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PRICING GENIUS: THE MARKET EVALUATION OF INNOVATION

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Economists have neglected a key issue for understanding and increasing technological change, in failing to study how talented individuals produce innovations. This paper takes a quantitative approach to this problem. Regression analysis of auction data from 1965-2015 reveals that the age-price profiles of Jackson Pollock and Andy Warhol – the two greatest painters born in the 20th century – closely resemble the profiles of the two artists' careers derived both from textbooks of art history and from retrospective exhibitions. The agreement of these sources confirms that the auction market assigns the highest prices to the art that scholars judge to be the most important, and examination of the artists' careers reveals that this art is the most important because it is the most innovative. These results lend strong support to our understanding of creativity at the individual level, with a sharp contrast between the extended experimental innovation of Pollock and the sudden conceptual innovation of Warhol.

JEL classification codes: J01, J24, O30

Key words: creativity, technological change, hedonic regression analysis, life cycles

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I. Introduction

There is, it seems, a graph of creativity which can be plotted through an artist's career.

Sir Alan Bowness (1990)

Both theoretical models and empirical studies consistently identify technological change as the most important source of economic growth: Richard Nelson (2012) recently declared that "There is no informed arguing against the proposition that technological advance is the principal cause of long-run productivity growth." Concerning the source of technological change, Kenneth Arrow (1962) observed that "There is really no need for the firm to be the fundamental unit of organization in invention; there is plenty of reason to suppose that individual talents count for a good deal more than the firm as an organization." For this reason, Simon Kuznets (1962) called for more study of creative individuals, noting that "we need far more empirical study than we have had so far of the universe of inventors; any finding concerning inventors, identified in either uniform or diverse fashion, would be of great value."

Although more than five decades have passed since Arrow's observation and Kuznets' appeal, few economists have responded to them. Instead, the study of individuals effectively remains a disciplinary taboo for economists, and the processes by which talented individuals make innovations largely remain a mystery. This paper will demonstrate the gains from studying important individual innovators, in an industry in which analysis of the market valuation of their products leads to fundamental new insights into the processes of creativity. The innovators in question are great painters, and the market is the public auctions in which their works are bought and sold.

II. Importance in art

Perhaps the importance that we must attach to the achievement of an artist or a group of artists may properly be measured by the answer to the following question: Have they so wrought that it will be impossible henceforth, for those who follow, ever again to act as if they had not existed?

Walter Sickert (2001)

To interpret the market evaluation of art, it is necessary to understand the source of artistic importance. Despite the many misunderstandings and misconceptions that surround the issue, the truth is straightforward, for it is the same as in other intellectual activities: the importance of art is a function of innovation. Important artists are innovators whose work influences the practices of other artists; important works of art are those that embody their innovations.

The only necessary qualification of this proposition involves the period of time to which it applies. The importance at issue here is not the short-run interest that may gain an artist immediate critical or commercial success, but the long-run impact that causes his work to hang in major museums and makes his contribution the subject of study by scholars. There is a widespread belief that artistic success can be fabricated by persuasive critics, entrepreneurial dealers, or wealthy collectors. In the short run, prominent critics, dealers, and collectors can clearly gain an artist considerable fame and fortune. It is equally clear, however, that unless this attention leads to influence on other artists, it cannot gain that artist an important place in art history (Galenson 2006b).

III. Age-price profiles

Each stylistic portion of an artist's total time span constitutes a separate sum of artifacts, and this is recognized by the art market in the values it places upon certain "periods" of an artist's work in contrast with others.

Harold Rosenberg (1983)

For important artists, the auction market provides the basis for systematic measurement of an artist's life cycle, through its valuation of works done at different ages. Econometric analysis of auction outcomes collected over time can be done to estimate an age-price profile for an individual artist. This paper will analyze the careers of two great modern artists, Jackson Pollock (1912-56) and Andy Warhol (1928-87). Quantitative analysis of dozens of narratives of art history reveals that art scholars consider Pollock and Warhol the two greatest painters born in the twentieth century (Galenson 2009).

Measurement of the relationship between the value of an artist's work and the artist's age at the date of its execution can be done by hedonic regression analysis

of data from auctions. This paper will utilize all auction sales of paintings by Pollock and Warhol from the years 1965-2015. It might be noted that age-price profiles were previously published for Pollock and Warhol, more than 15 years ago (Galenson 2000). Those profiles were based on auction data from 1980-96. The current study therefore expands the auction data from 17 years to 51; this results in an increase of sales of Pollocks by more than a factor of three, and a remarkable increase in the sales of Warhols by a factor of six. And as the latter increase in the volume of sales might suggest, the past 15 years have witnessed a considerable increase in the values of paintings. Thus the highest price realized for any Pollock at auction prior to 2000 was \$22.1 million; this has since more than doubled, to \$59.3 million. Even more dramatically, the Warhol record price of \$7.9 million prior to 2000 has since increased by a factor of more than 13, to \$107.2 million.¹

In hedonic regression analysis, both the selection of the relevant characteristics and the form of the relationship are empirical matters (Griliches 1971). In an initial analysis, the natural logarithm of the auction price of a painting is expressed as a function of a third-degree polynomial in the age of artist at the time of the painting's execution. Independent variables are also included for the size of the painting and its support (generally paper or canvas). Fluctuations in the art market are controlled with a series of binary variables representing the period in which the painting was auctioned. And finally, the artist's age at execution and the size of the painting are interacted to allow for possible trends over time in the effect of size on price.

Table 1 presents the initial estimates for both artists. For both, there is a pronounced inverse U-shaped relationship between the auction price of a painting and the artist's age when it was made. Pollock's profile peaks at age 37, slightly higher than his second-highest age of 38; Warhol's profile peaks at 35, slightly above his second-highest age of 34. The age-size interaction variable has a positive estimated coefficient for Pollock, and negative for Warhol; these will be discussed later in the paper.

¹ All prices are in 2014 dollars.

