**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 8 and 9 show our results, alongside 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 10). 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 11 through 13 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. 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 an 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 14 through 16 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.

**THREE EXPERIMENTS**

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. Specifically, we test whether one artist serves as an anchor for the other, and vice-versa. This allow us directly test our anchoring regressions on known substitutes, and evaluate our results more thoroughly. Only Contemporary artist pairs were provided for us.

**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). We were told that works by these two artists tend to also attract the same kinds of clients.

Tables 18 and 19 show the anchoring regression results for Miro and Dali (in our assorted art dataset) 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. Nevertheless, due to our mixed results, we cannot say that our and regressions detect significant anchoring between Dali and Miro.

**SUBSTITUTION EXPERIMENT #2:**

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

Picasso and Chagall, former friends turned opponents[[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). The two painters are featured together at exhibitions[[9]](#footnote-9) [[10]](#footnote-10), apparently more often than Dali and Miro are, and the works of Picasso and Chagall frequently fetch 7- and even 8-figure sums at auction.

Overall, and give very similar results for this comparison (Tables 20 and 21). Anchoring seems to be much stronger and detectable in this comparison between Picasso and Chagall. It is also associated with the presence of significant control terms this time, which suggests that even after controlling for substitution, anchoring is still very much at play. Also, the coefficients are large: if the price of the substitute is 10% higher than the hedonic value of the current good, we should expect to see a 15% increase in the current good’s price due to anchoring (if we use; 25% increase if we use). In the case, the intercept is also much stronger and highly significant, compared to that of. We are also explaining a huge amount of variation in the data: the values are extremely low. This indicates that for Picasso and Chagall, other influences are probably at work, and that our two measures of substitution, although significant and generally a step in the right direction, could be improved. Time effects are fairly small, and do not seem to affect price much if at all.

Overall, while anchoring effects were less conclusive for Miro and Dali, for Picasso and Chagall we see highly significant evidence of strong anchoring cross-effects. Thus, we should expect prices for one artist’s works to noticeably impact those for the other’s pieces.

**SUBSTITUTION EXPERIMENT #3:**

**EDVARD MUNCH (1863) AND HENRI DE TOULOUSE-LAUTREC (1864-1901)**

Munch and Toulouse-Lautrec were contemporaries in Europe who, as we learned in our interviews, met with comparable levels of economic and critical success during their lifetimes. However, their artistic styles differ somewhat. Munch, a Norwegian artist associated with Expressionism and Symbolism, is known for the intensely psychological and brooding themes he imbued into his paintings and prints[[11]](#footnote-11). On the other hand, Toulouse-Lautrec is known for his Post-Impressionist, drawing-like depictions of people, often those from lower-class, urban environments[[12]](#footnote-12). It seems that Munch and Toulouse-Lautrec are featured together less frequently: a quick Google search only turns up a 1965 exhibition at the Metropolitan Museum of Art[[13]](#footnote-13). Nevertheless, both artists pull in hefty sums: Toulouse-Lautrec’s work “Au Lit: Le Baiser” fetched $16.3 million at Sotheby’s in early 2015[[14]](#footnote-14), and Munch’s Internet-famous “The Scream” sold for nearly $120 million at Sotheby’s in 2012[[15]](#footnote-15).

Tables 22 and 23 show the respective and anchoring regression results for Munch and Toulouse-Lautrec in our assorted art dataset. No significant or strong anchoring effects appear this time, regardless of whether we use or. Even if the two artists did enjoy comparable success during their concurrent lifetimes, their artistic styles may be too different to permit anchoring cross-effects. It is also possible that the comparison between Munch and Toulouse-Lautrec is less conducive to anchoring in light of even more renowned artists during the same time period, such as Vincent Van Gogh (1853-1890) and Paul Gauguin (1848-1903). Works by Toulouse-Lautrec, in particular, seems to be auctioned off alongside those Impressionist artists[[16]](#footnote-16). Our measure of substitution is insignificant in both the cases, which seems to further suggest that Munch and Toulouse-Lautrec are not particularly close hedonic substitutes. That said, has a somewhat larger coefficient, which could be due to its inclusion of near-significant time effects (p-value: 5.38). The value indicates that we do seem to explain more variation in the data than we did for other artist pairs, but relatively low F-statistics suggest that our model is not as relevant for the Munch/Toulouse-Lautrec pair. In fact, the only significant variable is the hedonic price prediction. Hence, we do not find any evidence of anchoring between Munch and Toulouse-Lautrec – which is understandable, given their relatively divergent artistic styles.

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)
11. http://www.theartstory.org/artist-munch-edvard.htm [↑](#footnote-ref-11)
12. http://www.toulouse-lautrec-foundation.org/biography.html [↑](#footnote-ref-12)
13. <http://libmma.contentdm.oclc.org/cdm/ref/collection/p16028coll12/id/1460> [↑](#footnote-ref-13)
14. http://www.theguardian.com/artanddesign/2015/feb/04/sothebys-auction-highest-sales-total-ever [↑](#footnote-ref-14)
15. http://www.nytimes.com/2012/05/03/arts/design/the-scream-sells-for-nearly-120-million-at-sothebys-auction.html?\_r=0 [↑](#footnote-ref-15)
16. http://www.bloomberg.com/news/articles/2015-02-05/here-s-why-sotheby-s-and-christie-s-just-sold-444-8-million-in-impressionist-art [↑](#footnote-ref-16)