

Second-to-fourth digit ratio predicts success among high-frequency financial traders

John M. Coates^{a,b,1}, Mark Gurnell^{c,1}, and Aldo Rustichini^{d,1}

^aDepartment of Physiology, Development, and Neuroscience, University of Cambridge, Cambridge CB2 3DY, United Kingdom; ^bJudge Business School, University of Cambridge, Cambridge CB2 1AG, United Kingdom; ^cDepartment of Medicine and Institute of Metabolic Science, University of Cambridge, Cambridge CB2 0QQ, United Kingdom; and ^dDepartment of Economics, University of Cambridge, Cambridge CB3 9DD, United Kingdom

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Prenatal androgens have important organizing effects on brain development and future behavior. The second-to-fourth digit length ratio (2D:4D) has been proposed as a marker of these prenatal androgen effects, a relatively longer fourth finger indicating higher prenatal androgen exposure. 2D:4D has been shown to predict success in highly competitive sports. Yet, little is known about the effects of prenatal androgens on an economically influential class of competitive risk taking—trading in the financial world. Here, we report the findings of a study conducted in the City of London in which we sampled 2D:4D from a group of male traders engaged in what is variously called “noise” or “high-frequency” trading. We found that 2D:4D predicted the traders’ long-term profitability as well as the number of years they remained in the business. 2D:4D also predicted the sensitivity of their profitability to increases both in circulating testosterone and in market volatility. Our results suggest that prenatal androgens increase risk preferences and promote more rapid visuomotor scanning and physical reflexes. The success and longevity of traders exposed to high levels of prenatal androgens further suggests that financial markets may select for biological traits rather than rational expectations.

2D:4D | neuro-economics | risk taking | market selection | testosterone

Successful trading in the financial markets requires more than correct beliefs about the value of securities. Traders must also possess confidence enough to place their bets, risk preferences high enough to place bets of meaningful size, and the ability to process information quickly enough to keep one step ahead of competitors. Furthermore, traders engaged in “noise” or “high-frequency” trading require additional skills because their rapid style of trading is a demanding physical activity: they engage in extended periods of vigilance and visuomotor scanning, and they must react quickly to place a trade before other traders arbitrage it away. The physiological demands made on traders raise the possibility that success in the markets depends as much on traders’ biological traits as it does on the truth of their beliefs.

These biological traits may derive in part from traders’ prenatal exposure to androgenic steroids. Prenatal androgens have organizing effects on the developing brain, increasing its later sensitivity to the activational effects of circulating testosterone (1–3). According to both animal and human studies, these effects may include increased confidence (4), risk preferences (5–7), and search persistence (8), as well as heightened vigilance and quickened reaction times (9). A number of surrogate markers have been proposed for measuring the effects of fetal androgens (10), but perhaps the most convenient is the second-to-fourth digit length ratio (2D:4D), a relatively longer fourth finger (i.e., lower 2D:4D) indicating higher fetal androgens (11). Digit ratios have been found to predict performance in competitive sports, such as soccer (12), rugby, basketball (13), and skiing (14), so 2D:4D may also predict the risk preferences and physical speed required for high-frequency trading. We therefore formulated the hypothesis that higher prenatal testosterone exposure would improve

a trader’s performance. Specifically, we predicted that traders with a lower 2D:4D would make greater long-term profits and would remain in the business for a longer period of time.

To test our prediction we recruited 49 male traders from a trading floor in the City of London (15). This floor employed ≈200 traders, of which all but 3 were male. The more successful of these traders earn in excess of £4 million per year. The floor is typical of others in the financial world with respect to its physical layout, the markets traded, and the traders’ average age and income (Fig. 1). The traders on this floor specialize in noise or high-frequency trading: they buy and sell securities, specifically futures contracts, sometimes in sizes of up to £1 billion, but hold their positions for only a few minutes, sometimes mere seconds (16). Other types of traders, such as investors at mutual and pension funds or arbitrageurs at hedge funds and investment banks, take more time to analyze a security’s value and hold their trades for weeks, months, or years. Investors and arbitrageurs try to profit from market trends, whereas high-frequency traders make their money by trading temporary variations around the trend.

We used individual traders’ profit and loss (P&L) statements as the primary measure of their relative performance. Trader P&Ls are recorded continuously by the firm’s back office, so they are free of reporting bias. Traders had equal access to capital and information, and their risk limits were determined by their track records. P&L for this cohort was thus an objective and comparable measure of trading skill and, after profit sharing with the employing firm, determined their individual income. These traders received no salary or year-end bonus, and their P&Ls did not have the benefits of an underlying client business. Consequently, selective pressures act more quickly and insistently on these traders than on investment bankers or fund managers.

For ease of measurement and reproducibility we used 2D:4D as a surrogate measure of prenatal androgen exposure. Support for this measure, according to some researchers, derives from the fact that digit growth and gonadal development are linked by the common influence of *hox* genes (11, 17). Members of the homeobox-containing gene family (e.g., *hoxa* and *hoxd*) are strongly expressed in the genital bud and give rise to the urogenital system; yet, they also pattern limb development and digit growth (18). Indeed, loss-of-function mutations in *HOXA13* result in both shortening of the digits and defects in the urogenital tract (hand–foot–genital syndrome) (19).