Table 1. Parametric regression analysis of auction prices, by artist

Variables	Jackson Pollock	Andy Warhol
Age	-4.2145*** (1.0706)	2.2902*** (0.2015)
Age2	0.1393*** (0.0332)	-0.0529*** (0.0046)
Age3	-0.0015*** (0.0003)	0.0004*** (0.0000)
Age*Size	0.0343* (0.0178)	-0.0081*** (0.0016)
Paper	-0.4172 (0.2893)	-1.9235*** (0.1032)
Other Support	-0.1268 (0.3514)	-0.6609*** (0.1422)
Size	-0.3424 (0.5840)	1.0489*** (0.0768)
Constant	50.6621*** (12.0874)	-22.7393*** (2.9787)
Sale year	Yes	Yes
Adj. R ²	0.612	0.638
Observations	160	2,870

Notes: Dependent variable is natural log of sale price; sale price = hammer price prior to 1975, and hammer price plus buyer's premium thereafter (Horowitz 2011). Prices are in constant 2014 dollars, adjusted with the CPI. Size is the natural log of the surface area of the painting in square inches. The sale-year variables are 5-year periods (1965-9, 1970-4,...), except for the excluded category, which is 2010-15. Canvas is the omitted support group. *** denotes significance at the 1% level, ** at 5%, and * at 10%. Robust standard errors are in parentheses. Source: 1965-86: Mayer (1966-87); 1983-June 2015: Artnet (2016).

To examine the age-price profiles in a way that imposes less structure on the relationship, Tables 2 and 3 present the estimates of non-parametric regressions in which the age variables of Table 1 are replaced by a series of binary variables (as indicated, small cell sizes sometimes caused us to group several years). The non-parametric regressions again produce estimated peak ages of 37 for Pollock and 35 for Warhol, but they also show that for Pollock, ages 36 and 38 are not statistically significantly different from 37, and that for Warhol, 34 is not statistically significantly different from 35.

Table 2. Non-parametric regression analysis of auction prices for Jackson Pollock

Age	D[Age=j]	Robust SE	D[Age=37] - D[Age=j]	N[Age=j]
19-24	6.693	0.577	-3.10***	9
25-27	7.572	0.471	-2.23***	11
28-30	7.409	0.505	-2.39***	27
31	7.776	0.526	-2.02***	7
32	7.797	0.566	-2.00***	12
33	8.827	0.499	-.975*	6
34	7.994	0.614	-1.80***	13
35	8.935	0.634	-.867*	7
36	9.387	0.741	-0.415	9
37	9.802	0.888	-	15
38	9.02	0.734	-0.783	10
39	8.816	0.508	-.986*	22
40	8.131	0.757	-1.67**	4
41	5.996	0.95	-3.80***	3
43-44	8.403	0.541	-1.39***	5
Paper	-0.697	0.335		
Other Support	-0.645	0.394		
Size	0.895	0.1		
Sale year	Yes			
Adj. R ²	0.643			
Observations	160			

Notes: Age variables are categorical, as indicated. For age variables, the fourth column indicates the difference between the estimated coefficient and that of the peak age (37 for Pollock), with associated statistical significance. Other variables are defined as in Table 1. Source: see Table 1.

Table 3. Non-parametric regression analysis of auction prices for Andy Warhol

Age	D[Age=j]	Robust SE	D[Age=35] - D[Age=j]	N[Age=j]
20-24	8.134	0.276	-2.75***	16
26-28	8.6	0.283	-2.29***	40
29-31	8.913	0.293	-1.97***	31
32-33	9.648	0.504	-1.24**	15
34	10.76	0.185	-0.13	153
35	10.89	0.186	-	67
36	10.08	0.155	-.806***	407
37	10.05	0.206	-.835***	56
38	10.45	0.293	-.435*	28
39	9.507	0.214	-1.38***	63
40	9.234	0.376	-1.65***	6
41	9.093	0.296	-1.79***	7
42	7.575	0.233	-3.31***	5
43	8.178	0.254	-2.71***	7
44	9.127	0.355	-1.76***	25
45	10.11	0.195	-.777***	88
46	8.882	0.234	-2.01***	42
47	8.83	0.169	-2.06***	86
48	8.887	0.196	-2.00***	69
49	8.291	0.185	-2.60***	49
50	8.779	0.178	-2.11***	110
51	9.242	0.18	-1.65***	136
52	8.467	0.167	-2.42***	140
53	8.984	0.159	-1.90***	192
54	8.602	0.167	-2.29***	142
55	8.512	0.156	-2.38***	257
56	8.451	0.167	-2.44***	112
57	8.135	0.16	-2.75***	222
58	9.02	0.161	-1.87***	292
59	8.361	0.352	-2.53***	7
Paper	-1.65	0.11		
Other Support	-0.714	0.132		
Size	0.655	0.015		
Sale year	Yes			
Adj. R ²	0.677			
Observations	2870			

Notes: Age variables are categorical, as indicated. For age variables, the fourth column indicates the difference between the estimated coefficient and that of the peak age (35 for Warhol), with associated statistical significance. Other variables are defined as in Table 1. Source: see Table 1.

Some works are obviously more important than others in introducing and embodying innovations even at a particular time of an artist's career, so the averaging that is the very basis of regression analysis is not necessarily desirable for identifying the timing of an artist's creativity. *Outliers* create problems for econometrics, and are often simply discarded from regressions (e.g., Judge, et al. 1980). But in normal usage, just the opposite is true, as outliers are the geniuses who enjoy exceptional success (e.g., Gladwell 2008). In the present context, outliers are the exceptional works that produce extraordinarily high prices at auction. Tables 4 and 5 provide systematic evidence on these, by presenting distributions by each artist's age at the date of execution of the works that later sold for extremely high prices.

Table 4. Age distributions of most expensive paintings by Jackson Pollock (millions of dollars)

Age	\$1m+	\$5m+	\$10m+	\$25m+	\$50m+
19					
21					
22					
24					
25					
26					
27					
28					
29	1				
30					
31					
32	1				
33	1				
34	4	1	1		
35	3	1			
36	5	2	1	1	1
37	10	6	2	1	
38	4	3	2		
39	9	4	4	1	
40	1	1			
41	1				
43	2	2	1		
44					
Total	42	20	11	3	1

Notes: Columns tabulate numbers of paintings sold for more than the amounts indicated, distributed by the artist's age at the painting's date of execution. Prices are in constant 2014 dollars. Source: see Table 1.

