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Soft Skills for Hard Constraints

Evidence from High-Achieving Female Farmers

Joao Montalvao
Michael Frese
Markus Goldstein
Talip Kilic

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Abstract

This paper documents the positive link between the noncognitive skills of women farmers and the adoption of a cash crop. The context is Malawi, one of the poorest countries in the world, where the majority of rural households practice subsistence farming. The analysis finds that a one standard deviation increase in noncognitive ability related to perseverance is associated with a five percentage point (or 33 percent) increase in the probability of adoption of the main cash crop. This link is not explained by differences across women in education and cognitive skills. It is also not explained by the fact that women with higher noncognitive ability tend to be married to husbands of higher noncognitive ability and education. The effect of female noncognitive skills on adoption is concentrated in patrilocal communities, where women face greater adversity and thus where it would be expected that the returns to such skills would be highest. One main channel through which noncognitive skills seem to work is through the use of productive inputs, including higher levels of labor, fertilizer, and agricultural advice services.

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Soft Skills for Hard Constraints: Evidence from High-Achieving Female Farmers*

Joao Montalvao Michael Frese Markus Goldstein Talip Kilic†

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† Montalvao: World Bank, jmontalvao@worldbank.org; Frese: National University of Singapore, Business School and Leuphana University of Lueneburg, michfrese@gmail.com; Goldstein: World Bank, mgoldstein@worldbank.org; Kilic: World Bank, tkilic@worldbank.org.

1. Introduction

Most women farmers in the developing world practice subsistence agriculture. The adoption of a cash crop to sell in the market can offer an important route out of poverty. Yet for adoption to occur, farmers must exercise personal initiative amid a myriad of challenges that can put to the test their will to persevere.

A few however are able to break into profitable cash crop markets. This paper documents the psychological characteristics that set these high achieving women farmers apart. Specifically, we examine the effect of "strength of will" or "grit", which is generally defined as perseverance, and is also related to passion for long term goals and optimism.[1]

Why could these non-cognitive skills be useful for the adoption of a cash crop? To be profitable a cash crop typically requires large costly investments in farm labor, inputs, and specific knowledge on how to grow and sell it. Market imperfections in remote areas, such as difficult access to agricultural markets, limited supply of quality inputs, and incomplete financial markets raise the *economic* costs of these investments. However, by enhancing personal motivation non-cognitive skills reduce the non-pecuniary *psychic* costs of adoption, and thus, all else equal, raise the perceived profitability of adoption. Moreover, psychological barriers to adoption could exacerbate existing market imperfections. An environment where adversity is absent makes it less necessary for a farmer to have a high degree of perseverance, passion, and optimism.[2]

Perseverance bolsters a farmer's stamina to sustain effort and motivation in spite of a new set of risks and challenges associated with the production of a cash crop. Passion for work goals increases the ability to cope with the typically long production and marketing cycle

[1] The concept of non-cognitive skills is often seen as a psychological concept in economics. As such it does not exist in the psychological literature – from a psychological point of view what is meant here is a motivational factor that is tied to both personality and to actions.

[2] Bowles *et al.* [2001] refer to non-cognitive skills as *incentive-enhancing preferences*. If non-cognitive skills are related to preferences, then their importance in determining farm choices is related to the quality of market institutions. This follows from the standard separation result in agricultural household models [Krishna 1964].

of a cash crop, and the utility from spending the required time and effort throughout the cycle. More optimistic farmers tend to perceive the odds to be in their favor, and thus might be more willing to take the increased risk and uncertainty associated with a cash crop. These character traits can also provide the psychological aid women farmers need to challenge possible traditional gender role norms in agriculture.

We study this issue in the context of Malawi, one of the poorest countries in the world. We look specifically at the adoption of tobacco, a crop exclusively grown for selling in export markets, which accounts for 60 percent of the country's export revenue, 70 percent of which is cultivated by smallholder farmers. Despite decreasing smoking rates in rich economies and tightening tobacco regulations in developing countries, the production and marketing of tobacco remains an important source of income for rural households in Malawi, and in fact one of the major entrepreneurial options available to them.

