Early-life exposure to hardship increased risk tolerance and entrepreneurship in adulthood with gender differences

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Many entrepreneurs credit their success to early hardship. Here, we exploit geographical differences in the intensity of China's Great Famine to investigate the effect of hardship during formative years on individual personality and engagement in business entrepreneurship. To exclude factors that might confound the relation between famine intensity and entrepreneurship, we model famine intensity by random weather shocks. We find robust evidence that individuals who experienced more hardship were subsequently more likely to become entrepreneurs (defined broadly as self-employed or business owners). Importantly, the increase in entrepreneurship was at least partly due to conditioning rather than selection. Regarding the behavioral mechanism, hardship was associated with greater risk tolerance among men and women but increased business ownership only among men. The gender differences were possibly due to the intricate relationship between a Chinese social norm—men focus more on market work, while women focus more on domestic work—and interspousal risk pooling associated with occupational choices. Scientifically, these findings contribute to a long-standing debate on whether entrepreneurship is due to nature or nurture, particularly how hardship conditions people to be entrepreneurial. The findings also highlight the importance of gender differences in shaping the effect of early-life experience on life cycle outcomes.

entrepreneurship | hardship | gender difference | conditioning | risk attitudes

Significance

We investigate the effect of hardship on entrepreneurship using China's Great Famine as a quasinatural experiment. This yielded robust evidence that individuals who experienced more hardship were subsequently more likely to become entrepreneurs. Importantly, the increase in entrepreneurship was at least partly due to conditioning rather than selection. Regarding the behavioral mechanism, hardship was associated with greater risk tolerance among men and women but conditioned business ownership only among men. The gender differences were possibly due to a Chinese social norm that men focus on market work and women focus on domestic work combined with interspousal risk pooling in occupational choice.

> We live through adversity but die through ease.
>
> —Mencius 6B15.5 (ref. 1, p. 170)

What motivates people to establish and grow businesses is an intriguing and important question for economics, management, and policy (2, 3). Knight (4) famously defined entrepreneurship as the capability to perceive, evaluate, and deal with uncertainty and ambiguity. Ambiguity aversion is distinct from, yet correlated with, risk aversion (5–7). Hence, research showing that hardship during formative years shapes long-term attitudes to risk (8–13) has implications for ambiguity aversion. However, the prior research relating hardship to risk tolerance and entrepreneurship (14, 15) did not distinguish two very different mechanisms—conditioning of individual behavior and selective mortality—whose policy and managerial implications are radically different. Moreover, the prior research gave little attention to gender differences in the effect of hardship on entrepreneurship, which are especially important in the context of economic development (16–18).

Here, we investigate how hardship in formative years affects subsequent engagement in entrepreneurship and differences in the effect by gender. The key challenge in our research is to design a study in which hardship is plausibly exogenous. As a quasinatural experiment, we exploit China's Great Famine of 1959 to 1961, which arose from the government's decision to extract resources from agriculture to support manufacturing and exports (19, 20). Local officials based procurement targets on previous year's harvests and differed in their political zeal (20–22). However, random fluctuations in weather could cause agricultural production to fall short. Faced with production shortfalls, officials refused to relax procurement or redistribute food, causing localized shortages of food (21, 23).

To identify the causal effect of famine intensity, we proxy the intensity of the famine in each county by the loss of population in the famine cohort induced by exogenous weather shocks. As explained in *Materials and Methods*, the construct excludes any persistent county factor (fixed effect) that could possibly affect both the severity of the famine and subsequent entrepreneurship. Our identification strategy can be explained by considering two otherwise identical counties. Suppose that, prior to the famine, one county experienced good weather and high grain production, while the other suffered bad weather and low grain production. Then, the former targeted much higher grain procurement, inspired by political ferment, and suffered more intense hardship during the famine period. This prediction is empirically verified. Good weather in 1 y reduced

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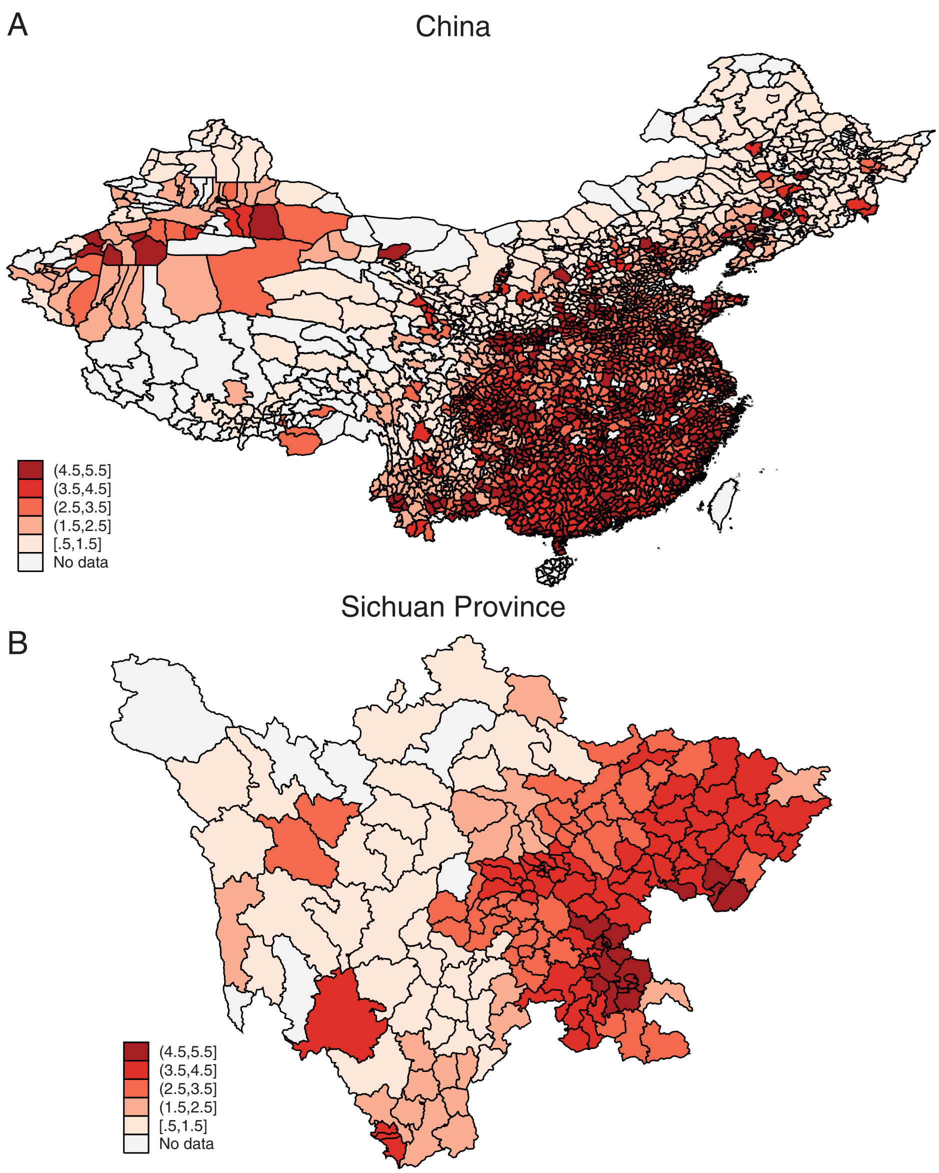