Table 5. Age distributions of most expensive paintings by Andy Warhol (millions of dollars)

Age	\$1m+	\$5m+	\$10m+	\$25m+	\$50m+
20					
23					
24					
26					
27					
28	1				
29					
30					
31					
32					
33	4	1			
34	50	26	13	9	2
35	42	25	15	7	3
36	113	25	7		
37	14	5	2	1	
38	19	7	2	1	
39	11	6	3		
40	1				
41					
42					
43	2				
44	6	1	1		
45	30	6	5		
46	10	1	1		
47	11				
48	20	2			
49	3				
50	17	5	1		
51	30	6			
52	26	5	1		
53	38	6	1		
54	9	1	1		
55	5				
56	18	1			
57	12	1			
58	66	16	7	4	
59	2	1	1		
Total	560	147	61	22	5

Notes and source: see Table 4.

There is a clear tendency for the very most valuable paintings to date from the same periods at which the age-price profiles peak. Thus the three Pollocks that exceeded \$25 million each were made at ages 36, 37, and 39, and 16 of the 22 Warhols that exceeded \$25 million – 73% – were made at ages 34 and 35. The spread of the age distributions increases at lower prices, but 15 of the 20 Pollocks that exceeded \$5 million were nonetheless made at ages 36-39, and 51 of the 147 Warhols – 35% – were made at ages 34-35, and another 25 were made one year later, at 36.

But a striking difference appears between Pollock and Warhol in the lower tails of the age distributions. So for example 4 of the 20 Pollocks that brought more than \$5 million were made at ages below his mode of 37, whereas only 1 of 147 Warhols that brought more than \$5 million was made before his modal age of 34. Similarly, 15 of 42 Pollocks that sold for more than \$1 million (36%) were executed before the artist was 37, whereas only 5 of a remarkable 559 Warhols in this price category – less than 1% – were made prior to the age of 34. The mappings of the careers of the two artists that emerges from this disaggregation of auction market outcomes thus contrast sharply: whereas Table 4 suggests that Pollock produced a significant proportion of his important work prior to his peak years, Table 5 indicates that the same was not true for Warhol, as he produced almost none of his important work prior to his peak period.

IV. Scholars' evaluations

[Q]uality in art is not just a matter of private experience. There is a consensus of taste. The best taste is that of the people who, in each generation, spend the most time and trouble on art, and this best taste has always turned out to be unanimous, within certain limits, in its verdicts.

Clement Greenberg (1993)

The art market is often dismissed by art scholars as having no relevance to true art appreciation, with the claim that prices are determined arbitrarily. A typical example is the declaration of the *Time* magazine critic Robert Hughes (1990) in 1978 that “The price of a work of art is an index of pure, irrational desire.” This charge has become increasingly common with the rapid escalation of prices for contemporary art since the 1960s, because of the belief that many current wealthy collectors are ignorant of art history. Some art experts are in fact dubious of any

systematic analysis of art markets, as for example Robert Rosenblum, a curator at New York's Guggenheim Museum, told the *Wall Street Journal* in 1998 that "I immediately distrust anybody trying to detect patterns...in art, especially in terms of economics" (Duff 1998). An important question is therefore whether the auction sales on which the econometric estimates are based represent decisions that reflect educated judgments. How do the results presented above compare to the opinions of experts?

The life cycles produced by the regression estimates can be systematically compared to the evaluations of art scholars in two distinct ways. For two very different sources can be made to yield quantitative evidence of scholars' judgments of when an artist's most important work was produced.

Published surveys of art history nearly always contain illustrations of the work of important artists. These are chosen to represent each artist's major contribution or contributions. No single book can be assumed to be definitive, but pooling the evidence of the many available books can effectively survey art scholars' opinions of what constitutes any given artist's best work. The scores of authors of textbooks of art history include many distinguished academics and prominent critics. But whatever the eminence of the authors, all are likely to be among those who, in Clement Greenberg's words, "spend the most time and trouble on art," for all have made substantial efforts to present their views on the history of art in a systematic way.²

Table 6 presents the distributions of all the illustrations of the work of Pollock and Warhol, tabulated by each artist's age at the date of the work's execution, contained in 61 surveys of art history published in English since 1990.³ The total number of illustrations of the two artists' work is almost the same, as both have an average of just over two illustrations per book.

² Use of textbook illustrations to measure an artist's importance is analogous to using citations to measure a scholar's importance. And illustrations are substantially more costly than citations: in addition to the greater space taken up by illustrations, and the greater printing costs, authors must obtain copyright permission to reproduce each painting, and a suitable photograph. These costs in time and money may make authors more selective in their use of illustrations, thus tending to make them a better indication than citations of what authors consider genuinely important. For further discussion, see Galenson (2006a).

³ The periods covered by the books vary, but every book covers at least the entire period spanned by the careers of Pollock and Warhol.

Table 6. Distributions by age of textbook illustrations

Age	Pollock		Warhol		Age	Pollock		Warhol	
	N	%	N	%		N	%	N	%
23	3	2			41	4	3	2	1
...					...				
26	2	1			43	2	1		
27			1	1	...				
28	4	3			45			2	1
29	3	2			...				
30	4	3			47			1	1
31	18	13			48			2	1
32	1	1	2	1	...				
33	2	1	1	1	50			1	1
34	4	3	62	45	51			2	1
35	12	9	19	14	...				
36	14	10	16	12	53			1	1
37	4	3	5	4	...				
38	47	33	6	5	57			1	1
39	6	4	9	7	58			2	1
40	11	8	2	1					
					Total	141	100	137	100

Source: see Appendix.

The peak ages are clearly identified for both artists: the single year from which Pollock's work is most frequently illustrated is age 38, while that for Warhol is 34. Warhol's illustrations are more highly concentrated than Pollock's. Thus Warhol's best year accounts for 45% of his total illustrations, whereas Pollock's accounts for 33% of his total. More strikingly, Warhol's best three consecutive years, from ages 34-36, account for 71% of his total illustrations, whereas Pollock's best period of three years, from ages 36-38, accounts for a much smaller 46% of his total. And an even more remarkable contrast appears in the timing of the two artists' peak years within their careers. Thus fully 50% of Pollock's illustrations are of paintings he made before his peak age of 38, whereas only 3% of Warhol's illustrations are of works he made before his peak age of 34. So from the vantage point of art scholars, Warhol's most important contribution came at the very beginning of his

career as a painter, whereas Pollock's came after he had been producing significant work for more than a decade.