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¹To whom correspondence may be addressed. E-mail: jmc98@cam.ac.uk, mg299@mole.bio.cam.ac.uk, or aldo.rustichini@gmail.com.

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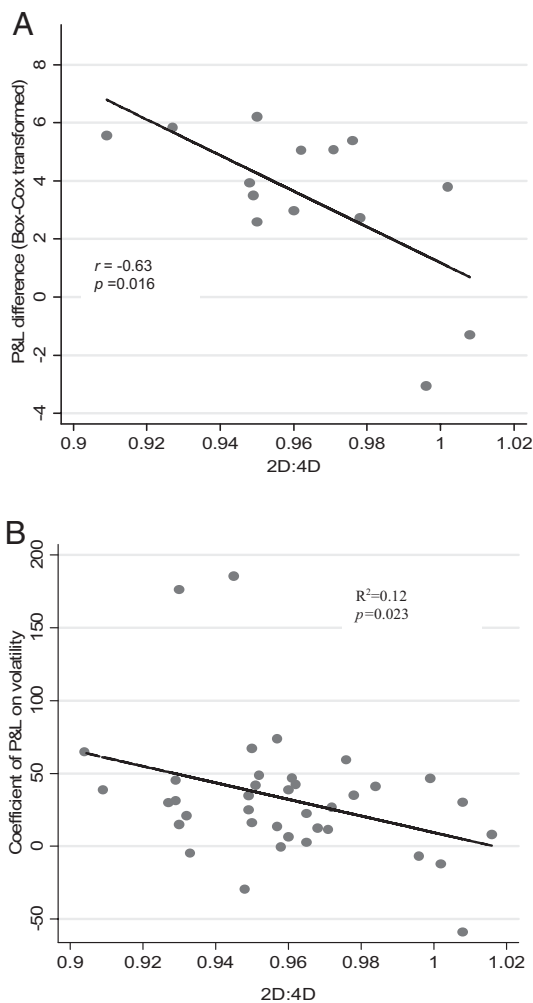


Fig. 3. Circulating testosterone, volatility, and P&L. (A) The difference in each trader's P&L between days of high and low morning testosterone plotted against their 2D:4D. (B) Traders' 2D:4D plotted against the sensitivity of their P&L to changes in volatility. The plot was derived in 2 stages: First, each trader's P&L, recorded over a 20-month period, was regressed against the volatility of the Euribor futures contract over the same period. The slope of the resulting curve gave us a measure of the sensitivity of each trader's P&L to changes in volatility. Second, the slope of each trader's curve was plotted against his 2D:4D. The two outlier data points were handled by robust regression and did not distort the results.

In this second line of analysis, we used the volatility of Euribor (3-month European interbank rates) as a proxy for market volatility. Euribor is one of the core assets traded on this floor, and its variance displayed a high correlation with P&L over a 20-month period averaged from all traders ($R^2 = 0.735$, $P < 0.0005$, $n = 20$). We first estimated a regression coefficient for each trader, which displayed how his P&L responded when Euribor volatility increased or decreased. We next regressed these coefficients against each trader's 2D:4D and found that the regression was significant ($R^2 = 0.12$, $F_{1,36} = 5.61$, $P = 0.023$; Fig. 3B). Regressing these coefficients against experience, on the other hand, did not give a significant result ($b = 12.9$, $P = 0.301$). Put simply, these results show that the lower a trader's 2D:4D, the more money he makes as volatility increases.

Discussion

We have found that digit ratios together with years of training predict a high-frequency trader's long-term P&L. Our model

suggests a roughly even split between the contributions of biology and experience; biology in this case being the organizing effects of prenatal androgens on an individual's body, brain, and behavior. As digit ratios are set early in life, there can be no feedback mechanism of the sort one might find between P&L and circulating testosterone (30); digit ratios predict profitability, not vice versa. Moreover, the correlations we have observed in this cohort between digit ratios and profits hold true over a 20-month period; and the correlations between digit ratios and years of experience hold over many years, in both bull and bear markets, so the survival of low-2D:4D traders does not appear to depend on particular market conditions.

The finding that a marker of prenatal testosterone levels predicts a trader's long-term profitability dovetails with an earlier study, which found that levels of circulating testosterone predict short-term profitability (30). Indeed, 2D:4D gauges the sensitivity of P&L to changes in circulating testosterone. Taken together, these two studies lend support to the organizational/activational hypothesis of steroid action.