Fig. 1. Famine intensity. *A* depicts famine intensity by county across mainland China; *B* depicts famine intensity across Sichuan Province. Darker colors represent higher intensity of famine. Famine intensity represents the severity of the famine by the difference in the rate of cohort loss between the famine and normal periods predicted by thermal agricultural productivity that is induced by temperature shocks.

mortality in the next year, except during the famine when it increased mortality. The construct for famine intensity based on weather shocks is only meaningful for institutional reasons. Famine could have been averted had officials adjusted procurement standards or redistributed food to mitigate the weather shocks.

Empirically, we use the China 2005 Mini-Census to carry out a population study. In counties where the famine was one SD more severe, women and men were 17.1 and 12.7% more likely to engage in entrepreneurship (defined as self-employment or owning a business), respectively.

Hardship could have increased entrepreneurship through selective mortality of less entrepreneurial persons or conditioning of people to become entrepreneurial. Suppose that, if not for the famine, the populations of counties A and B would have been the same, with the same number of entrepreneurial persons. Suppose further that the famine was more severe in county A than B and increased entrepreneurship only through selective mortality by killing some nonentrepreneurial persons in county A but not in B. Then, after the famine, county A would have proportionately more entrepreneurs, but the absolute number of entrepreneurs would be the same. If, empirically, the number was higher in county A, the increase must be due to conditioning of personality. Indeed, we found that the number of entrepreneurs in each county increased with the severity of the famine, which shows that the famine conditioned some people to become entrepreneurial.

To investigate the behavioral mechanism, we use the 2013 China Household Finance Survey (CHFS), which covered 167 counties (24). In counties where the famine was more severe, both women and men were more risk tolerant. Yet, greater risk tolerance was associated with more men, but not women, owning a business. Importantly, the husband's entrepreneurship increased with the wife's risk tolerance but not vice versa. These gender differences in entrepreneurship were possibly due to the intricate relationship between a Chinese social norm—men focus more on market work, while women focus more on domestic work—and interspousal risk pooling associated with occupational choices.

Table 1. Hardship and entrepreneurship

	1) Self-employed or owner	2) Business owner	3) Self-employed or owner: Income
Both genders			
Famine intensity	0.084***	0.013***	0.532***
Cluster bootstrap SE	(0.012)	(0.004)	(0.161)
Region fixed effects	Yes	Yes	Yes
Observations	729,401	729,401	24,716
Counties	2,589	2,589	2,343
Outcome mean	0.034	0.007	6.561
Females			
Famine intensity	0.058***	0.001	0.423
Cluster bootstrap SE	(0.010)	(0.002)	(0.279)
Region fixed effects	Yes	Yes	Yes
Observations	361,211	361,211	6,733
Counties	2,588	2,588	1,845
Outcome mean	0.019	0.003	6.239
Males			
Famine intensity	0.111***	0.026***	0.724***
Cluster bootstrap SE	(0.018)	(0.006)	(0.169)
Region fixed effects	Yes	Yes	Yes
Observations	368,190	368,190	17,983
Counties	2,589	2,589	2,272
Outcome mean	0.049	0.011	6.682

The sample includes persons enumerated by the 2005 Population Mini-Census born before 1962 who lived in the county of their hukou registration for 5 or more years (columns 1 and 2) and is further limited to the self-employed or business owners (column 3). Values are estimated by ordinary least squares, controlling for region fixed effects, and weighted by the census weights. In column 1, the dependent variable is the indicator of whether a person was self-employed or a business owner. In column 2, the dependent variable is the indicator of whether a person was a business owner. In column 3, the dependent variable is the logarithm of annual income if a person was self-employed or a business owner with income data available. Cluster bootstrap SEs are reported in parentheses. ***$P < 0.01$.

Our findings contribute to two lines of research. The first is how early-life experience shapes personality and adulthood socioeconomic outcomes (25–27). Previous research into the effect of past experience of natural shocks found both increased (12–15) and reduced risk tolerance (9, 10). However, the findings of reduced risk tolerance might be confounded by the failure to control for time preference (13). Furthermore, except for ref. 12, which found an effect only among men, the previous research did not examine gender differences.