We use the *Malawi Integrated Household Panel Survey, 2013* (IHPS) data set. For farm households, the survey included a questionnaire with items eliciting the non-cognitive skills of the managers of the farm. We use exploratory factor analysis to construct an index of non-cognitive skills capturing perseverance, combined with passion and optimism. Our working sample comprises nearly 500 farm households with valid non-cognitive skills data for both spouses and a rich set of socioeconomic and farm characteristics, which allows us to investigate the role of the non-cognitive skills of the women farmers holding constant other individual, spousal, household, farm, and community characteristics.

We show that farms managed by higher non-cognitive ability women are significantly more likely to produce tobacco. A one standard deviation increase in female non-cognitive skills is associated with a 5.4 percentage point increase in tobacco adoption, which corresponds to a one-third increase relative to the sample mean of 16 percent. This result is not explained by differences across women in education and cognitive skills. It is also not explained by the fact that higher non-cognitive ability women tend to be married to husbands of higher non-cognitive ability and education. This result holds across neighbor

households within the same community. We find no evidence that this result is stronger among women for whom we expect reverse causality to be more likely to occur.

To further support a causal interpretation, we provide suggestive evidence that the link between female non-cognitive skills and adoption is concentrated in patrilocal communities (relative to matrilocal communities), where women face greater adversity and thus where we expect the returns to such skills to be highest. We show that the amount of time she and her family allocate to the farm, the acquisition of specific knowledge on how to grow and sell tobacco, and investment in non-labor inputs account for almost half of the total effect of female non-cognitive skills on adoption.

Our paper contributes to three strands of academic literature: non-cognitive skills, technology adoption, and family economics. On non-cognitive skills, while the literature has mostly focused on labor market outcomes and social behavior in rich country or urban settings [see e.g. Bowles *et al.* 2001, Heckman *et al.* 2006, Duckworth *et al.* 2007, Borghans *et al.* 2008, Lindqvist and Vestman 2011, Blattman *et al.* 2016, Allan *et al.* 2016], our study is among the first to measure the impact of non-cognitive skills on agricultural production decisions in a rural developing setting.

A related study is Ali *et al.* [2017], who focus on the association between non-cognitive skills and the adoption of a low-risk agricultural technology (transplanting) among rice farmers in Ghana. We complement this work by examining the channels through which non-cognitive skills can affect adoption of a complex and risky cash crop in order to underpin a causal interpretation. Another related study is Laajaj and Macours [2017], who test the reliability and validity of commonly used non-cognitive skills measures (as the ones used in our paper) among farmers in Kenya. In this paper, we follow their recommendation to use exploratory factor analysis to analyze the IHPS measures of non-cognitive skills seriously.[3]

[3] Laajaj and Macours [2017] show that the latent constructs that result from an exploratory factor analysis of commonly used non-cognitive measures do not map in the non-cognitive domains typically found in rich

On technology adoption, our analysis of non-cognitive skills driving cash crop adoption pushes forward the nascent literature bridging behavioral and agricultural economics [e.g. Duflo *et al.* 2010, Liu 2013]. In doing so we also add to the literature emphasizing heterogeneity across individuals in the returns to technology adoption [Suri 2011, Zeitlin 2012]. On family economics, our finding that female non-cognitive skills matter for household adoption of a cash crop, *holding constant* her husband's non-cognitive skills, complements the literature refuting the standard model of household decision making that treats the farm household as a single unit [e.g. Udry 1996, Duflo and Udry 2004, Goldstein and Udry 2008].

The remaining of the paper is organized as follows. Section 2 discusses the IHPS data and the methodology to measure non-cognitive skills, together with the characteristics of women farmers, their families, farms and communities. Section 3 presents evidence on the impact of female non-cognitive skills on cash crop adoption, together with robustness checks and potential mechanisms. Section 4 concludes.

2. Data

2.1. Sample

The data used in this paper come from the second wave of the *Malawi Integrated Household Panel Survey* (IHPS), collected in 2013. We examine the effect of the non-cognitive skills of women farm managers on tobacco adoption. To avoid the confounding effect of marital status we focus our attention on married women. This restriction is appropriate because only a very small number of non-married women grow tobacco.