Finally, the results of the current study suggest that the traits signaled by 2D:4D are likely to confer the greatest advantage in noise or high-frequency trading, an occupation that requires, in addition to the ability to take risks, heightened vigilance and quick reactions. Our findings may therefore be replicated among amateur day traders, high-frequency traders at other banks, and local traders on the floors of stock and futures exchanges. But the correlation may weaken among traders who require additional skills. Flow traders at the investment banks, for example, engage in high-frequency trading, but they also require an ability to deal with clients and a sales force, and these traders often make the bulk of their P&L from client business rather than pure risk-taking. The correlation could even reverse sign among traders who adopt a more analytical and long-term approach to the markets. For example, arbitrage traders at the investment banks and hedge funds are increasingly hired from the math and science departments of universities, and one study, which looked at average digit ratios in university departments found that faculty from math, science, and engineering exhibited higher, more feminine digit ratios (35). A similar result may well be found among traders with a long-term holding period.

The financial markets are made up of many sectors and types of trading, and each of these may select for different biological traits. But if markets select traders on the basis of their profitability and their occupational preferences (36), then low-2D:4D traders will continue to influence asset prices and equilibria in some of these sectors. Contrary to the assumptions of the rational expectations hypothesis, financial market equilibria may be influenced as much by traders' biological traits as by the truth of their beliefs.

Materials and Methods

Subjects. During recruitment we approached potential subjects on the trading floor and invited them to participate in the study. They were given an introductory note that explained briefly that we were looking at the effects of prenatal testosterone on the shape of their right hand. No information was given about our hypothesis. Interested traders were informed that they would receive a summary of our findings; they were not offered payment. Of the traders asked to participate, all but 3 agreed. Before giving a handprint, all subjects completed a short questionnaire asking their age, years of trading, P&L history, number of older brothers, and whether they had broken the index or ring finger of their right hand. They also signed an informed consent form. All handprints, questionnaire data, and P&L from the bank were coded by an independent laboratory technician in Cambridge, so our analyses were conducted blindly with respect to the identity of the traders. The study was approved by the Ethics Committee of the School of Biological Sciences at the University of Cambridge.

Five of the traders volunteering for the study could not be included because they had broken either the index or ring finger of their right hands. From the remaining 49 subjects, 2 were subsequently excluded because their handprints

were of insufficient quality to be assessed, and 3 were excluded because they received a different compensation package from the other traders, making it difficult to compare their P&Ls (although retaining them in the study left all results significant).

P&L Sampling. During the study some traders left the firm while others joined, so for some traders we had less than 20 months of P&L data, and the dates of their samples varied. Traders' P&Ls are often correlated as they collectively go through good and bad times, so gauging one trader's performance relative to another may be misleading if we compare their P&Ls at different times. However, as reported above, we controlled for the possibility of a missing time variable affecting P&L.

2D:4D Measurement. 2D:4D was determined from right-hand measurements only, because right-hand digit ratios have been shown previously to display more robust sex differences and are thus thought to be more sensitive to prenatal androgens (37, 38).

When measuring 2D:4D from soft tissue, care must be taken to distinguish regular from irregular or secondary creases. Irregular creases form later than regular creases, after the 11th week of gestation when the fingers start to bend, disrupting the dermal surface (25, 39). For example, fingers often develop an extra crease that is parallel, but distal, to the metacarpophalangeal crease. When this pattern is found, digit measures are taken from the proximal crease. Also common is an oblique crease angled off from the proximal crease, giving the appearance of a horizontal Y, or several oblique creases feathering the major crease (25). In these cases, measurement is taken from the middle of the Y pattern. On rare occasions, the proximal regular crease may be broken or unconnected, indicating a gap in the digital pads during development, and the broken crease may overlap in the middle of the finger. In the one case in our study where this pattern occurred, we averaged measures from the 2 halves of the broken crease. Last, it is possible, but again rare, to encounter a major crease that is indiscernible among a pattern as complicated and unique as a fingerprint (39). The only print in our study to display this pattern had already been excluded because of a broken finger. Traders' handprints were measured for 2D:4D by one of the authors (J.M.C.) and by an independent observer using callipers accurate to 0.2 mm, and these measures displayed a high repeatability (intraclass correlation = 0.974).

2D:4D research has often encountered difficulties with behavioral variables, difficulties that have led to inconsistencies between published results.

It should be noted that these inconsistencies exist largely between studies measuring psychological variables, such as aggression, status seeking, and perceived social dominance (40). Variables such as these are notoriously difficult to define and measure with any degree of repeatability. However, complications are not so common in 2D:4D research looking at performance variables that can be measured with less ambiguity. For example, achievements in sports such as soccer (12) and skiing (14), and performance in running and athletics (41) are more easily measured, and thus they display more consistent relationships with 2D:4D. The financial markets offer particularly promising variables in this respect. Financial variables, such as P&L, volatility, and years of experience, are objective and readily measured. The objective nature of our dependent variables goes some way toward accounting for the high statistical significance of the relationships we observed.

Market Volatility. To measure asset price volatility, we used the annualized standard deviation of the price changes of the Euribor futures contract. A total of 77% of the traders traded a European interest rate future, and the other traders, whose main trading security was a stock index, also traded interest rate futures as a secondary trading instrument. The estimation of a coefficient relating variance of Euribor to P&L converged for 38 of the 44 traders.