Second, we contribute to research into the determinants of entrepreneurship and particularly, to a long-standing debate over whether entrepreneurs are "born or bred" (28–31). De Blasio et al. (15) showed that Italians who were more frequently exposed to earthquakes were more likely to engage in entrepreneurship, and Cheng et al. (14) found similar results for Chinese who were more severely affected by the Great Famine. However, their research did not isolate the effect due to conditioning of personality as distinct from selective survival. We show that the increase in entrepreneurship was due at least in part to conditioning. This finding has major policy implications. If hardship conditions entrepreneurship, then that rationalizes the "School of Hard Knocks" and the promotion of entrepreneurship as a pathway for less developed countries. Further, if hardship conditions entrepreneurship, then in the wake of economic recessions or natural disasters, policy makers should support new businesses as a way to restore economic growth. Moreover, the previous research said little about gender differences, and Cheng et al. (14) estimated the effects of hardship on entrepreneurship and risk tolerance separately without examining risk tolerance as a mediating mechanism.

Exploiting much larger samples on longer timescales than previous studies, we find that hardship during China's Great Famine conditioned both women and men to increase engagement in entrepreneurship. Moreover, the famine was associated with greater risk tolerance among both men and women but increased business ownership only among men. The gender disparity was possibly due to a social norm on the intrahousehold division of labor.

Results

Table 1, columns 1 and 2 report ordinary least squares estimates of Eq. 7 on individuals in the 2005 Mini-Census, with the dependent variable being an indicator of an entrepreneur. With entrepreneurship defined broadly as being self-employed or owning a private enterprise, among women, the coefficient of famine intensity, 0.058 (SE 0.010), is positive and significant. This implies that a one-SD increase in famine intensity would increase female entrepreneurship by 17.1% over the mean of 0.019. As for men, the coefficient of famine intensity, 0.111 (SE 0.018), is positive and significant and implies that a one-SD increase in famine intensity would increase male entrepreneurship by 12.7% over the mean of 0.049. By contrast, with entrepreneurship defined narrowly as owning a private enterprise, the coefficient of famine intensity is positive, small, and imprecise among women and positive and significant among men.

To investigate the effect on the intensive margin, Table 1, column 3 reports ordinary least squares estimates of Eq. 7 with the dependent variable specified as the logarithm of monthly income. The estimate is limited to the subsample of entrepreneurs with income data available. Among female entrepreneurs, the coefficient of famine intensity is positive but not statistically significant, while among male entrepreneurs, the coefficient is positive, statistically significant, and 1.7 times that among females. The weaker effect among females is possibly due to their engagement in entrepreneurship through self-employment rather than business ownership. The average monthly income of self-employed persons, 805 Yuan, was less than half of that of business owners, 1,711 Yuan. (At 8.19 Yuan to the US dollar, the income might seem low, but it far exceeded the average in the general population, 487 Yuan, with all averages limited to people with nonzero reported income.)

Overall, these estimates suggest that people who experienced greater hardship during the famine were subsequently more likely to engage in entrepreneurship. However, the effects differed by gender. While both women and men who experienced more hardship were more likely to be self-employed, only men were more likely to own a business, and if engaged in entrepreneurship, only men earned more.

Robustness. *SI Appendix*, Table S4 reports three sets of robustness analyses of entrepreneurship broadly defined. First, we estimate Eq. 7 including additional covariates or limiting the sample. One specification adds individual characteristics to examine whether the effect of the famine on entrepreneurship was due to changes in individual education and health. As *SI Appendix*, Table S4, column a reports, the estimated effects exceed the main estimates (Table 1, column 1), consistent with the famine eroding education and health, both of which support entrepreneurship. The next estimate (*SI Appendix*, Table S4, columns b and c) limits the sample to individuals aged 60 and younger as well as 50 and younger. The estimated effects are larger than the main estimates, consistent with the effect of hardship on entrepreneurship attenuating with age.

SI Appendix, Table S4, column d adds county-level government expenditure in the year 2000 to examine whether the effect of the famine on entrepreneurship was due to government redistributive policies after the famine. The estimate is almost identical to the main estimates. *SI Appendix*, Table S4, column e includes county-level agricultural productivity in the 1990s to check whether our construct for famine intensity successfully removed county fixed effects. The estimates are quite similar to the main estimates, which is to be expected as, by construction, the cross-county variation in our construct for famine intensity is due solely to random temperature shocks and abstracts from county characteristics.

Next, *SI Appendix*, Table S4, columns f–j report estimates that control for local economic conditions that might favor entrepreneurship. These are in migration, population, gross domestic product per capita, shares of primary and secondary sectors, and share of large enterprises. In all these estimates, the coefficients of famine intensity are positive and significant, and they are similar to the main estimates. These suggest that our main findings are robust to local economic conditions.

The second set of robustness analyses addresses concerns with the constructs for famine intensity and thermal agricultural productivity. *SI Appendix*, Table S4, columns l–t report estimates using alternative measures of famine intensity (based on other methods of projecting population, the 2000 Census, a combination of the 1990 and 2000 Censuses, and excluding persons born after 1958) and alternative measures of thermal agricultural productivity. Our results are robust to these alternative constructs.

The third set of robustness analyses addresses potential econometric concerns, estimating by probit rather than ordinary least squares and clustering SEs by province or prefecture. Referring to Fig. 1, famine intensity appears to be spatially correlated. Note that Eq. 7 includes region fixed effects. Still, we carry out a county-level estimate, which accounts explicitly for spatial correlation. Referring to *SI Appendix*, Table S4, columns u–x, our results are robust to these alternative methods.