Farm households were asked to identify "who in the household makes decisions concerning crops to be planted, input usage, and timing of cropping activities?" We use the answers to this question to identify women farm managers. It is common for women to be involved in

country settings (where such measures have been validated). Moreover, they show that combining the measures according to such pre-existing scales leads to low internal consistency.

farm management decisions. This occurred for three-fourths of the farm households with married women. Almost always these women manage their farms jointly with their husbands. In fact, more than 90 percent of the women do so.

Our working sample is based on about 500 joint farm manager couples from 146 communities for whom data on non-cognitive skills are available for both spouses.[4] This sample allows us to estimate the effect of the non-cognitive skills of women farmers on the adoption of tobacco, holding constant the non-cognitive skills of their husbands. This is important in light of evidence from rich country marriage markets documenting that men and women match assortatively on personality traits [Dupuy and Galichon 2014]. In fact, in Section 3.3 we will show that in our data higher non-cognitive ability women in rural Malawi tend to be married to higher non-cognitive ability men.

2.2. Measuring Non-Cognitive Skills

The IHPS collected information on the non-cognitive skills of the farm managers. The questions were developed by entrepreneurial psychologists [see Frese and Gielnik 2014 for a review], and have been used in recent studies on microentrepreneurs in developing countries [e.g. De Mel *et al.* 2009, 2010]. We focus on 14 questions capturing mental attitudes related to perseverance in challenging tasks and environments (e.g., "I continue to work on hard projects even when others oppose me," and "I can think of many times when I persisted with work when others quit"), and the related constructs of optimism (e.g., "In uncertain times I usually expect the best") and passion for work (e.g., "I look forward

[4] Reasons for missingness may have been related to respondent unavailability at the time of the interview as well as to interviewer effort. We compared summary statistics between our working sample and the remaining households in the IHPS rural sample. We find that the communities in our sample are not randomly selected. For example, on the one hand our sample over-represents communities in which there is a tobacco club and an agricultural extension officer. On the other hand it under-represents matrilocal communities, on which there is a commercial bank or MFI. Within communities however households in our sample do not appear to be strongly selected. While we are careful to note that our inferences only apply to the population we examine, reassuringly our main estimates are qualitatively similar when weighted by the inverse of the probability of complete non-cognitive data for both spouses to systematically correct for potential sample selection bias [Wooldridge 2007].

to returning to my work when I am away from it"). All items are rated on a 5-point scale, with 1 indicating "strongly disagree" and 5 indicating "strongly agree".

There are two basic concerns with using the responses to these questions to measure non-cognitive skills. First, subjective questions are prone to measurement error [Bertrand and Mullainathan 2001, Cunha and Heckman 2008]. Second, the responses to the different questions are positively correlated with one another, which calls for their aggregation into summary measures. Following Heckman *et al.* [2013] and Laajaj and Macours [2017] we conducted an exploratory factor analysis on these questions in order to address these issues.

We considered the direction of wording and pairwise correlations between items to eliminate 3 negatively-worded items.[5] Appendix Figures A1 and A2 show the histograms of the remaining 11 items, for women and their husbands, respectively. We used the methods developed by Horn [1965] to determine the optimal number of factors among these items. Appendix Figures A3 and A4 show that only the first factor was found to have an eigenvalue substantially above one. We thus decided to consider one single factor. We then followed the rule-of-thumb of retaining items with factor loadings of at least .40. All 11 items comfortably passed this test.

Table 1 shows the 11 items and corresponding factor loadings, for women in Column 1 and their spouses in Column 2. The first six items relate to perseverance. The next five items relate to optimism and passion. These 11 items have a high degree of internal consistency (Cronbach's alpha =.78 for women, and =.80 for men). Our measure of non-cognitive skills is the average of these items weighted by their factor loadings. In order to get a more normally distributed measure, we follow the approach in Lindqvist and Vestman [2011] and transformed it into a percentile ranking, and then converted it by taking the inverse of the standard normal distribution.

