



## Does rice farming shape individualism and innovation?



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### ABSTRACT

Talhelm et al. (2014) provided an original rice theory to explain large psychological differences across countries and even within countries and their impact on innovation. However, their findings are subject to the problems of sample bias, measurement error, and model misspecification. After correcting these problems, most findings in the original paper no longer hold. We collected data on collectivism from other sources and linked them with rice areas but failed to find any relationship as predicted by the rice theory. The role of rice farming in shaping cultural psychology and innovations seems to be much more muted than asserted in Talhelm et al. (2014).

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### Introduction

Large psychological differences in individualism, analytic thinking, and loyalty/nepotism across countries and even within countries have been noted in the real world and literature for a long time (O'Neill, 1973; Kim, 1994; Triandis, 1995; Vandello and Cohen, 1999). Talhelm et al. (2014) offered an original rice theory to explain such a difference. Their story is intuitively appealing. Rice farming is both labor and water intensive (primarily for paddy rice). During the peak seasons, farmers adjust their schedules of transplanting and harvest so that they can exchange labor to ease the problem of seasonal labor shortage. Paddy field requires standing water.<sup>1</sup> Therefore, people in rice regions must collaborate to build elaborate irrigation systems, coordinate water use, and share the cost of construction and maintenance. All these activities involve comprehensive collaboration and coordination, encouraging farmers to form tight reciprocal relationship and avoid conflict. The rice

theory hypothesizes that after thousands of years of farming practice, people living in rice-cultivating regions develop a higher degree of interdependence and collectivism than those living in wheat areas.

However, it is difficult to test the theory across countries because of inherent differences in many factors, such as language, religion, politics, and climate. The authors chose to test it within China by taking advantage of the homogeneity among the Han population. They surveyed more than 1000 Han Chinese college students and found that rice-growing southern China exhibits lower individualism and more holistic thinking than the wheat-growing north. By using secondary data at the provincial level, they also showed that people in rice-cultivating areas of China are subject to a lower divorce rate and hold fewer patents for inventions compared to wheat-cultivating areas. Because rice culture emphasizes avoiding conflict and valuing relationships, the lower divorce rate in rice-cultivating provinces provides strong evidence in support of the rice theory. As individualism and analytical thinking are normally tied to creativity, the smaller number of successful invention patents in rice areas in comparison to wheat areas offers additional support to the rice theory. Drawing on the findings of the paper, Henrich (2014) speculated that wheat farming in Europe may have contributed to the industrial revolution. The rice theory is so appealing and profound that *Science* highlighted the article on the cover page and many media covered the story.

The theory is truly original. It sheds new light on understanding the interplay among environment, culture, psychology, and innovations. Given the originality and potential far-reaching impact of Talhelm et al. (2014), it is critical to replicate and validate the

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<sup>1</sup> Talhelm et al. (2014) use the term “paddy rice,” probably referring to paddy field. Paddy rice means rice with husks. Although irrigation is central to rice production, upland rice grows with much less need for water. Paddy rice can also be produced in dryland. In principle, including dryland rice area in the analysis may result in misleading conclusions. Considering that the cropping area of dryland rice accounts for less than 2% of total rice cropping area (Wan, 2009), the impact of including dryland rice areas on the main results is likely to be minimal. Thanks an anonymous reviewer for raising this point.

findings of the paper. This is the main objective of this paper. We found that Talhelm et al.'s analyses were subject to sample bias, measurement errors, and model misspecifications. After correcting these problems, most findings in the original paper no longer hold. We further collected data on collectivism from other sources and linked them with rice areas but failed to find any relationship as predicted by the rice theory. The role of rice farming in shaping cultural psychology and innovations seems to be much more muted than asserted in Talhelm et al. (2014).

### Sample bias

Talhelm et al. (2014) conducted three experiments to measure cultural thought, implicit individualism, and loyalty/nepotism in six sites. Ideally, the sampling size in each province should be proportional to the total population in the province. However, as shown in Table 1, the sample distribution is highly uneven. In the experiment on holistic thought, there are a total of 1019 observations scattered across 28 provinces. Among the sample, Guangdong province commands the largest number of observations (193, or 18.94 percent of the total), more than double its population share. Fujian province accounts for 14.62% of the total sample size, compared to its 2.88% of population share. In comparison, only 2 individuals were surveyed in Beijing, constituting merely 0.20% of the sample, much lower than its population share of 1.53%.

The experiment on implicit individualism covers 515 subjects. Fujian province dominates the sample with 142 observations, constituting 27.57% of the total sample size. By contrast, only 1 and 2 students were surveyed in Qinghai and Shanghai, respectively. The small sample size makes it impossible to draw a strong inference in these provinces. The sample size for the loyalty nepotism experiment is much smaller at 166. There is only 1 observation in three provinces (Ningxia, Shanghai, and Chongqing). Since the share of the cultivated rice paddy area is measured at the province level, the results on the relationship between rice area and the three outcome variables hinges crucially on spatial variations across provinces. The uneven distribution of sample sizes across provinces, in particular the extremely small number of observations in some provinces, may result in spurious estimates.