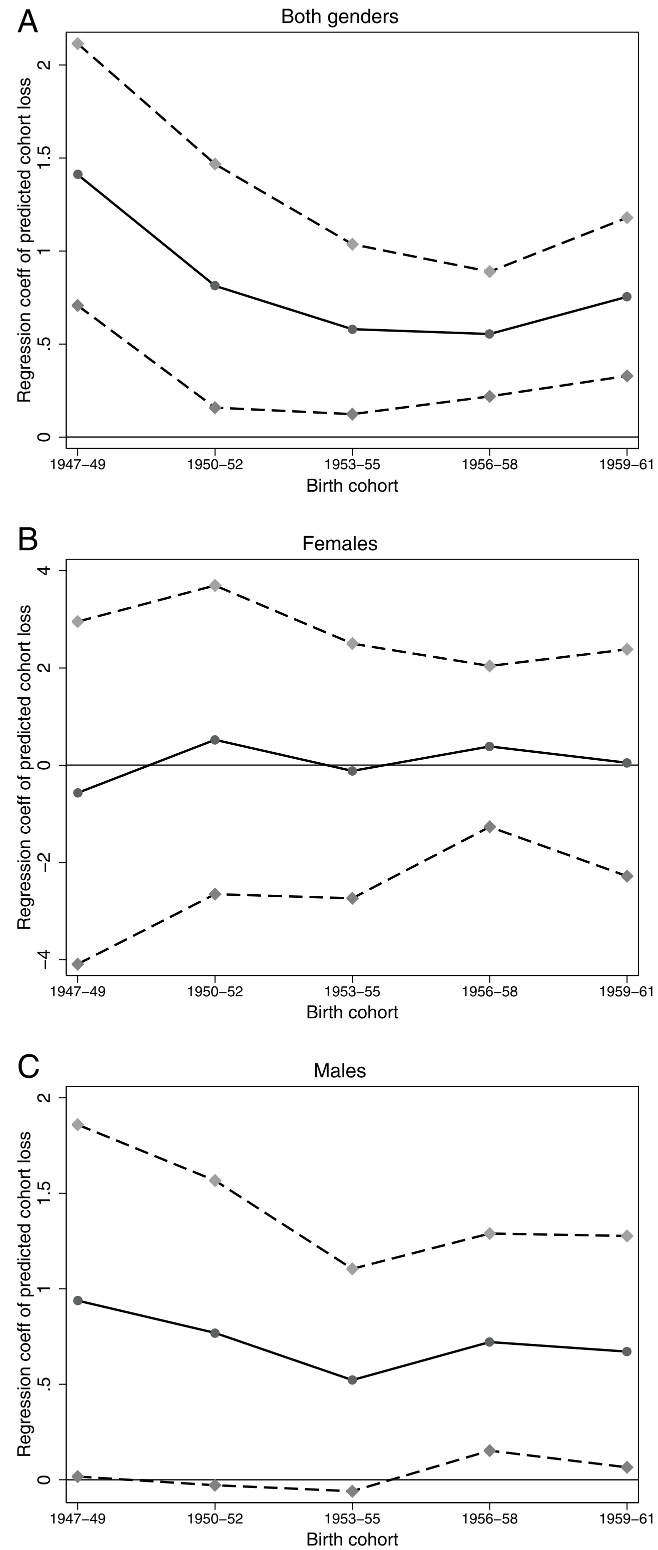

Fig. 2. Operant conditioning. The figure depicts the estimated coefficients of predicted cohort loss in regressions of county-level entrepreneurship on predicted cohort loss and other controls (Eq. **8**) by birth cohort and 95% CIs. The sample includes persons enumerated by the 2005 Mini-Census born before 1962 who lived in the county of their hukou registration for 5 or more years. The dependent variable is the logarithm of the number of entrepreneurs in each birth cohort in the county. The coefficient of predicted cohort loss represents the effect of hardship during the famine on the logarithm of the actual number of entrepreneurs in the cohort in the county in the year 2005. (*A*) Both genders. (*B*) Females. (*C*) Males.

Table 2. Hardship, risk aversion, and entrepreneurship

	1) Business owner	2) Risk tolerance	3) Business owner	4) Business owner
Both genders				
Famine intensity	0.082***	0.168***	0.072***	0.064**
Cluster bootstrap SEs	(0.027)	(0.049)	(0.028)	(0.029)
Risk tolerance (self)			0.055***	
Cluster bootstrap SEs			(0.013)	
Risk tolerance (spouse)				0.028***
Cluster bootstrap SEs				(0.009)
Individual controls	Yes	Yes	Yes	Yes
Observations	12,188	12,188	12,188	9,427
Counties	167	167	167	167
Outcome mean	0.021	0.063	0.021	0.015
Females				
Famine intensity	0.045	0.158**	0.044	0.041
Cluster bootstrap SEs	(0.028)	(0.072)	(0.029)	(0.029)
Risk tolerance			0.006	
Cluster bootstrap SEs			(0.009)	
Risk tolerance (spouse)				−0.004
Cluster bootstrap SEs				(0.006)
Individual controls	Yes	Yes	Yes	Yes
Observations	5,104	5,104	5,104	5,391
Counties	166	166	166	167
Outcome mean	0.011	0.048	0.011	0.011
Males				
Famine intensity	0.102***	0.174***	0.088**	0.107**
Cluster bootstrap SEs	(0.034)	(0.066)	(0.035)	(0.042)
Risk tolerance			0.078***	
Cluster bootstrap SEs			(0.018)	
Risk tolerance (spouse)				0.081***
Cluster bootstrap SEs				(0.023)
Individual controls	Yes	Yes	Yes	Yes
Observations	7,084	7,084	7,084	4,036
Counties	167	167	167	167
Outcome mean	0.028	0.074	0.028	0.021

The sample includes respondents in the 2013 CHFS born before 1962 who lived in the county of their hukou registration for 5 or more years. Values are estimated by ordinary least squares, controlling for age, ethnicity, educational level, rural residence, and health status, and weighted by sampling weights. The dependent variable for columns 1, 3, and 4 is an indicator of a person being a business owner, and for column 2, it is measure of risk tolerance. Cluster bootstrap SEs are reported in parentheses. $^{**}P < 0.05$; $^{***}P < 0.01$.

Heterogeneous Effects. The hardship imposed by the Great Famine ranged to fatal extremes, which begs the question of whether our analysis generalizes to less extreme hardship. To check on this, we divide counties into four quartiles by the intensity of famine and estimate Eq. **7** with quartile-specific coefficients for famine intensity on individuals in the 2005 Mini-Census. The dependent variable is an indicator for being self-employed or owning a private enterprise. Referring to *SI Appendix*, Table S5, column a for both genders and women, the coefficient of famine intensity is positive and significant for all quartiles, albeit marginally smaller for the second quartile. For men, the coefficient of famine intensity is positive, significant, and not statistically different across the quartiles.