[5] The 3 negatively-worded items eliminated were "I hardly ever expect things to go on my way," "I rarely count on good things happening to me," and "If something can go wrong for me, it will." The use of negatively-worded items has been under increased scrutiny in the psychometrics literature. They tend to generate artefactual factors due to inattention and confusion [Schmitt and Stults 1985, Van Sonderen *et al.* 2013]. We reached the same conclusion with our data.

2.3. Descriptive Statistics

Figure 1 shows the proportion of household farms in our working sample producing tobacco, separately for households with above and below-median female non-cognitive ability. Farms managed by high non-cognitive ability women are almost 7 percentage points more likely to produce tobacco (p-value<.05). This difference corresponds to a 43 percent increase in the likelihood of tobacco adoption relative to the sample mean of 16 percent. The remainder of the paper will try to explain what causes this difference.

2.3.1. Differences across Communities

Table 2 presents summary statistics. Column 1 reports means and standard deviations for the full working sample of 494 households. Column 2 shows the average difference and corresponding p-value on each characteristic between household farms with above and below-median non-cognitive ability women.

Panel A examines the community environment within which women operate their farms. We use information from the FAO's *Global Agro-Ecological Zones* (GAEZ) database to proxy for the agroclimatic suitability of the community for cultivating tobacco [Fischer *et al.* 2012].[6] The tobacco suitability index combines information on local climate conditions, soil and terrain characteristics, with the growing requirements of tobacco to measure whether tobacco can be grown productively in the area (on a continuous scale from 0 to 100). We see that farms managed by high non-cognitive ability women are located in communities with higher potential tobacco yields (p-value<.01).

We proxy for access to tobacco markets and farm inputs with whether a tobacco club is present in the community. Tobacco clubs provide local communities with improved access to the tobacco auction floors (where most of the tobacco produced in Malawi is sold to international buyers), as well as to farm labor, non-labor inputs, and information [Negri and Porto 2016]. Nearly 40 percent of the women operate in communities where such clubs

[6] The GAEZ project supplies global estimates of tobacco (and other crops) suitability at a spatial resolution of 5 arc minutes (approximately in grids with cells size of 9x9 km). This corresponds to an area larger than most enumeration areas ("communities"). We construct an average tobacco suitability index value derived for each enumeration area.

are present, with this figure being 8 percentage points higher among high non-cognitive ability women (p-value<.10).

In terms of access to financial services, only 12 percent of the households are located in communities where microfinance institutions (MFIs) or commercial banks are available, with higher non-cognitive ability women being 8 percentage points more likely to reside in such communities (p-value<.01). On remoteness, there are no differences between farms managed by high and low non-cognitive ability: 27 percent of the communities are accessible by a paved road, and 51 percent have a regular bus service.

In terms of gender-related sociocultural structures, 31 percent of the households in the sample come from matrilocal communities, with the remaining households coming from patrilocal communities. We see that high non-cognitive ability women are 13 percentage points more likely to come from matrilocal communities (p-value<.01).

2.3.2. Differences within Communities

The remainder of Table 2 examines whether there are observable differences between women types within the same community.[7] The differences presented in Column 2 for Panels B-E are thus conditional on community fixed effects. Panel B focuses on the characteristics of the women. High and low non-cognitive ability women have similar ages: the average woman is 37 years old. The average length of schooling is 5.2 years, with high non-cognitive ability women having an additional 1.4 years of schooling relative to low non-cognitive ability women (p-value<.01). We proxy for cognitive ability with a backward digit span recall test for short term working memory.[8] The average woman

[7] A *community* corresponds to a single village or group of villages within a given enumeration area – the level at which the IHPS community questionnaire was administered.

[8] The digit span test was implemented as follows. The enumerator starts by reading aloud two three-digit numbers to the respondent. After reading each number, the enumerator asks the respondent to repeat back the digits in reverse order. If the respondent remembers at least one of the three-digit numbers, the number of digits is then incremented by one and the testing continues, up to seven digits. The digit span test has been shown to be positively correlated with IQ [e.g. Colom *et al.* 2014].

recalls 2.5 digits, with this score being .28 digits higher for high non-cognitive ability women (p-value<.01).