Unlike the illustrations in textbooks, which are generally chosen to show an artist's most important contributions, critical evaluations of an artist's work over an entire career are implicit in the composition of retrospective exhibitions. Curators who organize retrospectives reveal their judgments of the relative importance of an artist's work at different ages by their decisions on how many works to include from each phase of the artist's career. The distribution by age at execution of the works included in these exhibitions can consequently serve as another independent measure of the quality of work over the course of an artist's career.

Retrospectives are often organized by a single curator, and it might consequently be thought that their composition represents the opinion of only one scholar. In fact, however, organizers of retrospectives work closely with many other art scholars, both within and outside their own institutions. Retrospectives of important artists at major museums therefore constitute careful and considered reviews of the artists' careers, based on the opinions of large numbers of experts (Galenson 2001).

There have been two full retrospective exhibitions for Jackson Pollock, at New York's Museum of Modern Art (MoMA) in 1967 and at MoMA and London's Tate Gallery in 1998-99, and two for Andy Warhol, at MoMA in 1989 and at London's Tate Modern and Berlin's Neue Nationalgalerie in 2001-02. The age distributions of the works included in these exhibitions are presented in Tables 7 and 8.

For both artists, the retrospectives' distributions are less dominated by the peak ages and periods: this is of course to be expected, since these exhibitions are specifically designed to illustrate the artists' entire careers. Yet the distributions of the retrospectives nonetheless resemble those of the textbooks. The individual years most heavily represented in the Pollock exhibitions, ages 39 and 36, bracket the textbooks' peak age of 38, while the peak individual age for Warhol in both his retrospectives, 34, is the same as that of the textbooks. As in the textbooks, these peak individual years make up larger shares of the total Warhol exhibitions – 20% and 16% – than of the Pollock exhibitions – 13% and 11%. And also as in the textbooks, a considerably larger share of the total works in the Pollock retrospectives were executed prior to the peak year – 76% and 57%, respectively – than was the case for Warhol, with only 22% and 26% of the total works.

Table 7. Distributions by age of works included in Pollock retrospectives

Age	[1] 1967		[2] 1998-99	
	N	%	N	%
21	1	1		
22	2	1	1	0
23	2	1	1	0
24	4	2	1	0
25	2	1	2	1
26	14	8	15	7
27	2	1	5	3
28	6	4	4	2
29	7	4	12	6
30	2	1	9	4
31	13	8	12	6
32	11	6	13	6
33	7	4	19	9
34	10	6	14	7
35	7	4	11	5
36	7	4	22	11
37	17	10	14	7
38	16	9	19	9
39	23	13	18	9
40	6	4	4	2
41	6	4	6	3
42	2	1	3	2
43	3	2	2	1
44	2	1		
Total	172	100	207	100

Source: (1) O'Connor (1967); (2) Varnedoe (1998).

Table 8. Distributions by age of works included in Warhol retrospectives

Age	[1] 1989		[2] 2001-02		Age	[1] 1989		[2] 2001-02	
	N	%	N	%		N	%	N	%
14	1	0	1	0	39	15	3	9	4
...					40	4	1	0	0
20	0	0	1	0	41	1	0	2	1
21	1	0	3	1	42	0	0	1	0
22	0	0	2	1	43	3	1	1	0
23	1	0	1	0	44	7	2	1	0
24	0	0	0	0	45	11	2	6	3
25	0	0	0	0	46	7	2	2	1
26	1	0	3	1	47	3	1	1	0
27	11	2	5	2	48	4	1	9	4
28	6	1	5	2	49	10	2	0	0
29	33	8	13	6	50	11	2	15	6
30	2	0	4	2	51	5	1	7	3
31	0	0	0	0	52	6	1	2	1
32	29	7	14	6	53	9	2	2	1
33	16	4	10	4	54	8	2	4	2
34	88	20	38	16	55	3	1	0	0
35	41	9	19	8	56	6	1	2	1
36	38	8	35	15	57	21	5	7	3
37	7	2	3	1	58	32	7	10	4
38	7	2	2	1	59	2	0	0	0
Total						450	100	240	100

Source: (1) McShine (1989); (2) Bastian (2001).

In general, both the textbooks and the retrospectives yield results that clearly resemble those of the auction data with respect to the creative life cycles of Pollock and Warhol. Table 9 summarizes the peak ages yielded by all the specifications and sources used in this study for both artists. Pollock's age-price profiles peak at ages 36-38, his textbook illustrations peak at 38, and his retrospectives peak at 39 and 36. Warhol's age-price profiles peak at 34-35, and his textbook illustrations and retrospectives all peak at 34. All of the sources similarly show the same overall patterns for both artists, with a sharp sudden increase to the peak for Warhol, compared to a longer and more gradual period of increase for Pollock. That the estimates of the peak age among the various sources are more dispersed for Pollock than for Warhol suggests that Warhol's major contribution was made within a shorter period of time than that of Pollock, as does the fact that the distributions of both the textbook illustrations and the works included in the retrospectives are more highly concentrated in Warhol's peak year than are those for Pollock.

Table 9. Estimated peak ages for Pollock and Warhol, by source

Artist	Prices			Textbook illustrations	Retrospectives	
	Parametric regression	Non-parametric regression	Auction prices of \$5 million+		(1)	(2)
Pollock	37	36-8	37	38	39	36
Warhol	35	34-5	34	34	34	34

Sources: all entries in this table are derived from tables presented above in this paper. For Pollock, the relevant tables are 1, 2, 4, 6, 7; for Warhol, 1, 3, 5, 6, 8. See the text for methods of analysis and interpretation.

V. Collectors' motivations

I must admit that the artistic judgement of current big bucks is better than the average among, say, critics. (Like the prospect of being hanged, shelling out millions may concentrate the mind wonderfully.)

Peter Schjeldahl (1990)

The close correspondence between auction outcomes and the opinions of scholars might be taken to imply that collectors are knowledgeable about art history, and that their purchases demonstrate their appreciation of quality in modern art. Yet this inference is not necessarily warranted, for other motives are also consistent with the observed patterns.

One of these was famously identified by Thorsten Veblen (1994): “Conspicuous consumption of valuable goods is a means of reputability to the gentleman of leisure.” There is little doubt that this remains true today, and public fascination with the value of art has in fact probably increased as prices at public auctions have risen in recent decades. Yet it seems clear that the greatest benefits in “reputability” are gained not merely by the expenditure of large sums, but by spending these sums on art of recognized excellence: conspicuous consumers generally want to be known for their discerning taste, and the safest way to ensure this is to buy works regarded as excellent by scholars.

