitutes about that of the current good. This allows to capture both the spread of hedonic differences as well as the magnitude of those differences. Conversely, the variable measures similarity across art pieces according to insight from our interviews, and represents the importance of size, price, and time effects.

**Q1: SECOND MOMENT OF HEDONIC PRICE DIFFERENCES**

Tables <> through <> show the results of running the above regression for our Impressionist, Contemporary, and assorted art datasets. There are several results particularly worth noting here.

First, after controlling for substitution, anchoring effects lose significance for Contemporary art, and only retain significance for Impressionist and recent assorted art. It is possible that anchoring is no longer significant because Contemporary art tends to be especially diverse: <compare and contrast: scatterplot of hedonic values for Impressionist and Contemporary art>. As a result, a piece to be auctioned may lack obvious precedents for its value, which means that current price will be determined by the piece’s own characteristics as well as unobserved inputs into price such as general demand for Contemporary art. These seem to be confirmed by the highly significant, non-negative substitute residual, as well as the insignificant measure of substitution. For Impressionist art, we would expect past prices of substitutes, and unobserved inputs into those substitutes, to significantly affect the price for a current piece since as Beggs & Graddy (2009) show, Impressionist art prices have steadily risen over the decades. Here, while no doubt hedonic characteristics such as authenticity and artist do help determine value, the auction history of an Impressionist piece and its relatives are also informative. However, the anchoring coefficient for Impressionist art is small, suggesting that other factors into value (e.g. publicity for a well-known Impressionist work) are more influential. Finally, our assorted art dataset exhibits strong and highly significant anchoring effects. This could be due to the vastly larger and more diverse range of artworks, which could yield a higher chance of finding appropriate substitutes and other pieces that have closer hedonic price predictions.

Furthermore, while time effects (months since last sale) seem to be relatively strong (and significant) for Contemporary and assorted art sales, they are weaker for Impressionist art. From our interviews, we learned that buyers of art tend to be relatively myopic, in that they do not tend to internalize the full range of historical prices (only recent prices, i.e. anchoring). This is confirmed here by small coefficients. For example, in the assorted art dataset, a 100 month (8.3 year) time interval between sales only corresponds to a -8% decrease in the current price. For Contemporary art, the same gap corresponds to a -5% decrease, while for Impressionist art the association is almost nonexistent. This finding is corroborated for Impressionist art by the price indices in Beggs & Graddy (2009), who find small time coefficients for both Impressionist and Contemporary art. It seems that myopic buyers do not internalize earlier, lower prices which allows prices to climb up over time.

It is clear that our measure of substitution is a stronger and more relevant predictor of price for Impressionist and assorted art than for Contemporary art. As we discussed earlier, it is more difficult to identify substitutes for Contemporary goods, which tend to be far more heterogeneous in their hedonic characteristics. For instance, based on our interviews, we learned that over time the boundaries between art mediums have become finer as mediums are combined in “mixed media” formats. These unusual Contemporary artworks do seem to fetch competitive sums at auction[[1]](#footnote-1) [[2]](#footnote-2). Conversely, Impressionist works tend to have better-defined mediums such as oil and watercolor, which makes it easier to accurately assess substitution. Though significant, the coefficients are overall still relatively small, which indicates that price may not be hugely impacted by our measure. In the case of assorted art, a 100% increase in substitution quality only corresponds to a 2% increase in sale price, through the channel of anchoring.

The values are generally in line with our results for the original anchoring regression: there is generally much less variation in the Impressionist and Contemporary datasets than in our assorted art one. High F-statistics confirm the relevance of our variables, as before.

**Q2: DOMAIN KNOWLEDGE**

Tables <> through <> show the results of using as a control for substitution. We see many similar results since both artwork size and hedonic price prediction enter into both measures of substitution, but some differences are apparent.

First, the measure of substitution becomes significant for Contemporary art. Size, which was already significant in our hedonic regression results, plays a much larger role in and may be key behind this result. Unlike Impressionist art, which seems to be purchased more as an alternate investment or showpiece rather than for its hedonic characteristics, Contemporary art which is often newer seems to be evaluated more based on hedonic characteristics. This is demonstrated in our hedonic regression results: the much higher intercept for Impressionist art suggests that non-hedonic factors such as buyer wealth and general demand for Impressionist pieces are at play. Thus for Contemporary art, based on our results, focusing on major hedonic characteristics such as size may be a more appropriate measure of similarity for Contemporary art. For Impressionist art, is less significant and may be less relevant than our previous measure. We suspect this is because time effects seem to be more impactful for Contemporary art than for Impressionist art (though the coefficients are still relatively small). Prices for Impressionist pieces, in general, seem to be somewhat resistant to long intervals between sales.