To check further, we compare individuals in urban areas, where the famine was less severe, with those in rural areas (32). *SI Appendix*, Table S5, columns b and c report estimates of Eq. **7** with the dependent variable being an indicator of entrepreneurship broadly defined. Hardship increased entrepreneurship among both women and men in both urban and rural areas.

Operant Conditioning. How did hardship during the famine increase subsequent entrepreneurship? The famine could have selectively killed less entrepreneurial people (Darwinian selection), or it may have changed people to become more entrepreneurial (operant conditioning). To distinguish these two mechanisms, we estimate Eq. **8** using the broad definition of entrepreneurship. To include people who were teenagers during the famine, we extend the projection of cohort losses to the years 1947 and 1948. *SI Appendix*, Table S6 reports estimates by 3-y birth cohorts (1947 to 1949, 1950 to 1952, 1953 to 1955, 1956 to 1958, and 1959 to 1961), and Fig. 2 depicts the estimated coefficient of predicted cohort loss. To ensure comparability across estimates, the sample is limited to counties with nonzero entrepreneurs in all cohorts.

Referring to Fig. 2*A*, for both genders, the coefficients of famine intensity in Eq. **8** are positive and statistically significant in all cohorts, suggesting that the famine conditioned people of all formative ages to become more entrepreneurial. The effects are largest in the oldest cohort (aged 10 to 12 y at the onset of the famine). However, the effects differ by gender. Among women (Fig. 2*B*), the coefficients of famine intensity are not significantly different from zero. Still, this does not rule out operant conditioning among women as in Eq. **8**, that $\gamma > 0$ is sufficient but not necessary to prove conditioning. By contrast, among men (Fig. 2*C*), the coefficient of famine intensity is positive and largest in the oldest cohort and somewhat smaller among other cohorts.

Overall, the census data yield strong evidence of operant conditioning of engagement in entrepreneurship. To further examine the behavioral change underlying the effect of hardship on entrepreneurship, we turn to the CHFS data.

Risk Attitudes. Previous research suggests that hardship conditions long-term risk tolerance (12, 13). Tolerance for risk and ambiguity underlies entrepreneurship (2, 33). Lacking suitable data on ambiguity tolerance, we focus on risk tolerance, relying on its correlation with ambiguity tolerance. Table 2 presents estimates of Eqs. **9** and **10** using the CHFS data with entrepreneurship defined narrowly as business ownership. (The CHFS only reports entrepreneurship defined narrowly.)

Referring to Table 2, column 1, both women and men who suffered more hardship were more engaged in entrepreneurship. However, the result is statistically significant only among men. Referring to Table 2, column 2, both women and men who suffered more hardship exhibited higher risk tolerance. Specifically, if hardship was one SD higher, women and men were 18.4 and 13.2% more likely to be risk tolerant, respectively. [*SI Appendix*, Table S7 reports additional estimates showing the effect of hardship on other measures of risk tolerance. Further, to check for possible confounders between risk and time preferences (13), *SI Appendix*, Table S8 reports an estimate showing that hardship during the famine did not affect time preference.]

Next, Table 2, column 3 estimates the separate effects of hardship and own risk tolerance. Among women, neither hardship nor risk tolerance significantly increased women's engagement in entrepreneurship. However, among men, both hardship and risk tolerance increased entrepreneurship. Notably, the coefficient of famine intensity is about 15% smaller than in Table 2, column 1, suggesting that hardship did at least partly increase entrepreneurship through increasing risk tolerance.

Why did hardship increase risk tolerance among both women and men but increase entrepreneurship only among men? One possible reason is a Chinese social norm of men engaging more in market work and women performing more domestic work (34) coupled with the joint choice of the man's engagement in entrepreneurship according to the risk attitudes of both spouses (35). To investigate, Table 2, column 4 reports regressions of entrepreneurship on spouse's risk tolerance. Consistent with our conjecture of intrahousehold risk sharing, male entrepreneurship increased with the wife's risk tolerance. Unfortunately, the CHFS surveyed the risk tolerance of only one spouse, and so, we could not estimate an equation including both own and spouse's risk tolerance.

SI Appendix, Table S9 uses the CHFS to present additional evidence that the effect of hardship on entrepreneurship was moderated by the social norm that men and women specialize in market and domestic work, respectively. We construct an indicator of the woman being the head of household to represent her bargaining power within the household. We hypothesize that to the extent that the woman was the head of household, the social norm would be weaker. Indeed, the estimates suggest that in counties where more women were household heads, the effect of hardship on entrepreneurship was stronger among women and weaker among men.

Discussion

Exploiting geographical differences due to random weather shocks in the intensity of China's Great Famine, we found robust evidence of gender differences in the effect of hardship on entrepreneurship. Among those who experienced more hardship, both women and men were conditioned to be more risk tolerant, but greater risk tolerance increased business ownership only among men. The limited available data point to social norms as explaining the gender differences.

Entrepreneurship depends on other aspects of personality other than tolerance of risk and ambiguity (2, 14). *SI Appendix*, Tables S10–S12 report estimates of other factors, which might have been selected or conditioned by hardship—self-confidence, tenacity, resilience, and opportunism. However, none of these were significant in the direction that would increase entrepreneurship.

Our research was based on measures of risk tolerance and relied on the correlation between the tolerance for risk and ambiguity aversion. To the extent that entrepreneurship depends on tolerance for ambiguity (4) rather than risk, our results should be interpreted with caution. Accordingly, an important direction for future research is the effect of hardship on ambiguity tolerance.

A second concern is that our analysis is quite limited in quantifying the degree to which hardship conditioned individuals to engage more in entrepreneurship. Our county-level estimates by cohort (Fig. 2) showed that selective mortality could not account for the entire effect of hardship on entrepreneurship, which implies that at least part of the effect was due to operant conditioning. Our individual-level estimates combined the effects due to selective mortality vis-à-vis operant conditioning and so, overestimated the effect of conditioning. Still, this is mitigated to the extent that the famine degraded cognitive skills (36, 37), which diminished risk tolerance (38). Further research is needed to more precisely quantify how much hardship conditions people to engage more in entrepreneurship.