Another motive for buying art is investment. Thus collectors may buy paintings just as they buy other assets, in the hope of making a profit when the works rise in value. Although collector-investors may devote considerable effort to spotting trends in taste, the safest investments will generally be in works already held in high regard in the art world. The more cautious the investor, the more likely he will buy what art scholars judge to be the best work of important artists.

The motives examined here are not mutually exclusive: collectors who love art may increase their purchases of it both for the fame it brings them and the possibility of capital gains. Nor will any of these motives necessarily lead collectors to follow the opinions of scholars: the taste of a sophisticated collector may differ from the general consensus of scholars, some collectors may seek to gain reputations as mavericks, and some collectors may enjoy making investments in works currently considered unimportant, in the hope of future changes in taste. Yet it seems likely that any of these motives, individually or collectively, will lead most collectors to value most highly those works most valued by art scholars. In view of this, the close correspondence observed here between auction prices and the judgements of art scholars is not surprising.⁴

⁴The question might be raised of causation: do scholars' opinions cause auction outcomes, or vice versa? This would be difficult to resolve, not least because the two mechanisms are not mutually exclusive. But resolving this question is unnecessary for present purposes, for what matters here is simply that the evaluations of scholars and auction market outcomes produce the same judgement of when an artist produced his most important work.

VI. Creative life cycles

Painting is self-discovery.

Jackson Pollock (Rodman 1961)

The reason I'm painting this way is that I want to be a machine.

Andy Warhol (Goldsmith 2004)

Pollock and Warhol were archetypal experimental and conceptual innovators, respectively. This might not appear to be the case, since conceptual innovators typically make their greatest contributions earlier in their lives than do their experimental counterparts (Galenson 2006b). The quantitative measures presented above do show that Warhol's peak ages, of 34-35, were younger than those of Pollock, of 36-39, but this difference is obviously small.

Yet the true variable that is relevant to the analysis of experimental and conceptual creativity is not an innovator's age, but his experience. This is because of the differences in the methods these innovators use. Experimental innovators generally have to work within a discipline for an extended period before arriving incrementally at their major contributions, whereas conceptual innovators typically innovate more quickly, and much sooner after entering a discipline. The careers of Pollock and Warhol clearly fit these patterns.

Pollock studied art in high school in Los Angeles, but left after being expelled twice, the second time for punching a teacher. His problems with school were due in part to the alcoholism that would dog him for the rest of his life. He moved to New York and enrolled in art school in 1930. In three years at the Art Students League, Pollock studied with several distinguished American artists, most notably the realist painter Thomas Hart Benton, with whom he developed a strong friendship. Pollock studied mural painting with Benton, and also at the New York studio of the Mexican muralist David Siqueiros, who was experimenting with new techniques, including spraying and pouring paint to create accidental effects. In 1935, Pollock joined the Federal Arts Project of the Works Progress Administration, where he signed up for the mural division.

Pollock's early work, heavily influenced by Benton's regionalist style, was not promising: his older brother Sande, also an aspiring artist, later reflected that a kind adviser looking at Jackson's art in the late '30s would have suggested that

he take up another profession. But Pollock persevered: in 1941, Sande reported to another family member that Jackson had “thrown off the yoke of Benton completely,” and begun doing genuinely creative work (Varnedoe 1998). Pollock worked as a janitor to support himself, and began to exhibit his art, with his first solo show at Peggy Guggenheim’s New York gallery in 1943, at the age of 31. He would have three more shows at Guggenheim’s gallery during 1945-47, then after Guggenheim’s departure from New York, five more solo shows at Betty Parsons’ gallery during 1948-51.

Over time, Pollock developed a method of producing paintings that was designed to draw on the unconscious. He wanted to discover images in the process of working. To avoid preconception, in a practice derived from Surrealist automatism, he would begin by applying paint to a canvas randomly, then inspect the result to see how he might develop the image. The process was open-ended: he might work on a painting for weeks, or even months, as he alternated between applying paint and studying what emerged. He explained that “I have no fears about making changes, destroying the image, etc., because the painting has a life of its own. I try to let it come through.” Deciding that a painting was finished was equally based on visual inspection. His widow, the painter Lee Krasner, recalled that finishing paintings was difficult: “I’d think everything was settled...and then he’d have last minute thoughts and doubts. He hated signing. There’s something so final about a signature” (Karmel 1998).

Pollock’s greatest contributions are associated with the “drip” or “pour” technique that became his trademark. By creating a method by which the painter’s brush did not touch the canvas, Kirk Varnedoe (1998) declared that “Pollock in 1947 ruptured the existing definitions of how art could be made.” Yet Varnedoe noted that “There is no grand incident to mark this passage – no legendary effort or single ‘breakthrough’ picture.” Pollock’s innovations were not declared at a specific moment, because it was not his technique, but rather its products, that constituted his real contribution. Pollock himself said as much, in a 1950 interview: “the result is the thing – and – it doesn’t make much difference how the paint is put on as long as something has been said. Technique is just a means of arriving at a statement” (Harrison 2000).

Pollock’s innovations grew out of the combination of the drip technique with his longstanding interest in murals, as he produced large paintings with all-over compositions, that had no central focal points, but gave equal emphasis to the

entire picture surface. His lines no longer defined figures or bounded spaces, but became an autonomous element in the composition. Abandoning the easel, he placed lengths of canvas flat on the floor, and moved around them so he could apply paint from all four sides. The edges of the large drip paintings no longer constituted a discrete ending of the work, and the illusion that the images could extend indefinitely led some viewers to associate them with the open spaces of western prairies, and to consider them a distinctively American departure from traditional European art. These innovations gained Pollock widespread recognition as the leader of the Abstract Expressionist movement. His art inspired younger artists both for the beauty of the images he produced and the spontaneity and freedom that the drip technique symbolized.

If Pollock's contribution had been the invention of the drip technique, his greatest works would have been the first examples, in 1947, when he was 35. This was not the case, however. None of the measures presented above places his greatest work in that year. All of them instead place it later, from one to four years. Just as he developed the images in his paintings gradually, by trial and error, so Pollock developed his mastery of the drip technique over time, as he improved his ability to resolve images on a large scale. So for example four of his five individual works that were most often reproduced in textbooks – *Autumn Rhythm: Number 30, 1950*; *Lavender Mist: Number 1, 1950*; *Blue Poles: Number 11, 1952*; and *One: Number 31, 1950* were all more than 70 square feet in size, and two were more than 150 square feet.