For our assorted art dataset, is a hugely more impactful measure of substitution than: a 10% improvement in substitution quality corresponds to a 3.0% increase in sales price. Hence, we see that the quality of substitution is highly relevant to sale price, in that the former shapes the latter through anchoring (which remains roughly as impactful across and). Focusing on size, hedonic price, and time duration seems to be far more effective as a control, since for this assorted art dataset, it is possible that the hedonic price predictions in may capture too much noise to be helpful for measuring substitution. Nevertheless, regardless of which measure we use, we are still accounting for a lot of variation in the data, as evidenced by moderate-low values. This is as expected: the measure invokes a smaller subset of hedonic variables than does.

We see generally similar anchoring results regardless of whether we use or, which is expected since the two measures invoke some of the same variables. We do see a decrease in the anchoring coefficients across the board when we use, which indicates that might be a more stringent measure of substitution. Overall, even when controlling for quality of substitution we see significant anchoring cross-effects in the Impressionist and assorted art datasets. Anchoring cross-effects are vastly stronger in our assorted art dataset, which we attribute to our diversity of works. We can thus conclude that the price of a given art piece is indeed biased by the past sale prices of related goods (anchoring effect), although the exact mechanism by which this occurs remains a black box.

|  |  |  |
| --- | --- | --- |
|  | Anchoring under | Anchoring under |
| Impressionist Art | 0.034 \* | 0.026 \* |
| Contemporary Art | -0.03 | -0.02 |
| Assorted Art | 0.66 \*\*\* | 0.52 \*\*\* |

One domain expert in the art history department here (Princeton University) helped us to identify pairs of “similar” artists in our assorted art dataset. In the next section, we run our and regressions on three pairs of artists for comparison. This allow us directly test our anchoring regressions on known substitutes, and evaluate our results more thoroughly. Only Contemporary artist pairs were provided.

**SUBSTITUTION EXPERIMENT #1:**

**JOAN MIRO (1893-1983) AND SALVADOR DALI (1904-1989)**

Miro and Dali were two of the most iconic Spanish Surrealists, and created pieces that are at once abstract, imaginative, and occasionally absurd. The work of Miro draws heavily on well-defined geometric shapes and lines, filled with bright colors and political overtones[[3]](#footnote-3). Dali’s work, which ranges from bizarre scenes to nightmarish landscapes, is dreamlike yet shows an appreciation for the realistic nature of classical and Renaissance art[[4]](#footnote-4). Works by both Surrealists have sold at auction for 6- and 7-figure sums, and the two Surrealists are occasionally paired together at museum and gallery exhibitions[[5]](#footnote-5).

Tables <> and <> show the anchoring regression results with our respective controls and. First, it is notable that anchoring is entirely insignificant with, but gains a highly significant p-value and becomes much stronger when is used. However, is highly significant and impactful, but is not. This negative association between the anchoring effect and the measure of substitution in this dataset suggests that is not an appropriate control, which would indicate that the anchoring effects in the case may be illusory. Either way, there is a large amount of variation that our model cannot explain, as evidenced by our low values. It is also surprising that the hedonic price predictions are relatively weak and insignificant, and that unobserved inputs into the substitute’s price (the substitute’s residual) are impactful and highly significant. Even further, the intercept term is very large and significant. Together, all these observations suggest that there are other influential inputs at work (in the error term) beyond our identified variables. Thus, a substitution control better tailored to Dali and Miro might be required in this scenario, as anchoring effects between Dali and Miro pieces are inconclusive here. However, this experiment does highlight the importance of controlling for substitution to prevent anchoring effects from being falsely detected.

As confirmed by our earlier regressions, time effects are significant and influential for both Dali and Miro who (as Surrealists) may be classified as Contemporary artists. Despite the variation in our data, a high F-statistic ensures the relevance of our model.

**SUBSTITUTION EXPERIMENT #2:**

**PABLO PICASSO (1881-1973) AND MARC CHAGALL (1887-1985)**

Picasso and Chagall, former friends turned rivals[[6]](#footnote-6) and two of the best-known Contemporary artists, spanned multiple artistic traditions. The works of Picasso range from Cubist nude portraits to Neoclassical and Surrealist paintings, and frequently depict real life in abstract forms. Chagall drew upon a variety of movements including Surrealism, Cubism, and Expressionism for his works, many of which focus on scenes from Eastern Europe[[7]](#footnote-7) [[8]](#footnote-8). As with Dali and Miro, the two painters appear together at exhibitions[[9]](#footnote-9) [[10]](#footnote-10), and their works often fetch 7- and even 8-figure sums at auction.