Statistics. The right-skew in the P&L data was corrected by a Box-Cox transformation. All results remained significant or displayed greater significance and effect size if we used the alternative of a cube root or rank-order transformation. 2D:4D data approximated a normal distribution (SI). When reporting correlations with a single independent variable, we used Pearson correlation coefficient; where R^2 is reported instead, we were using a robust regression to dampen the effects of outlying data. Statistical analyses were performed with Stata, release 10/SE (Stata).

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- Goy R, McEwen B (1980) *Sexual Differentiation of the Brain* (MIT Press, Cambridge, MA).
- Breedlove S, Hampson E (2002) in *Behavioral Endocrinology*, eds Becker J, Breedlove S, Crews D, McCarthy M (MIT Press, Cambridge MA), 2nd Ed, pp 75–114.
- Tobet S, Baum M (1987) Role for prenatal estrogen in the development of masculine sexual behavior in the male ferret. *Horm Behav* 21:419–429.
- Boissy A, Bouissou M (1994) Effects of androgen treatment on behavioural and physiological responses of heifers to fear-eliciting situations. *Horm Behav* 28:66–83.
- van Honk J, et al. (2004) Testosterone shifts the balance between sensitivity for punishment and reward in healthy young women. *Psychoneuroendocrinology* 29:937–943.
- Booth A, Johnson D, Granger D (1999) Testosterone and men's health. *J Behav Med* 22:1–19.
- Apicella C, et al. (2008) Testosterone and financial risk preferences. *Evol Hum Behav* 29:384–390.
- Andrew R, Rogers L (1972) Testosterone, search behaviour and persistence. *Nature* 237:343–346.
- Salminen E, Portin R, Koskinen A, Helenius H, Nurmi M (2004) Associations between serum testosterone fall and cognitive function in prostate cancer patients. *Clin Can Res* 10:7575–7582.
- Cohen-Bendahan C, van de Beek C, Berenbaum S (2005) Prenatal sex hormone effects on child and adult sex-typed behavior: Methods and findings. *Neurosci Biobehav Rev* 29:353–384.
- Manning J, Scutt D, Wilson D, Lewis-Jones D (1998) 2nd to 4th digit length: A predictor of sperm numbers and concentrations of testosterone, luteinizing hormone and oestrogen. *Hum Reprod* 13:3000–3004.
- Manning J, Taylor R (2001) Second to fourth digit ratio and male ability in sport: Implications for sexual selection in humans. *Evol Hum Behav* 22:61–69.
- Tester N, Campbell A (2007) Sporting achievement: What is the contribution of digit ratio? *J Person* 75:663–677.
- Manning J (2002) The ratio of 2nd to 4th digit length and performance in skiing. *J Sports Med Phys Fit* 42:446–450.
- Lo A, Repin D (2002) The psychophysiology of real-time financial risk processing. *J Cognit Neurosci* 14:323–339.
- De Long B, Shleifer A, Summers L, Waldman R (1990) Noise trader risk in financial markets. *J Pol Econ* 98:703–738.
- Paul S, Kato B, Cherkas L, Andrew T, Spector T (2006) Heritability of the second to fourth digit ratio (2d:4d): A twin study. *Twin Res Hum Genet* 9:215–219.
- Kondo T, Zákány J, Innis W, Duboule D (1997) Of fingers, toes, and penises. *Nature* 390:29.
- Mortlock D, Innis J (1997) Mutation of HOXA13 in hand-foot-genital syndrome. *Nat Genet* 15:179–180.
- Malas M, Dogan S, Evcil H, Desdicioglu K (2006) Fetal development of the hand, digits and digit ratio (2D:4D) *Early Hum Dev* 82:469–475.
- Brown W, Hines M, Fane B, Breedlove M (2002) Masculinized finger length patterns in human males and females with congenital adrenal hyperplasia. *Horm Behav* 42:380–386.
- Okten A, Kalyoncu M, Yaris N (2002) The ratio of second- and fourth-digit lengths and congenital adrenal hyperplasia due to 21-hydroxylase deficiency. *Early Hum Dev* 70:47–54.
- Manning J, Bundred P, Newton D, Flanagan B (2003) The 2nd to 4th digit ratio and variation in the androgen receptor gene. *Evol Hum Behav* 24:399–405.
- McIntyre M (2006) The use of digit ratios as markers for perinatal androgen action. *Reprod Biol Endocrinol* 4:10.
- Kimura S, Schaumann B, Plato C, Kitagawa T (1990) Embryological development and prevalence of digital flexion creases. *Anat Rec* 226:249–257.
- Meaney M (1988) The sexual differentiation of social play. *Trends Neurosci* 11:54–58.
- Phoenix C, Goy R, Gerall A, Young W (1959) Organizing action of prenatally administered testosterone propionate on the tissues mediating mating behavior in the female guinea pig. *Endocrinology* 65:369–382.
- Williams C, Meck W (1991) The organizational effects of gonadal hormones on sexually dimorphic spatial ability. *Psychoneuroendocrinology* 16:155–176.
- Van den Bergh B, Dewitte S (2006) Digit ratio (2D:4D) moderates the impact of sexual cues on men's decisions in ultimatum games. *Proc Biol Sci* 273:2091–2095.
- Coates J, Herbert J (2008) Endogenous steroids and financial risk-taking on a London trading floor. *Proc Natl Acad Sci USA* 104:6167–6172.
- Falter C, Arroyo M, Davis G (2006) Testosterone: Activation or organization of spatial cognition? *Biol Psychol* 73:132–140.
- Hines M, et al. (2003) Spatial abilities following prenatal androgen abnormality: Targeting and mental rotations performance in individuals with congenital adrenal hyperplasia. *Psychoneuroendocrinology* 28:1010–1026.
- Yaffe, et al. (2003) Androgen receptor CAG repeat polymorphism is associated with cognitive function in older men. *Biol Psychiatry* 54:943–946.
- Andrew R (1991) in *The Development and Integration of Behaviour. Essays in Honour of Robert Hinde*, ed Bateson P (Cambridge Univ Press, Cambridge, UK), pp 171–190.