To check if it is the case, we first replicated the results of Talhelm et al. (2014) on the three key outcome variables (holistic thought, implicit individualism, and loyalty/nepotism) based on their original sample in Tables 2A–2C. The three outcome variables are taken from Talhelm et al. (2014). Holistic thought is measured by a triad task in which participants pair two out of three items through either abstract or functional relationship; individualism is measured as the difference in the circles of friends and self in a self-drawn social network; the variable of loyalty/nepotism measures whether people draw a sharp distinction between how they treat friends and how they treat strangers. The rice variable is defined as the percentage of cultivated land devoted to rice paddies. Regressions (R1 with only rice variable and R2 with both rice and GDP) in the three tables successfully replicate the original regressions for the three outcome variables. The rice variable is significant in R1 and R2 in all the three tables.

Next, we used bootstrap method to systematically examine whether the above results are robust to sample selections or not. The bootstrap method relies on constructing a number of resamples of the observed dataset. In specific, each time two provinces are randomly dropped and estimates are made on this subsample.<sup>2</sup>

<sup>2</sup> If dropping only one province each time, there are only 28 possibilities. The average estimates based on regressions over the 28 restricted samples is the jackknife estimator. Here, we use the bootstrap estimator by dropping two provinces each time to create more subsamples. Bootstrap and jackknife estimators yield very similar results. The results based on jackknife estimator are available upon request.

Among the 28 provinces, there are in total 378 possible combinations ( $28 \times 27/2$ ) of dropping two provinces each time.<sup>3</sup> The process repeats 50 times (based on a random seed number of 12345). Tables 2A–2C report the estimation results based on bootstrap method. In the regression on holistic thought, the rice variable remains highly significant. With respect to implicit individualism, the significance level for the rice coefficient changes from 1% to 10%, as shown in R4 in Table 2B. The result on loyalty/nepotism is more sensitive. The rice coefficient becomes insignificant, as shown in R4 in Table 2C. In short, the uneven sampling size distribution matters to the regression results.

### Model misspecification

One key objective of the Talhelm et al. (2014) study is to dismiss two other popular competing theories—the modernization hypothesis and pathogen prevalence hypothesis. The authors used per capita gross domestic product (GDP) to measure the impact of modernization and disease rates in earlier years to measure the precontemporary disease prevalence. The paper tested the three hypotheses independently by running three separate regressions. In principle, a more rigorous test should include all three key variables of interest in the same regression and examine their relative importance to the outcome variables. As a matter of fact, the paper later included both pathogens and per capita GDP variables when testing the impact of rice farming on innovations.

In Tables 2A–2C we added specifications including both per capita GDP and pathogens together with the rice variable. The results for the augmented original specification and bootstrap regressions are shown in columns R3 and R5, respectively. As shown in regression R3 in Table 2A, after controlling for the two variables in the original specification in Talhelm et al. (2014), the rice variable remains significant in the regression on holistic thought, while the significance level of the rice coefficient drops to 10%. It loses its significance in the bootstrap regression (R5 in Table 2A). The rice variable in augmented regressions on implicit individualism (R3 and R5 in Table 2B) and loyalty/nepotism (R3 and R5 in Table 2C) is insignificant no matter whether the bootstrap method is used. In the three tables, we also checked the potential multicollinearity problem due to the inclusion of all the three key variables in the same regression. The last row in Tables 2A–2C displays the variance inflation factor (VIF), a statistics for diagnosing multicollinearity. The VIFs are generally smaller than 2, far below the commonly used threshold of 10, indicating that multicollinearity is not an issue. When evaluating the three competing hypotheses simultaneously, the rice story does not exhibit any stronger explanatory power on the psychological differences than the modernization and pathogens mechanisms, in particular for implicit individualism and loyalty/nepotism.

### How to measure individualism?

The experiment on implicit individualism was likely subject to measurement errors. The experiment was conducted as follows, according to Talhelm et al. (2014, 606): “Researchers measure how participants draw a diagram of their social network, with circles to represent the self and friends. Researchers measure how large participants draw the self versus how large they draw their

<sup>3</sup> Given 28 provinces, if each time we drop one province, there are 28 ways of creating a new subsample of 27 observations. Conditional one province has been dropped, if we further drop one more observation from a subsample, there are 27 options under each subsample. So in total there are  $28 \times 27 = 756$  potential combinations. However, since the chosen 26 provinces are indifferent to the order of sampling, among the 756 subsamples, 378 are distinct ( $756/2$ ).

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