Panel C shows evidence on the characteristics of the husbands. High non-cognitive ability women tend to be married to more educated husbands (1.2 years of additional schooling, p-value<.05). There is strong evidence of positive assortative mating on non-cognitive skills. Men married to above-median non-cognitive ability women are 33 percentage points more likely to have above-median non-cognitive ability themselves (p-value<.01).

Panel D focuses on characteristics of the household. High and low non-cognitive ability women have similar availability of adult farm labor. They are also equally likely to be in a polygamous relationship. We measure whether the household is liquidity constrained with a dummy for whether in the last 12 months it tried to borrow money and was turned down, or it did not attempt to borrow because it felt discouraged to do so.[9] According to this measure 54 percent of the households are liquidity constrained, and this figure is similar between high and low non-cognitive ability women.

Panel E focuses on the characteristics of the farm. The average farm has 2.1 hectares, is located 941 feet above sea level, and is exposed to 1,093 mm of yearly rainfall. We constructed an index of soil quality equal to the sum of 7 indicators for desirable soil characteristics. Farms managed by high and low non-cognitive ability women do not differ on any of these characteristics.[10]

[9] The top three most common reasons for feeling too discouraged to attempt to borrow were: "Believed would be refused", "Too expensive", and "Too much trouble for what it's worth."

[10] The measures of soil quality, terrain elevation, and rainfall were obtained from third-party geospatial data sets, which have been linked to household and plot-level data, and are public alongside the IHPS 2013 data. The variable soil quality is the sum of 7 indicator variables that equal 1 if the soil is unconstrained on nutrients' availability, retention capacity, rooting conditions, oxygen availability to roots, excess salts, toxicity, and workability.

3. Results

3.1. Main Result

We start by assessing the extent to which the correlation between female non-cognitive skills and tobacco adoption can be explained by observable differences across women, their families, farms, and communities that also drive adoption. To do so we estimate the following linear probability model using our working sample,

$$y_{ic} = \alpha\theta_{ic} + \beta W_{ic} + \gamma H_{ic} + \delta F_{ic} + \lambda_c + \epsilon_{ic}, \quad (1)$$

where y_{ic} is a dummy variable equal to 1 if farm i in community c cultivates tobacco, and 0 otherwise. θ_{ic} is the measure of non-cognitive ability for the woman managing farm i. W_{ic}, H_{ic}, and F_{ic} are vectors of woman, family, and farm level background characteristics, respectively.[11] λ_c is a community fixed effect, which allows us to isolate variation in tobacco adoption across neighboring households within the same community. This allows us to purge our estimates of community level factors that can drive adoption, such as agroecological characteristics, proximity to markets, and village institutions. The parameter of interest is α, which measures the effect size of a one standard deviation increase in woman's non-cognitive ability on the likelihood that her farm produces tobacco.

Table 3 reports the results. To ease exposition, only the coefficient of interest ($\hat{\alpha}$) and a selected set of controls are presented. Column 1 only controls for the non-cognitive skills of the woman. It shows that unconditionally a one standard deviation increase in her non-cognitive ability is associated with a 4.7 percentage point increase in the likelihood of adoption. Column 2 shows that controlling for community fixed effects does very little to change the coefficient of interest, despite increasing the R-squared to .47, from a baseline value of .02 in Column 1. This indicates that the effect of women's non-cognitive ability

[11] Woman characteristics include her age, digit span test score, and years of education. Family characteristics include her husband's age, his measure of non-cognitive skills, digit span test score, and years of education, number of adults in the household, number of children in the household, a dummy for whether the household is liquidity constrained, and a dummy for whether the household is polygamous. Farm characteristics include log of farm size, the soil quality score, log of elevation, and log of annual precipitation.

on tobacco adoption is not driven by variation across communities, but by variation within communities.

Columns 3-5 examine whether within a community the correlation between women's non-cognitive skills and adoption is explained by differences in background characteristics of the women, their families, or their farms. Column 3 shows that despite the previous evidence that women with higher non-cognitive ability tend to be more educated and have higher cognitive ability, controlling for these factors also does little to change the coefficient of interest. It is also worth noting that conditional on the woman's non-cognitive abilities these variables do not predict adoption.