35. Brosnan M (2006) Digit ratio and faculty membership: Implications for the relationship between prenatal testosterone and academia. *Br J Psychol* 97:455–466.
36. Blume L, Easley D (2006) If you are so smart why aren't you rich? Belief selection in complete and incomplete markets. *Econometrica* 74:929–966.
37. Williams T, et al (2000) Finger-length ratios and sexual orientation. *Nature* 404:455–456.
38. Manning J, Churchill A, Peters M (2007) The effects of sex, ethnicity, and sexual orientation on self-measured digit ratio (2D:4D). *Arch Sex Behav* 36:223–233.
39. Ashbaugh D (1999) *Quantitative-Qualitative Friction Ridge Analysis: An Introduction to Basic and Advanced Ridgeology* (CRC Press, Boca Raton, FL).
40. Vermeersch H, T'Sjoen G, Kaufman J, Vincke J (2008) 2d:4d, sex steroid hormones and human psychological sex differences. *Horm Behav* 54:340–346.
41. Paul S, Kato B, Hunkin J, Vivekanandan S, Spector T (2006) The big finger: The second to fourth digit ratio (2d:4d) is a predictor of sporting ability in females. *Br J Sports Med* 40:981–983.

Supporting Information

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SI Text

2D:4D Ratio in the Sample. Fig. S1 shows the distribution of the digits ratio in the sample. The variable 2D:4D ratio has a mean in the sample of 0.959 (SE = 0.004) and median of 0.957, with a range between a minimum of 0.904 and a maximum of 1.016.

Fig. S1B illustrates the asymmetry of the distribution around the median value of the 2D:4D ratio. The diagram is obtained by arranging the values in an increasing order and then computing the pair of values given by the difference, respectively, between the top value and the median, and that between the median and the lowest value. This pair is plot as a dot in the scatter plot. Then, the corresponding differences between the second highest value and the second to last are computed, and so on.

The Distribution of the Average P&L. The average monthly P&L of each trader has a mean of £24,749, with a standard error of £8,774. The range is between a minimum value of £-410 and a maximum value of £355,990. Few very large values dominate the mean. The histogram below (Fig. S2) illustrates the distribution of the average P&L and compares it with the normal distribution.

Clearly, the average P&L is strongly skewed to the right. Fig. S3 illustrates the asymmetry of the distribution around the median value and is constructed as Fig. 1B. Note the difference in scale between the horizontal and vertical axes, which is necessary to make the diagram readable.

Fig. S4 indicates the distribution of the average P&L against the uniform distribution on the range of the same variable. That is, for every value x on the horizontal axis, the curve reports the value y of corresponding quantile in the average P&L. For example, half of the data (at $x = 0.5$) are in a range of values very close to 0.

The Box–Cox Transformation of the Average P&L. The Box–Cox transformation (1) is obtained by first adding a constant to the average P&L to make all values positive, and then estimating by maximum likelihood the value of the power so that the skewness of the Box–Cox power transformation is zero.

This new variable has a mean value of 1.768 and a median of 1.679. Fig. S5, Fig. S6, and Fig. S7 below correspond to Fig. S2,

and Fig. S3, and Fig. S4 for the average P&L. They show that this variable is symmetrically distributed.

Analysis of P&L. Average P&L and years of experience. Fig. S8 plots the Box–Cox transformation of the average P&L and the years of experience.

Average P&L and years of experience. Table S1 reports the regression of the 2 dependent variables that we used to measure performance of traders: rank and the Box–Cox transformation of the average P&L of the trader. The independent variables are experience, age, and the 2D:4D. Age and the 2D:4D have been normalized to take values in (zero, one), so their coefficients are comparable. The regression is computed for the entire sample of 44 traders.

Average P&L for a subset of traders. We consider the subset of 25 traders that have been active in the same interval of 20 months. The results are reported in Table S2, which is the exact correspondent of Table S1 for this subset.

Panel data analysis. Table S3 reports the panel data analysis (2) for the entire subset of 44 traders. The data were collected in the period from October 2004 to October 2007, for 37 months overall. The analysis extends over the same periods. Quarters 1 to 9 are the 4-month periods in that time interval (so quarter 1 is a variable equal to 1 in the period October 2004 to January 2005 included, and equal to 0 otherwise). Age and 2D:4D are normalized to take values in (zero, one).