The positive estimated coefficient in Table 1 for the interaction between Pollock's age and the size of his paintings further reflects Pollock's growing mastery over time. Throughout the history of Western art, large paintings have generally been considered the greatest test of an artist's skill, and the most important paintings have disproportionately been very large (Galenson 2002). Pollock was concerned with the issue: in a 1947 application for a fellowship, he stated that "the tendency of modern feeling is toward the wall picture or mural," and declared that his goal was to paint "large movable pictures" that would "point out the direction of the future" (Karmel 1998). He succeeded, as his greatest paintings were among the largest drip paintings he made. The positive coefficient on the age-size interaction demonstrates the sensitivity of the auction market in evaluating his creativity.

Andy Warhol's career was radically different. In 1949, at the age of 21, he graduated from Carnegie Institute of Technology, in his hometown of Pittsburgh,

with a major in Pictorial Design. He moved to New York a week later, and within days began to work for *Glamour* magazine, drawing women's shoes. During the next decade Warhol became one of New York's leading commercial artists: his work appeared in the major fashion magazines, he designed stationery for Tiffany and Bergdorf Goodman, and he drew advertisements for several national corporations. His drawings of women's shoes, published weekly in the *New York Times*, won him a series of awards, including the highest honor of the Art Directors Club in 1957. Warhol became so busy that he hired assistants to make preliminary versions of his drawings, and used simple mechanical printing techniques to save time (Bourdon 1989).

Having gained wealth as an illustrator, Warhol set out to gain fame as an artist. In 1960, he began to make paintings based on comic strips and advertisements. Sometime during 1961-62, he made what the critic John Coplans (1978) called his "most decisive move," in rejecting paint handling; he would never again make paintings with the traditional techniques of fine art. Early in 1962, he used stencils to make 32 paintings of Campbell's soup cans – one for each flavor the company produced. These made up his first gallery exhibition of paintings, in Los Angeles in July (Garrels 1989). In August he began to make paintings by silkscreening, a printing technique he would use for the rest of his life. Marilyn Monroe committed suicide on August 4, 1962, and Warhol decided to silkscreen a series of portraits of her, based on a publicity photograph. In November, his first solo New York gallery exhibition included *Marilyn Diptych* and *Gold Marilyn*, the two of his paintings most frequently illustrated in the textbooks surveyed for this study (Bockris 1997).

Warhol wanted the process of making a painting to be mechanical. He would select a photograph from a newspaper or magazine, then send it to a manufacturer with instructions about the sizes and numbers of silkscreens (one for each color). Working alone in his living room in the three months beginning in August of 1962, Warhol made 100 paintings. To increase his productivity even further, the next year he began to employ assistants. Smaller paintings would be made entirely by an assistant, while Warhol might help with the larger ones. Gerard Malanga, Warhol's first assistant, reported that making a painting took about four minutes. Neither Malanga nor Warhol was trained as a printer, and they regularly made mistakes, but Warhol didn't care: "We never rejected anything. Andy would say, 'It's part of the art'" (Bockris 1997). Warhol frequently did not even sign his paintings himself, but instead used a rubber stamp (Goldsmith 2004).

Warhol's work of 1962 was not only identified as his most important by all three types of evidence presented above, but a separate study of textbook illustrations found that it was the second most important body of work made by any artist in a single year during the entire 20th century, behind only Pablo Picasso's invention of Cubism in 1907 (Galenson 2009). In the paintings of Campbell's soup cans and Marilyn Monroe – the first paintings he ever exhibited – Warhol made three far-reaching formal innovations: he used serial imagery, he devised mechanical techniques to produce paintings, and he based paintings entirely on photographs. These innovations were important as new ideas, and consequently it was the very first works that embodied them, in 1962, that were the most important ones Warhol ever made. These paintings gained Warhol recognition as the leader of the Pop Art movement, and the innovations they embodied became common practices for most of the greatest artists for the balance of the 20th century and beyond. Warhol would make – or have assistants make – thousands of paintings during the remaining 25 years of his life, and these would bring him ever greater fame and fortune. Yet after 1962 he would never again make any significant innovation in painting.

Interestingly, Warhol himself realized this very quickly. In 1965, he announced that he was retiring from painting. He later wrote that “Art just wasn't fun for me anymore,” because “the basic Pop statements had already been made.” He explained to his dealer that he was bored: “I didn't want to keep repainting successful themes” (Warhol and Hackett 1980). Warhol planned to concentrate on making movies, but to his disappointment he never succeeded in making a deal with a major Hollywood studio. And in spite of his public posture, he never actually stopped making paintings (Scherman and Dalton 2009). But his succinct analysis in 1965 was accurate: his innovations in Pop art had already been made.

The negative coefficient in Table 1 for the interaction between Warhol's age and the size of his paintings underscores the conceptual nature of his innovations. As discussed above, all of Warhol's innovations were introduced in 1962, and they appeared in both small and large works. Yet one of his innovations – the use of serial imagery – was most conspicuous in the large paintings: *Marilyn Diptych*, for example, repeated a single photograph 50 times, and other paintings from 1962 presented 200 or more Coca Cola bottles or Campbell's soup cans. A great modern conceptual innovator, Marcel Duchamp, praised this element of Warhol's innovative work of 1962, commenting that “If you take a Campbell's soup can and repeat it 50 times, you are not interested in the retinal image. What interests you is the concept that wants to put 50 Campbell's soup cans on a canvas” (Girst 2014).

The negative coefficient on the age-size interaction is a consequence of the nature of Warhol's innovation, for the first statement of a new idea is the most important. This effect thus provides further evidence of the sensitivity of auction prices to artistic importance.

Experimental innovators work by trial and error toward imprecise esthetic goals. Jackson Pollock spent nearly two decades working toward a new way of making the large paintings that he believed were the future of art. At 35, he arrived at his novel drip technique, and spent several more years developing it before he produced the monumental masterpieces for which he is celebrated today. In contrast, conceptual innovators arrive suddenly at novel ways of expressing specific ideas. Andy Warhol decided to become a painter only after he spent a decade as a successful commercial illustrator. Within barely two years of his decision, he was making photographs into paintings using mechanical printing techniques. These early paintings, which would influence generations of young artists, were the most important ones he would ever make.