Column 4 also rules out the explanation that the effect of female non-cognitive skills on adoption is due to higher non-cognitive ability women being married to more educated, higher non-cognitive ability men. In fact, accounting for such differences raises the coefficient of interest to 5.3 percentage points from 4.8 percentage points in Column 2. Conditional on her non-cognitive ability, the coefficient on his non-cognitive ability is indistinguishable from zero. The fact that conditional on both spouses' non-cognitive skills only hers matter, suggests that female non-cognitive skills help farm households overcome constraints that undermine women's motivation to engage in the production and marketing of cash crops.

Finally, our preferred specification in Columns 5 adds in farm characteristics. Farm size and tobacco adoption are highly correlated: a one percent increase in farm land size raises the likelihood of adoption by 21 percentage points. We see that the coefficient on the non-cognitive ability of women farmers is robust to the inclusion of farm characteristics. With the full set of controls a one-standard deviation increase in the non-cognitive ability of women farmers is associated with a 5.4 percentage points increase in tobacco adoption. This effect corresponds to a one-third increase in the likelihood of producing tobacco relative to the sample mean of 16 percent.

Taken together, the evidence presented in this section establishes that observable differences in women, family, farm, and community characteristics do not account for the difference in adoption between farms managed by high and low non-cognitive ability women. In order to establish causality however we also need to allay concerns related to omitted variable bias and reverse causality.

3.2. Robustness

3.2.1. Omitted Variable Bias

There are two key econometric concerns with our core result on the impact of female non-cognitive skills on adoption. The first concern is that there might be unobservable determinants of adoption that are also correlated with female non-cognitive skills. The rich set of controls used in the previous section (including farm land size and the measure of liquidity constraints) might for example fail to account for unobservable differences in wealth across households, which in turn can drive a wedge in their ability to invest and take on risk.

To address this concern, we use the method recently developed by Oster [2016] to formally test for omitted variable bias. This method allows us to estimate identified sets for the parameter of interest (α) in the presence of omitted variable bias, under the assumption that selection on observable controls is proportional to selection on unobservable controls. The test for omitted variable bias consists of whether the identified sets include zero.[12] The identified sets are reported at the bottom of Table 3. We see that throughout all specifications the identified sets never include zero, and indeed are very tightly bounded around the estimated coefficient of interest. We thus reject the explanation that the correlation between women's non-cognitive ability and adoption is driven by unobservable

[12] The computation of these bounds requires assumptions on the degree of proportionality (δ) between selection on observables and selection on unobservables, as well as on the hypothetical R-squared from a regression including all observed and unobserved control variables (R_{max}). Following Oster's [2016] recommendation, we set $\delta = 1$ and $R_{max} = 1.3R$ where R is the R-squared from equation (1) when all observables are controlled for.

heterogeneity correlated with women's non-cognitive abilities and also driving the adoption of tobacco.

3.2.2. Reverse Causality

The second econometric concern is that there can be reverse causality from tobacco adoption to female non-cognitive skills. An extensive psychology literature and emerging economics literature recognize the introspective nature of personality [Benabou and Tirole 2002]. For example, if a female farmer successfully ventures into the production of tobacco, she might become more motivated. If she fails at it however she might lose interest and develop less optimistic views about her ability to persevere and succeed. In such cases, the previously documented effect of female non-cognitive skills on adoption will overestimate the true causal impact.

To address this concern, we exploit two factors that can affect the stability of non-cognitive skills, and thus the likelihood of reverse causality, emphasized in the personality psychology literature. First, Roberts and DelVechio [2000] provide meta-analytic evidence that the stability of non-cognitive skills steadily increases with age, peaking only in late adulthood. We estimate a specification analogous to (1) and additionally interact the female non-cognitive ability measure with her age (normalized to have mean zero). If there is reverse causation between adoption and female noncogntive skills, the magnitude of the coefficient on female non-cognitive skills should be attenuated for older women, for whom personality is more likely to have stabilized. The result in Column 1 of Table 4 shows no evidence of such heterogeneity. The coefficient on the interaction term is a precisely estimated zero.