Analysis of Experience. Experience is defined as the number of years the trader has been in business at the moment of the collection of the last P&L data (experience). Fig. S9 shows the lowest (3) analysis of experience as function of the 2D:4D ratio.

The scatter analysis of the relationship suggests an exponential relationship between the two variables. Table S4 displays the result of the regression analysis of the log of survival on 2D:4D ratio.

P&L and volatility. Fig. S10 displays the regression of the monthly P&L in the company against the SD of the 3-months Euribor. The number of observations is 20 months. The coefficient of the SD is 6.53 ($P < 0.0001$, $R^2 = 0.735$). The analysis was conducted with Stata (Stata Corp.), Release 10/SE.

1. Box GEP, Cox DR (1964) An analysis of transformations. *J R Stat Soc [Ser B]* 26:211–246.
2. Baltagi BH (2001) *Econometric Analysis of Panel Data* (Wiley, New York).

3. Cleveland WS (1979) Robust locally weighted regression and smoothing Scatterplots. *J Am Stat Soc* 74:829–836.

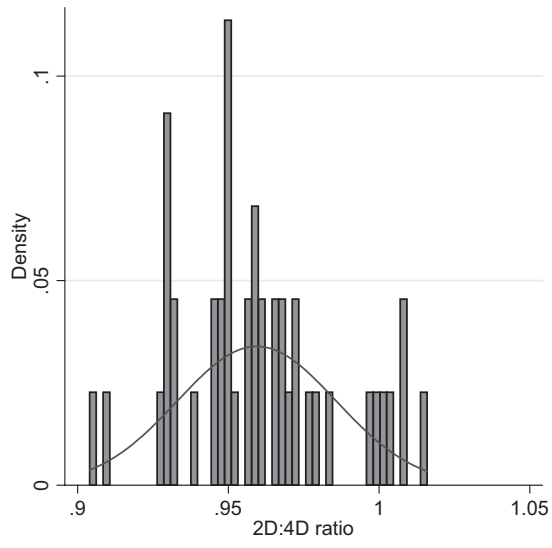


Fig. S1. Histogram of the 2D:4D ratio in the sample and normal distribution.

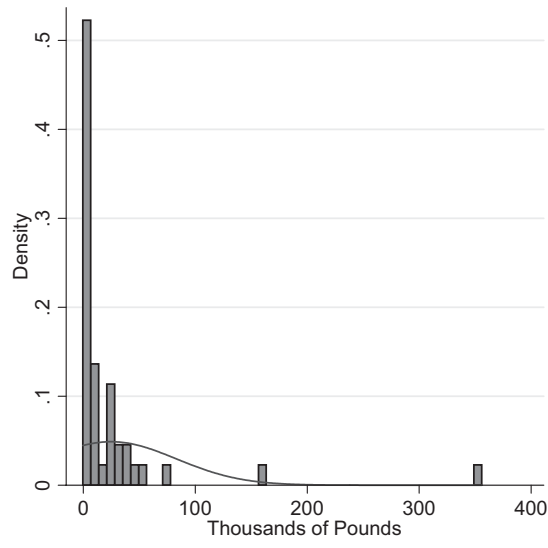


Fig. S2. Histogram of the average P&L. The continuous line describes the normal distribution approximating the real distribution.

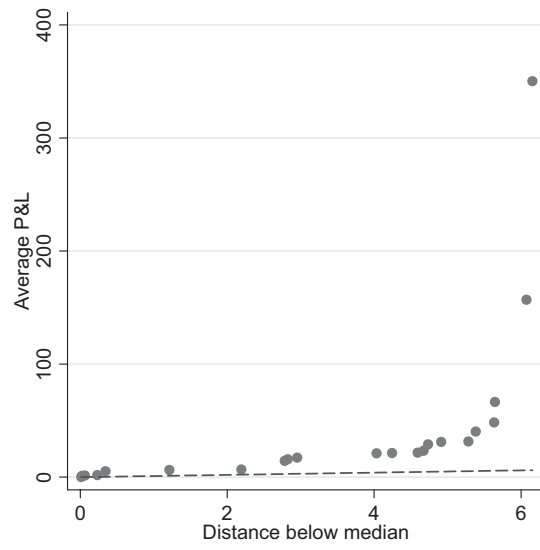


Fig. S3. Skewness of the average P&L.

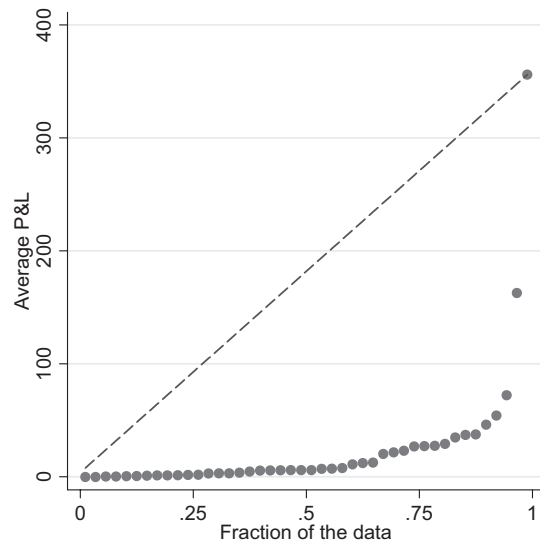


Fig. 54. Average P&L and the uniform distribution.