Materials and Methods

Institutional Setting. In 1958, the Communist government of China, led by Chairman Mao Zedong, launched the Great Leap Forward, aiming to catch up with industry in Britain and the United States. The government collectivized agriculture, forced people to eat in communal canteens, and redirected up to 100 million people from agriculture to collective works and industry. It aggressively procured grain from rural areas to feed urban residents, support manufacturing, and export to foreign countries (19, 20). Local government officials set targets for procurement, likely based on the previous year's harvest, but when shortages resulted, officials would not or could not relax procurement or redistribute food (20, 21). The result was a famine starting in the winter of 1959 and lasting until 1961, when Chairman Mao reluctantly reversed his policies. The government blamed the famine on bad weather (19, 39).

The severity of the Great Leap Forward famine differed geographically across and within provinces. Based on a construct that we introduce below, Fig. 1 depicts the intensity of the famine by county, with darker colors representing more severe famine. Evidently, the degree of hardship varied substantially across the country and even within provinces (Fig. 1*B* depicts Sichuan, one of China's most populous provinces). A major factor in the geographical variation was random fluctuations in weather relative to predetermined procurement targets. Another was differences among government officials in their political zeal (22).

Although our outcome of interest is entrepreneurship in the 2000s, over 40 y after the famine, it is worth understanding the economic and social structure during the famine period. At the time, the Chinese economy was nationalized, and all employment was assigned by the government. Personal choice was simply disallowed. Moreover, just before the famine, the government established the household registration (hukou) system. This prevented people from migrating to get food. About 20 y after the famine, in December 1978, Deng Xiaoping began to liberalize the economy and particularly, allow the operation of private businesses.

Data. Our study used data from multiple sources. Administratively, China is divided into provinces, prefectures, and counties. We carried out the analysis by county, which is the lowest level with data available. The principal sources of information are 1) the 1990 Population Census (1% sample) for the population by county and year of birth used to estimate cohort losses; 2) the 2005 Population Mini-Census (20% sample) used to measure entrepreneurship defined in two ways–narrowly as those who owned an enterprise in the private sector and broadly to also include the self-employed; 3) the 2013 nationally representative CHFS for business ownership and risk tolerance; and 4) the China Meteorological Administration for daily instrumental temperature records at 727 stations between 1951 and 1970 [records of weather prior to 1951 are fragmentary (40)].

SI Appendix, Table S1*A* summarizes the 2005 Mini-Census data limited to people born before 1962 who lived in the county of their hukou registration for 5 or more years. There were 729,401 such persons in 2,589 counties, of whom 3.4% were self-employed or owned private enterprises (1.9 and 4.9% among women and men, respectively).

SI Appendix, Table S1*B* summarizes the 2013 CHFS data limited to people born before 1962 who lived in the county of their hukou registration for 5 or more years. The survey covered 12,188 persons in 167 counties, among whom 1.1% of women and 2.8% of men owned businesses.

The CHFS asked respondents about their investment philosophy by choosing among 1) high risk for high returns; 2) above-average risk for above-average returns; 3) average risk for average returns; 4) below-average risk for below-average returns; and 5) no risk. Following previous research (8, 23), our construct for risk tolerance is an indicator that the respondent chose choice 1 or 2. The average risk tolerances were 0.05 and 0.07 among women and men, respectively.

Method: Construction of Famine Intensity. To estimate the effect of hardship on entrepreneurship, we exploited county-level variation in the severity of the Great Famine. The major empirical challenge is unobservable differences among counties, such as natural resources or transportation, which correlate with both the severity of the famine and subsequent entrepreneurship. To address unobservable cross-county heterogeneity, we constructed an exogenous measure of famine severity that purged county fixed effects and varied only with random weather shocks.

Our measure of famine intensity is founded on the institutional causes of the famine. Generally, officials set procurement targets for each year according to agricultural production in the preceding year (20, 21). In turn, agricultural production depended on county-specific agricultural endowment and time-varying weather shocks. The former is a county fixed effect, while the latter is random. For example, if (randomly) better temperatures raised production in a county in 1 y, the procurement target for the next year would be increased. However, production in the following year need not be equally high (empirically, *SI Appendix*, Table S2 shows that, controlling for weather station fixed effects, temperatures were not serially correlated). The crux is that between 1959 and 1961, when production fell short, officials would not or could not adjust procurement targets or redistribute food (20, 21).

The combination of excessive procurement targets (varying according to government policy and official zeal) and random fluctuations in weather with failure to adjust procurement or redistribute food resulted in starvation. Among the various causes of starvation, we focused on random changes in weather. Below, over four steps, we isolate the variation in famine intensity induced by weather shocks and show that this variation generates meaningful variation in the intensity of the famine across counties. To reiterate, our construct for famine intensity based on weather shocks is meaningful only for institutional reasons. If officials had behaved differently and adjusted procurement or redistributed food to mitigate the weather shocks, the shortages of food would have been alleviated, and our construct for famine intensity would not work.

Step 1. Cohort Loss Rate. In the first step toward an exogenous measure of famine intensity, we constructed a raw measure (19, 21, 41). Using the 1990 Population Census, for each county and birth year, stipulate the rate of cohort loss as the proportionate difference between the counterfactual population (based on a trend ignoring the famine years) and the actual population. Formally, for county c and birth year y,

$$\mu_{cy} = \frac{\tilde{P}_{cy} - P_{cy}}{\tilde{P}_{cy}} = 1 - \frac{P_{cy}}{\tilde{P}_{cy}}, \quad \textbf{[1]}$$

where $\tilde{P}_{cy}$ and P_{cy} represent the projected and actual populations in 1990, respectively.