Anchoring effects seem to be much stronger and detectable in the comparison between Picasso and Chagall, show in Table <> and <>

###

Table 4: Hedonic predictions, Impressionist Art (London). Half-year time dummies omitted for brevity.

Estimate Std. Error t value Pr(>|t|)

(Intercept) 10.667134 6.703545 1.591 0.112783

DATE\_PTG -0.002122 0.003513 -0.604 0.546317

DIM\_A 0.026975 0.007665 3.519 0.000512 \*\*\*

DIM\_B 0.016575 0.006388 2.595 0.010018 \*

SIGNED1 0.266633 0.350862 0.760 0.447990

SIGNED2 -0.064880 0.434096 -0.149 0.881308

SIGNED3 -0.429974 0.413009 -1.041 0.298822

ART\_MED6 1.779714 0.677907 2.625 0.009178 \*\*

ART\_MED9 0.348789 0.684150 0.510 0.610622

ART\_MED12 2.270866 0.674249 3.368 0.000874 \*\*\*

ART\_MED15 1.473253 0.698082 2.110 0.035791 \*

ART\_MED18 2.952254 0.642515 4.595 6.80e-06 \*\*\*

ART\_MED24 1.457382 0.771532 1.889 0.060030 .

ART\_MED27 1.093956 0.661039 1.655 0.099170 .

ART\_MED30 0.490681 0.658584 0.745 0.456923

ART\_MED33 1.278982 0.846104 1.512 0.131866

ART\_MED39 1.767484 0.660349 2.677 0.007918 \*\*

R^2: 0.8664

Adjusted R^2: 0.8251

F-statistic: 21.01 on 79 and 256 DF, p-value: < 2.2e-16

Table 5: Hedonic predictions, Impressionist Art (NYC). Half-year time dummies omitted for brevity.

Estimate Std. Error t value Pr(>|t|)

(Intercept) 20.536155 5.799675 3.541 0.000458 \*\*\*

DATE\_PTG -0.006033 0.002998 -2.013 0.044995 \*

DIM\_A 0.040589 0.007452 5.447 1.03e-07 \*\*\*

DIM\_B 0.012602 0.007114 1.771 0.077433 .

SIGNED1 1.059125 0.156739 6.757 6.69e-11 \*\*\*

SIGNED2 0.301338 0.245387 1.228 0.220348

SIGNED3 0.203128 0.217131 0.936 0.350234

ART\_MED6 -0.364772 0.687000 -0.531 0.595814

ART\_MED9 -0.060186 0.642117 -0.094 0.925382

ART\_MED12 1.014323 0.618434 1.640 0.101960

ART\_MED15 -0.131242 0.665053 -0.197 0.843687

ART\_MED18 1.248101 0.615153 2.029 0.043296 \*

ART\_MED21 0.773179 0.877041 0.882 0.378669

ART\_MED24 0.361094 0.661262 0.546 0.585401

ART\_MED27 -0.342484 0.656519 -0.522 0.602264

ART\_MED30 -0.075431 0.646362 -0.117 0.907170

ART\_MED38 -0.404069 0.807695 -0.500 0.617227

ART\_MED39 0.645365 0.630585 1.023 0.306876

R^2: 0.8377

Adjusted R^2: 0.8

F-statistic: 22.24 on 74 and 319 DF, p-value: < 2.2e-16

Table 6: Hedonic predictions, Contemporary Art. Half-year time dummies omitted for brevity.

Estimate Std. Error t value Pr(>|t|)

(Intercept) -1.54229 1.91849 -0.804 0.422029

log(date\_ptg) -0.67160 0.42660 -1.574 0.116371

log(len) 0.59158 0.11574 5.111 5.42e-07 \*\*\*

log(wid) 0.61585 0.11764 5.235 2.94e-07 \*\*\*

mediuma 0.37892 0.36754 1.031 0.303314

mediumbr -1.00407 0.47045 -2.134 0.033555 \*

mediumchk -0.51240 0.50577 -1.013 0.311749

mediumcol -2.01051 0.54342 -3.700 0.000253 \*\*\*

mediumcr -0.85626 0.37571 -2.279 0.023304 \*

mediumf -1.19646 0.49004 -2.442 0.015148 \*

mediumg -0.92343 0.40669 -2.271 0.023817 \*

mediumik -0.66618 0.38336 -1.738 0.083193 .

mediumo 0.33903 0.31500 1.076 0.282582

mediumpas -0.76427 0.55061 -1.388 0.166063

mediumpg 3.84267 0.64429 5.964 6.33e-09 \*\*\*

mediumph -2.97383 0.71974 -4.132 4.57e-05 \*\*\*

mediumpl 1.43608 0.66003 2.176 0.030281 \*

mediumpn 0.73305 0.79588 0.921 0.357696

mediums -0.30325 0.49084 -0.618 0.537122

mediumsk 2.78109 0.57888 4.804 2.36e-06 \*\*\*

mediumt -0.77276 0.39024 -1.980 0.048510 \*

mediumtp 0.25322 0.55431 0.457 0.648099

mediumw -0.41915 0.36663 -1.143 0.253758

R^2 0.9232

Adjusted R^2 0.8892

F-statistic: 27.17 on 146 and 330 DF, p-value: < 2.2e-16

Table 7: Hedonic predictions, assorted art. Half-year time dummies omitted for brevity. Artist and medium were omitted due to computational constraints.