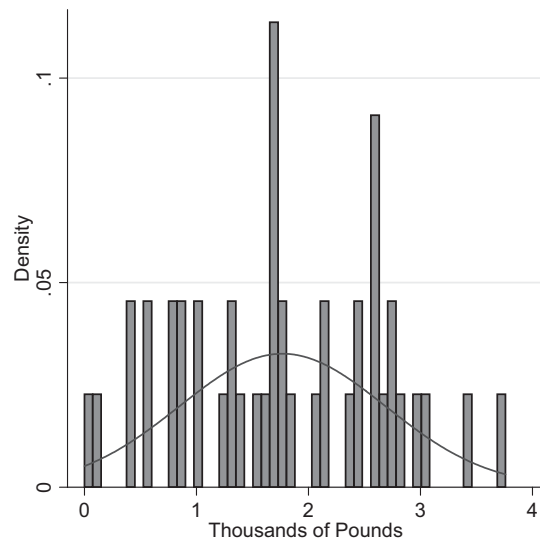


Fig. S5. Histogram of the Box-Cox transformation of the Average P&L. The continuous line describes the normal distribution approximating the real distribution.

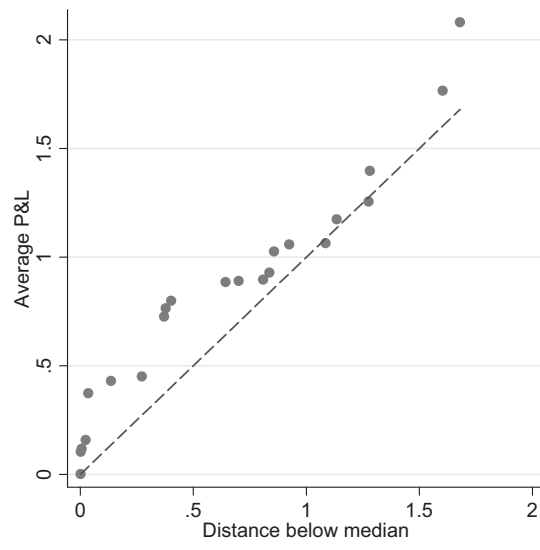


Fig. S6. Skewness of the Box-Cox transformation of the average P&L.

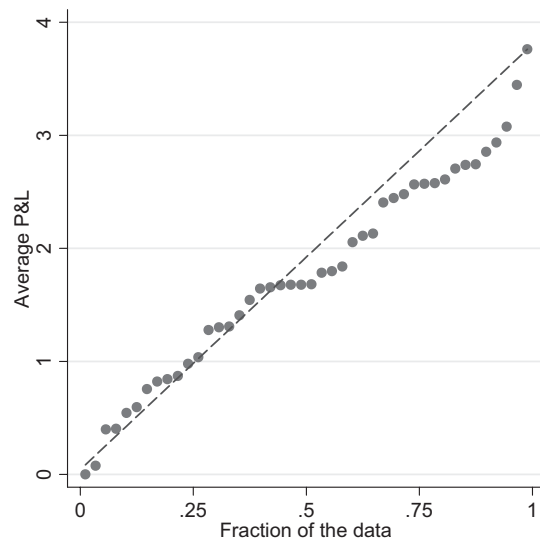


Fig. S7. Box-Cox transformation of the average P&L.

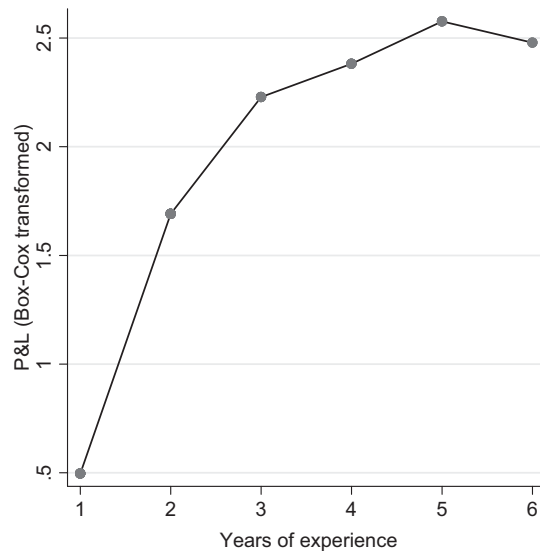


Fig. S8. P&L and years of experience.