SI Appendix, Fig. S1 depicts the linearly projected counterfactual and actual populations for China as a whole. Evidently, the actual population closely followed the projection in normal years but dropped sharply below during the famine. *SI Appendix*, section S2 details the construct.

The famine affected individual health, education, employment, marriage, and other outcomes in the long term (19, 36, 37, 42). By taking a retrospective view from 1990, the rate of cohort loss accounts for both immediate as well as long-term effects of the famine. Note that the purpose of the construct is not to measure excess mortality or depressed fertility during the famine as such. Rather, the objective is to represent geographical differences in the intensity of the famine in all ramifications up to 1990 for each cohort.

Step 2. Thermal Agricultural Productivity. As discussed above, the rate of cohort loss might differ among counties in ways related to subsequent entrepreneurship. To isolate the element of cohort loss due to random weather shocks, we next construct a measure of local agricultural productivity based on exposure to heat. Agronomic research shows that exposure to heat during the growing season affects yields in a nonlinear way. Plants absorb heat only if the temperature exceeds some threshold, and yields increase with temperature up to some ceiling, beyond which yields decrease (43). For each county c, year y, and day d, stipulate the "degree day," H_{cyd}, to be

$$H_{cyd} = \begin{cases} 0 & \text{if} \quad T_{cyd} < 8, \\ T_{cyd} - 8 & \text{if} \quad 8 \le T_{cyd} < 33, \\ \frac{25}{8}\left[41 - T_{cyd}\right] & \text{if} \quad 33 \le T_{cyd} < 41, \\ 0 & \text{if} \quad T_{cyd} \ge 41, \end{cases} \quad \textbf{[2]}$$

where T_{cyd} is the mean instrumental temperature on the day.

Then, define the thermal agricultural productivity in county c and year y as the sum of the degree days in the growing season (April to September),

$$\text{Agri}_{cy} = \textstyle\sum_{d=April\ 1}^{Sept\ 30} H_{cyd}. \quad \textbf{[3]}$$

We associate each county with the nearest weather station by the Euclidean distance from the county seat, which on average, associates three counties to each station. Robustness tests associate each county to the three nearest weather stations and weight temperatures by the inverse of distance.

Referring to *SI Appendix*, Fig. S2, thermal agricultural productivity fluctuated and fell only slightly below average in 1958 to 1960 and actually exceeded the average in 1961. These patterns belie the official explanation, which blamed the famine on bad weather. Still, temperatures did vary over time and across counties in normal periods before and after the famine. *SI Appendix*, Table S2 shows that, after controlling for station fixed effects, thermal agricultural productivity was not serially correlated. As discussed below, the randomness of thermal agricultural productivity is central to our empirical strategy.

Step 3. Cohort Loss: Random Element. Next, we estimated the following regression to isolate the element of cohort loss due to random weather shocks, excluding any county fixed effect:

$$\mu_{cy} = \beta_0 + \beta_1 Agri_{c,y-1} + \textstyle\sum_{t=1953}^{1970} \lambda_t Agri_{c,y-1} D_t + \sum_{t=1953}^{1970} \eta_t D_t + \nu_c + \varepsilon_{cy}. \quad \textbf{[4]}$$

In Eq. **4**, D_t is a year indicator; β_0, β_1, λ_t, and η_t are coefficients for estimation; ν_c are county fixed effects; and ε_{cy} is a random error. Among the coefficients, β_1 measures the average effect of the previous year's thermal agricultural productivity, λ_t measures the additional effect of the previous year's thermal agricultural productivity beyond the average in each year, and η_t measures any variation in cohort loss not explained by the previous year's thermal agricultural productivity.

SI Appendix, Table S3 presents the estimates. The coefficient of the average previous year's thermal agricultural productivity, $\beta_1 = -0.044$ (SE 0.023), is negative and marginally significant. Evidently, on average, a good harvest was associated with lower cohort loss in the subsequent year. This is consistent with part of surplus agricultural production (in excess of government procurement) accruing to people in the county.

The year-specific coefficients, λ_t, are mostly insignificant. However, the coefficients for the famine years are positive and significantly larger, and that for the peak famine year, 1960, is an order of magnitude larger. During the famine, higher agricultural productivity was associated with larger cohort loss in the following year. These positive estimates reveal the institutional cause of the famine: failure to adjust procurement or redistribute food to mitigate shortfalls in production (20, 21).

Step 4. Exogenous Measure of Famine Intensity. The final step uses the estimated coefficients, $\hat{\beta}_1$, $\hat{\lambda}_t$, and $\hat{\eta}_t$, from Eq. **4** to calculate the predicted rate of cohort loss based on thermal agricultural productivity:

$$\hat{\mu}_{cy} = \hat{\beta}_1 Agri_{c,y-1} + \sum_{t=1953}^{1970} \hat{\lambda}_t Agri_{c,y-1} D_t + \sum_{t=1953}^{1970} \hat{\eta}_t D_t. \quad [5]$$

Then, the following is an exogenous measure of famine intensity in county c:

$$\text{Famine}_c = \frac{1}{3}\sum_{y=1959}^{1961}\hat{\mu}_{cy} - \frac{1}{15}\left[\sum_{y=1953}^{1958}\hat{\mu}_{cy} + \sum_{y=1962}^{1970}\hat{\mu}_{cy}\right]. \quad [6]$$

The construct, Famine_c, represents the severity of the famine by the difference in the predicted rate of cohort loss between the famine and normal periods where, in turn, the prediction is based on thermal agricultural productivity. As discussed above, after controlling for station fixed effects, thermal agricultural productivity is not serially correlated. Referring to Eq. **4**, the estimated coefficients, $\hat{\beta}_1$, $\hat{\lambda}_t$, and $\hat{\eta}_t$, exclude county fixed effects and are purely determined by random temperature shocks. Furthermore, the construct, Famine_c, is defined as a difference, which further wipes out any possible county fixed effect. (To explain, suppose that $\hat{\mu}_{cy} = \breve{\mu}_{cy} + \nu_c$, where $\breve{\mu}_{cy}$ is purely random and ν_c is a county fixed effect. Then, substituting in Eq. **6**, $\text{Famine}_c = \frac{1}{3}\sum_{y=1959}^{1961}\breve{\mu}_{cy} - \frac{1}{15}[\sum_{y=1953}^{1958}\breve{\mu}_{cy} + \sum_{y=1962}^{1970}\breve{\mu}_{cy}]$, which is purely random.)