Estimate Std. Error t value Pr(>|t|)

(Intercept) 6.224144 0.018000 345.782 <2e-16 \*\*\*

log(height) 0.614017 0.008031 76.454 <2e-16 \*\*\*

log(width) 0.230060 0.008092 28.431 <2e-16 \*\*\*

signed -0.634735 0.008009 -79.255 <2e-16 \*\*\*

monogrammed -0.203214 0.022359 -9.089 <2e-16 \*\*\*

stamped 0.086423 0.016030 5.391 7e-08 \*\*\*

R^2 0.1006

Adjusted R^2 0.1006

F-statistic: 5907 on 5 and 264109 DF, p-value: < 2.2e-16

ANCHORING EFFECTS

Table 8: Anchoring effects, Impressionist Art

Estimate Std. Error t value Pr(>|t|)

(Intercept) -0.338390 0.192857 -1.755 0.0802 .

curr\_hed\_pred 1.018156 0.019093 53.327 < 2e-16 \*\*\*

anchoring 0.174402 0.072377 2.410 0.0165 \*

past\_control 0.503147 0.077019 6.533 2.29e-10 \*\*\*

months\_since\_last\_sale 0.007903 0.001873 4.219 3.13e-05 \*\*\*

R^2 0.9231

Adjusted R^2 0.9222

F-statistic: 1047 on 4 and 349 DF, p-value: < 2.2e-16

Table 9: Anchoring effects, Contemporary Art

Estimate Std. Error t value Pr(>|t|)

(Intercept) -0.1152982 0.0499920 -2.306 0.0223 \*

curr\_hed\_pred 1.0344742 0.0203640 50.799 <2e-16 \*\*\*

anchoring 0.1312881 0.0740504 1.773 0.0780 .

past\_control 0.1914626 0.0952936 2.009 0.0460 \*

months\_since\_last\_sale -0.0009164 0.0026884 -0.341 0.7336

R^2 0.9407

Adjusted R^2 0.9394

F-statistic: 698 on 4 and 176 DF, p-value: < 2.2e-16

Table 10: Anchoring effects, assorted art

Estimate Std. Error t value Pr(>|t|)

(Intercept) -1.598781 0.096913 -16.497 <2e-16 \*\*\*

log\_hed\_pred 1.147787 0.011706 98.054 <2e-16 \*\*\*

anchoring 0.590709 0.011442 51.626 <2e-16 \*\*\*

sub\_price\_hed\_pred -0.020331 0.012078 -1.683 0.0923 .

avg\_mon\_subdiff -0.042259 0.004782 -8.837 <2e-16 \*\*\*

R^2 0.4144

Adjusted R^2 0.4144

F-statistic: 3.046e+04 on 4 and 172189 DF, p-value: < 2.2e-16

ANCHORING CROSS EFFECTS

1. http://www.christies.com/lotfinder/paintings/invader-alias-hk-59-5875653-details.aspx [↑](#footnote-ref-1)
2. For instance, Matt Lamb’s “Figures” fetched $24K at Christie’s, London on June 22, 2010. http://www.christies.com/lotfinder/paintings/matt-lamb-figures-5332422-details.aspx [↑](#footnote-ref-2)
3. http://joanmiro.com/style-of-joan-miro/ [↑](#footnote-ref-3)
4. http://www.theartstory.org/artist-dali-salvador.htm [↑](#footnote-ref-4)
5. http://www.galeriemichael.com/current-exhibitions/miro-dali-poetic-visions-two-catalan-surrealists/ [↑](#footnote-ref-5)
6. http://www.pablopicasso.org/picasso-and-chagall.jsp [↑](#footnote-ref-6)
7. http://www.theartstory.org/artist-chagall-marc.htm [↑](#footnote-ref-7)
8. http://www.infoplease.com/encyclopedia/people/chagall-marc.html [↑](#footnote-ref-8)
9. http://www.operagallery.com/catalogues/picasso\_chagall\_dubai/cata.pdf [↑](#footnote-ref-9)
10. http://pueblopulp.com/picasso-matisse-chagall [↑](#footnote-ref-10)