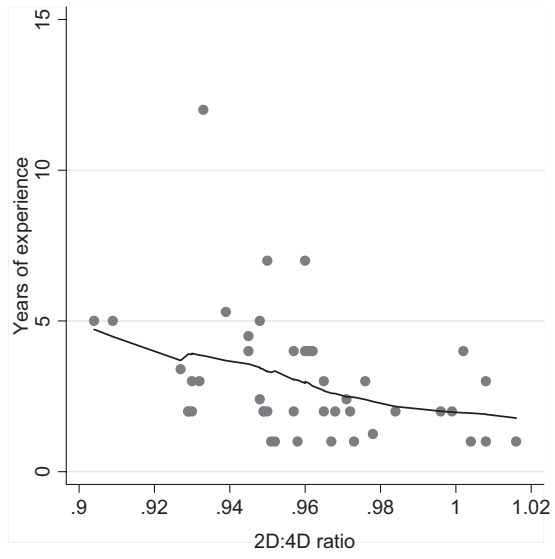


Fig. S9. Lowess analysis of the experience as function of 2D:4D. The bandwidth is 0.8 (that is, 80% of the data were used in each local regression).

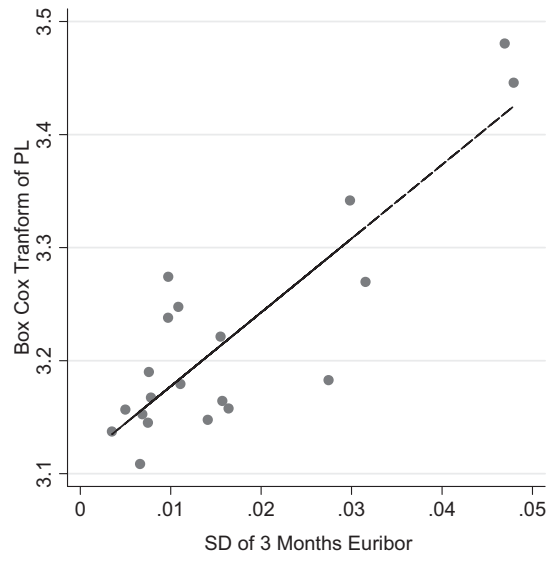


Fig. 510.

Table S1. Ordinary least squares regression of the rank and BC transformation of the average P&L on 2D:4D, experience, and age

Method	Dependent variable	2D:4D ratio	Experience 2 yr	Age	R ²	F _{3,40}	P	n
Robust OLS	Rank: coefficient (P value)	17.51 (0.00085)***	−13.576 (0.00003)***	−7.465 (0.071)	0.569	23.06	0.000017	44
Robust OLS	Box–Cox P&L: coefficient (P value)	−1.211 (0.00086)***	0.983 (0.00003)***	0.458 (0.163)	0.553	20.26	0.00046	44

*, Significant at the 10% level; **, significant at the 5% level; ***, significant at the 1% level.

Table S2. Ordinary least squares regression of the rank and Box–Cox transformation of the average P&L on normalized 2D:4D, age, and experience

Method	Dependent variable	2D:4D ratio	Experience 2 yr	Age	R ²	F _{3,21}	P	n
Robust OLS	Rank b/P value	21.98 (0.002)***	−13.104 (0.00067)***	−4.045 (0.348)	0.568	10.96	0.0002	25
Robust OLS	Box–Cox P&L b/P value	−1.403 (0.002)***	0.949 (0.0007)***	0.116 (0.740)	0.534	9.35	0.0004	25

*, Significant at the 10% level; **, significant at the 5% level; ***, significant at the 1% level.

Table S3. Panel data analysis of the Box–Cox transformation of P&L, regressed on 2D:4D, experience, age, and time dummies

Method	Panel data	Panel data
Dependent variable	Box–Cox P&L b/P value	Box–Cox P&L b/P value
2D:4D ratio	–0.995 (0.013)**	–1.031 (0.004)***
Experience 2 years	0.917 (0.00025) ***	0.994 (0.00037)***
Age	0.407 (0.362)	0.368 (0.362)
Quarter 1		0.212 (0.480)
Quarter 2		0.392 (0.183)
Quarter 3		0.631 (0.034)**
Quarter 4		0.667 (0.026)**
Quarter 5		0.900 (0.003)***
Quarter 6		0.284 (0.430)
Quarter 7		0.612 (0.050)**
Quarter 8		0.350 (0.230)
Constant		9.039 (0.004)***
R ²	0.546	0.505
Wald χ^2 (11)	46.74	140.45
Probability > χ^2	<0.00001	<0.00001
n of obs/groups	710/44	710/44

Table S4. OLS regression of the years of experience and log of years of experience on normalized 2D:4D and age

Method	Dependent variable	2D:4D ratio	Age	R ²	P	n
Ordinary least squares (OLS)	Years of experience <i>b/P</i> value	−3.11 (0.006)***	4.934 (0.000109)***	0.409	0.000023	44
OLS	Log of years of experience <i>b/P</i> value	−1.138 (0.003)***		0.188	0.0032	44
OLS	Log of years of experience <i>b/P</i> value	−1.057 (0.0013)***	1.454 (0.00006)***	0.451	0.0000059	44