We need the construct, Famine_c, to represent meaningful differences in the intensity of the famine. Helpfully, the cohort loss rate and the construct are well correlated. In a regression of the cohort loss rate in the years 1959 to 1961 on Famine_c, the coefficient of famine intensity, 1.125 (SE 0.0495), is positive, close to one, and highly statistically significant. Further, Fig. 1 confirms substantial geographical variation in the famine intensity construct.

Method: Regression Specification. Having developed an exogenous construct for famine intensity, we apply multiple regression methods to examine the effect of hardship experienced during the famine on entrepreneurship and risk attitudes.

Entrepreneurship. To examine the effect of famine on individual entrepreneurship, we estimate the equation,

$$Y_{icr} = \omega_0 + \omega_1 \cdot \text{Famine}_c + \psi_r + \upsilon_{ic}, \quad [7]$$

where the dependent variable, Y_{icr}, indicates that individual i in county c of region r engaged in entrepreneurship; Famine_c is the construct for famine intensity; ψ_r is a region fixed effect; υ_{ic} is an error term; and ω_0, ω_1, and ψ_r are coefficients to be estimated. Since the construct, Famine_c, excludes any county fixed effect, the cross-county variation in famine intensity is due solely to random temperature shocks. Accordingly, the estimated coefficient of the famine intensity, ω_1, renders a causal interpretation. To account for our main explanatory variable, the measure of famine intensity, being constructed from coefficients estimated in Eq. **4**, we report cluster bootstrap SEs (44) in the estimation of Eq. **7**.

Overall, the method that we developed above is similar in spirit to two-stage least squares. The construct for famine intensity is based on random weather shocks during the famine period, which are exogenous to entrepreneurship over 40 y later. Eq. **7** then estimates the effect of the famine on entrepreneurship without any confounding from cross-county heterogeneity. (We could not directly apply two-stage least squares owing to a difference in data structure. The famine intensity is constructed from a longitudinal analysis, whereas entrepreneurship [being measured just once] is estimated from a cross-sectional analysis.)

To check whether our empirical strategy successfully dealt with cross-county heterogeneity, we carry out robustness checks that estimate Eq. **7** controlling for government expenditure and agricultural productivity. If our method truly extracts the variation in famine intensity due solely to weather shocks and abstracts from county fixed effects, the results should be robust to these additional covariates (*SI Appendix*, Table S4, columns d and e).

Mechanism: Mortality or Conditioning. To investigate whether hardship affected entrepreneurship through selection (higher mortality of less entrepreneurial people) or conditioning of behavior, *SI Appendix*, section S4 develops the following equation for people in county c born in year y:

$$\ln E_{cy} = \gamma_0 + \gamma_1 \hat{\mu}_{cy} + \gamma_2 \ln \tilde{P}_{cy} + \varepsilon_{cy}. \quad [8]$$

In Eq. **8**, E_{cy} is the actual number of entrepreneurs; $\hat{\mu}_{cy}$ is the predicted cohort loss from Eq. **5**; $\tilde{P}_{cy}$ is the projected population absent the famine; ε_{cy} is an error term; and γ_0, γ_1, and γ_2 are coefficients for estimation.

Eq. **8** estimates the effect of the famine on the number of entrepreneurs in the county, conditional on the population absent the famine. Conditional on the population, selective mortality could not have increased the number of entrepreneurs. This intuition motivated us to examine the coefficient, γ_1. If $\gamma_1 > 0$, entrepreneurship increased so much as to outweigh deaths due to the famine, which points to conditioning of behavior.

Risk Attitudes. To investigate the conditioning of risk tolerance as a mechanism by which hardship increased entrepreneurship, we estimated the equations for individual i in county c:

$$r_{ic} = \psi_0 + \psi_1 \cdot \text{Famine}_c + \psi_2 X_{ic} + \zeta_{ic} \quad [9]$$

and

$$Y_{ic} = \theta_0 + \theta_1 \cdot \text{Famine}_c + \theta_2 \cdot r_{ic} + \theta_3 X_{ic} + \xi_{ic}. \quad [10]$$

In the above, r_{ic} represents the individual's risk tolerance; Y_{ic} is an indicator for entrepreneurship; ζ_{ic} and ξ_{ic} are error terms; X_{ic} are individual characteristics; and ψ_0, ψ_1, ψ_2 and θ_0, θ_1, θ_2, θ_3 are coefficients for estimation.

Data Availability. China Population Census 1990, China Population Census 2000, China Population Mini-Census 2005, and China Economic Census data are available from the National Bureau of Statistics-Peking University (NBS-PKU) Research Data Center, Peking University (https://microdata.stats.gov.cn/; click on the third link). CHFSs 2011 and 2013 data are available from the Survey and Research Center for China Household Finance, Southwestern University of Finance and Economics, Chengdu (https://chfs.swufe.edu.cn/; to access the data, apply through the official platform (https://chfser.swufe.edu.cn/datas/). China General Social Surveys 2008, 2010, 2011, 2012, and 2013 data are available from the National Survey Research Center, Renmin University of China, Beijing (http://cgss.ruc.edu.cn/English/Contact_Us.htm; to access the data, contact cgss@ruc.edu.cn). China Family Panel Studies 2010 data are available from the Institute of Social Science Survey, Peking University (http://www.isss.pku.edu.cn/cfps/; to access the restricted county-level data, apply through http://www.isss.pku.edu.cn/cfps/sjzx/xzsj/index.htm). China daily instrumental temperature records at 727 stations from 1951 to 1970 are available in Zenodo (https://zenodo.org/record/6084180#.YgsDzt9BxEY).

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