VII. Age vs. experience

The ambitious artist...has to assimilate the best new art of the moment, or the moments, just before his own.

Clement Greenberg (1999)

Radical conceptual breakthroughs are often made by very young innovators. Among important modern painters, for example, Pablo Picasso made his greatest work at 26, Georges Braque at 29, Giorgio de Chirico at 26, Jasper Johns at 25, and Frank Stella at 23 (Galenson 2006a, 2006b). But Andy Warhol's career serves as a reminder that what is strictly relevant to creativity is not an innovator's age, but his experience within his discipline.

As documented above, Warhol was in his mid-30s in 1962-63, when he made his most valuable paintings. What is striking, however, is that he had begun making paintings only in 1960, so that his radical innovations in Pop art were made when he had only 2-3 years of experience as a painter. Moreover, his paintings of 1962-63 differ little in concept from the very first paintings he made of comic strip characters and advertisements in 1960. Warhol's case is thus consistent with the generalization that making radical conceptual innovations depends on the ability to

perceive and appreciate the value of extreme deviations from existing conventions and methods, and that this ability will be greatest among those inexperienced in a discipline, before habits of thought have become established. Although Warhol had worked as a commercial illustrator for more than a decade, his masterpieces of 1962-63 were effectively made by a novice painter.

The experience relevant to creativity does not necessarily begin even when an innovator first begins working in a discipline, for the ability to contribute to a discipline generally requires a practitioner to understand the current state of advanced work in it. This was not an issue for Warhol, for during the 1950s he lived in New York, and regularly went to art galleries. In other cases, however, this understanding was significantly delayed.

A notable case in the modern era is that of Vincent van Gogh. Born in 1853 in rural Holland, van Gogh decided to become a painter only in 1881, at the age of 28. He then spent the first five years of his artistic career in Holland and Belgium, so it was not until 1886, when he travelled from Antwerp to Paris, that he discovered modern art: thus from Paris he reported that “In Antwerp I did not even know what the impressionists were” (van Gogh 1959). In Paris, van Gogh also met a number of young artists who were developing a new Symbolist art, that aimed to use the brilliance of Impressionist color for expressive purposes. George Heard Hamilton (1972) observed that van Gogh’s “two years in Paris transformed him from an awkward imitator of nineteenth-century Dutch realism into a master of modern design,” and this mastery became the foundation for van Gogh’s distinctive contribution to modern art, of a truly personal art based on a symbolic language that pervaded his entire oeuvre. This art was “expressive to such a degree that it became almost immediately... one of the principal sources for the broader currents of European Expressionism.” Van Gogh produced his greatest art in 1888 after he left Paris for Arles, where he created what Meyer Schapiro (1994) called “his first new art...transfigured by what he had learned in Paris, or could learn by himself thanks to his Paris experience.” Van Gogh (1959) was fully aware of the importance of Paris for his artistic development, as in 1887 he wrote to a fellow artist who remained behind in Antwerp, “There is but one Paris...What is to be gained is *progress* and what the deuce that is, it is to be found here.” Van Gogh’s great conceptual innovations, that would inspire generations of expressionist artists, were thus made when he was 35 years old, but just two years after his true artistic education began with his arrival in Paris in 1886.

Art scholars have marveled at the extraordinary speed with which van Gogh assimilated the innovations of modern art during just two years in Paris. But Robert Jensen (2007) has observed that this speed was a function of van Gogh's artistic goals, for he had always privileged conception over execution (thus in 1884 he had asked, "Do you think I do not care for technique? Certainly I do, but only in order that I may say what I have to say.") In terms that may apply as much to Warhol in 1962 as to van Gogh in 1888, Jensen explained: "Since conceptual artists are primarily occupied with ideas rather than craft skills, they do not require long apprenticeship before they reach artistic maturity."

VIII. Conclusion

The modern artist is committed to the idea of endless innovation and growth...In that respect he is like the most advanced natural scientists and mathematicians.

Meyer Schapiro (1999)

The art market recognizes not only great artists, but great art. The age-price profiles produced by regression analysis of auction data from a period of five decades demonstrate clearly that collectors understand that all paintings by such great artists as Jackson Pollock and Andy Warhol are not created equal. Comparison of these profiles to quantitative measurements based on the judgments of art scholars confirms that the auction market assigns the highest prices to the art that scholars consider the most important. And examination of the careers of the artists reveals that this art is the most important because it is the most innovative. The high degree of agreement among these very different kinds of evidence emphasizes the error of the frequent dismissals of auction prices by art experts.

The contributions of Pollock and Warhol neatly demonstrate the difference between experimental and conceptual innovation. Warhol's serial, mechanical reproduction of photographs introduced a radical new idea into painting, so it was the very first works that embodied it that became the most important. In contrast, Pollock's drip paintings were innovative above all for the beauty and power of the new images they presented. These depended not only on the novel method of applying paint, but also on the artist's progressive mastery of this new technique

and his growing visual sophistication. The greatest drip paintings consequently appeared only several years after Pollock began pouring and dripping paint onto canvases.

The precision of the age-price profiles, and that of the supporting profiles generated by the tabulations from textbooks and exhibitions, should furthermore demonstrate the error of economists' unwillingness to study the careers of individuals. If this disciplinary taboo is based on a belief that we lack sufficient evidence to produce accurate quantitative measures of the creative life cycles of individuals, it should now be recognized that this is mistaken. The measures presented in this paper are strong, and clearly allow us to respond to the appeal of Simon Kuznets for empirical study of the universe of innovators who make vastly disproportionate contributions to productivity growth and the wealth of nations. Improving our understanding of the creativity of these extraordinary individuals may allow us to increase their contributions, and help others to follow them.

Appendix

The 61 books surveyed for this paper are listed here, ordered by date of publication.

1. Horst de la Croix, Richard Tansey, and Diane Kirkpatrick, *Gardner's Art Through the Ages*, ninth ed. (San Diego: Harcourt Brace Jovanovich, 1991).
2. Ronald Tamplin, ed., *The Arts* (Oxford: Oxford University Press, 1991).
3. Daniel Wheeler, *Art Since Mid-Century* (New York: Vendome Press, 1991).
4. Philip Yenawine, *How to Look at Modern Art* (New York: Harry N. Abrams, 1991).
5. Sandro Sprocati, *A Guide to Art* (New York: Harry N. Abrams, 1992).
6. Carol Strickland and John Boswell, *The Annotated Mona Lisa*, second ed. (Kansas City: Andrews McMeel, 1992).
7. John Kissick, *Art: Context and Criticism* (New York: Brown and Benchmark, 1993).
8. Paul Wood, Francis Frascina, Jonathan Harris, and Charles Harrison, *Modernism in Dispute: Art Since the Forties* (New Haven: Yale University Press, 1993).
9. Nikos Stangos, ed., *Concepts of Modern Art*, third ed. (London: Thames and Hudson, 1994).

10. Jonathan Fineberg, *Art Since 1940* (New York: Harry N. Abrams, 1995).
11. William Fleming, *Art and Ideas*, ninth ed. (Fort Worth: Harcourt Brace College Publishers, 1995).
12. E.H. Gombrich, *The Story of Art*, sixteenth ed., (London: Phaidon Press, 1995).
13. Matthew Baigell, *A Concise History of American Painting and Sculpture*, revised ed. (New York: Harper Collins, 1996).
14. Rachel Barnes, et al., *The 20th Century Art Book* (London: Phaidon, 1996).
15. Liz Dawtrey, et al., *Investigating Modern Art* (New Haven: Yale University Press, 1996).
16. Robert Hughes, *American Visions* (New York: Alfred A. Knopf, 1997).
17. Edward Lucie-Smith, *Visual Arts in the Twentieth Century* (New York: Harry N. Abrams, 1997).
18. David Wilkins, Bernard Shultz, and Katheryn Linduff, *Art Past, Art Present*, third ed., *Century* (New York: Harry N. Abrams, 1997).
19. Julian Freeman, *Art* (New York: Watson-Guption Publications, 1998).
20. Volker Gebhardt, *The History of Art* (New York: Barron's Educational Series, 1998).
21. Bruce Cole, *The Informed Eye: Understanding Masterpieces of Western Art* (Chicago: Ivan Dee, 1999).
22. Matthew Collings, *This Is Modern Art* (London: Weidenfeld and Nicolson, 1999).
23. Edward Lucie-Smith, *Lives of the Great 20th Century Artists* (London: Thames and Hudson, 1999).
24. Jay Tobler, ed., *The American Art Book* (London: Phaidon Press, 1999).
25. David Hopkins, *After Modern Art* (Oxford: Oxford University Press, 2000).
26. Martin Kemp, ed., *The Oxford History of Western Art* (Oxford: Oxford University Press, 2000).
27. Cory Bell, *Modern Art* (New York: Watson-Guption Publications, 2001).
28. David Bjelajac, *American Art* (New York: Harry N. Abrams, 2001).
29. Bernard Blistène, *A History of 20th Century Art* (Paris: Flammarion, 2001).
30. H.W. Janson and Anthony Janson, *History of Art*, sixth ed. (New York: Harry N. Abrams, 2001).
31. Klaus Richter, *Art from Impressionism to the Internet* (Munich: Prestel, 2001).
32. Amy Dempsey, *Art in the Modern Era* (New York: Harry N. Abrams, 2002).

33. Erika Doss, *Twentieth-Century American Art* (Oxford: Oxford University Press, 2002).
34. Hugh Honour and John Fleming, *The Visual Arts: A History*, sixth ed. (New York: Harry N. Abrams, 2002).
35. Robert Hughes, *The Shock of the New*, revised ed. (New York: Alfred A. Knopf, 2002).
36. H.H. Arnason, *History of Modern Art*, fifth ed. (Upper Saddle River, NJ: Prentice Hall, 2003).
37. Paul Johnson, *Art* (New York: Harper Collins, 2003).
38. David Joselit, *American Art Since 1945* (London: Thames and Hudson, 2003).
39. Dana Arnold, *Art History* (Oxford: Oxford University Press, 2004).
40. Hal Foster, Rosalind Krauss, Yve-Alain Bois, and Benjamin Buchloh, *Art Since 1900* (New York: Thames and Hudson, 2004).
41. Sam Hunter, John Jacobus, and Daniel Wheeler, *Modern Art*, third ed. (New York: Prentice Hall, 2004).
42. David Cottington, *Modern Art* (Oxford: Oxford University Press, 2005).
43. Robert Cumming, *Art* (New York: DK Publishing, 2005).
44. Marilyn Stokstad, *Art History*, revised second ed. (Upper Saddle River, NJ: Pearson Education, 2005).
45. Ingo Walther, ed., *Masterpieces of Western Art*, Vol. 2 (Cologne: Taschen, 2005).
46. Ingo Walther, ed., *Art of the Twentieth Century*, Vol. 1 (Cologne: Taschen, 2005).
47. Laurie Adams, *Art Across Time*, third ed. (New York, McGraw Hill, 2006).
48. Michael Lewis, *American Art and Architecture* (London, Thames and Hudson, 2006).
49. Julian Bell, *Mirror of the World: A History of Art* (New York: Thames and Hudson, 2007).
50. Elke Buchholz, et al., *Art: A World History* (New York: Harry N. Abrams, 2007).
51. Flaminio Gualdoni, *Art: The Twentieth Century* (Milan: Skira, 2008).
52. Charles Harrison, *An Introduction to Art* (New Haven: Yale University Press, 2009).
53. Stephen Farthing, *Art* (London: Thames and Hudson, 2010).

54. Debra Mancoff, *50 American Artists You Should Know* (Munich: Prestel, 2010).
55. Christiane Weidemann and Christine Nippe, *50 Modern Artists* (Munich: Prestel, 2010).
56. Will Gompertz, *What Are You Looking At?* (New York: Dutton, 2012).
57. Camille Paglia, *Glittering Images* (New York: Pantheon Books, 2012).
58. Loredana Parmesani, *Art of the Twentieth Century and Beyond* (Milan: Skira, 2012).
59. Dorothea Eimert, *Art and Architecture of the Twentieth Century* (New York: Parkstone Press, 2013).
60. Martin Kemp, *Art in History* (London: Profile Books, 2014).
61. Andy Tuohy, *A to Z Great Modern Artists* (London: Cassell, 2015).

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