Second, Caspi and Herbener [1990] document that partner similarity in terms of personality also predicts increased personality stability. The idea is that interpersonal experiences among likes help crystalize their common personality traits. We compute the absolute value of the difference between the spouses' non-cognitive skills to construct an index of spousal personality mismatch. We then categorize couples into two groups: those above and below

the median spousal mismatch index, to estimate whether the coefficient on female non-cognitive skills is exacerbated among more mismatched couples. The results in Column 2 of Table 4 reject this hypothesis. In fact, the impact of female non-cognitive skills appears to be higher among better matched couples, although the coefficient on the interaction term is imprecisely estimated. Taken together, these results cast doubt on the explanation of reverse causality between tobacco adoption and female non-cognitive skills.

3.3. Potential Mechanisms

3.3.1. Copying with Adversity

In Malawi, there is sharp natural variation across communities in terms of gender-related sociocultural structures. Patrilocal and matrilocal communities co-exist. Women in matrilocal communities enjoy higher status and power than women in patrilocal communities. Under patrilocality, the woman moves to the village of her husband when they get married. She is thus far away from her kin and original social networks. She also has limited land ownership since the couple farms on the husband's land, and when he dies she must return to her original community [Berge *et al.* 2014].

Under matrilocality, in contrast, the man migrates to his wife's village upon marriage. They reside in the wife's family and farm her clan's land, over which she has greater control. Gender roles are more blurred in matrilocal communities, and women have greater power relative to women in patrilocal communities [Phiri 1983]. If non-cognitive skills provide the psychological aid women need to overcome adversity, then we should expect such skills to be especially important in patrilocal (relative to matrilocal) environments where women farmers face greater adversity.

We estimate a specification analogous to (1) and additionally interact the measure of female non-cognitive skills with a dummy equal to one for matrilocal communities, and zero for patrilocal communities. Since the goal is to exploit variation in the returns to female to non-cognitive ability across communities, we use region fixed effects in lieu of

community fixed effects. We also control for a vector of community level characteristics that can affect the general costs and benefits of adoption.[13]

Table 5 reports the results. Column 1 only controls for female non-cognitive skills, the matrilocality dummy, their interaction, as well as woman, family, and farm controls. It shows that that a one standard deviation increase in female non-cognitive skills raises the likelihood of adoption by 5.9 percentage points in patrilocal communities, the omitted category. In contrast, we cannot reject that female non-cognitive skills have no effect on adoption in matrilocal communities. The interaction effect is negative and statistically significant. Columns 2 and 3 show that this result is robust to controlling for region fixed effects and community level characteristics.

3.3.2. Investment in Farm Inputs

To assess the extent to which investment in farm inputs accounts for the effect of female non-cognitive skills on adoption, we re-estimate equation (1) sequentially conditioning on different farm inputs.

Table 6 reports the results. Column 1 reports the baseline specification of Column 5 of Table 3. Column 2 includes the log of total family farm labor (in hours), and a dummy for whether any non-family farm labor was used. Due to the high correlation in spousal farm labor supply we decided to pull together all family farm labor to avoid multicollinearity problems. We see that family farm labor supply is strongly correlated with tobacco adoption, and it accounts for 22 percent of the total effect of female non-cognitive ability on tobacco adoption: the coefficient on female non-cognitive ability falls to .042 from .054, significant only at the 10 percent level.

[13] Community characteristics include the log of the tobacco suitability index, log of number of households in the community, and dummies indicating the presence of a tobacco club, MFI/bank, paved road, and bus service in the community.

Column 3 includes a dummy for whether the household received advice on how to cultivate and sell tobacco.[14] This measure is highly correlated with tobacco adoption and it further reduces the coefficient of interest to .032, no longer significant. Column 4 adds in two dummies for whether the farm used fertilizer and pesticide (only 21% and 7% do so, respectively). Farms growing tobacco are significantly more likely to invest in these inputs, and controlling for that further reduces the coefficient of interest to .029. Column 5 includes the log of number of farm tools owned. This measure is insignificant and does not affect the coefficient of interest.

Overall, we find that almost half of the total effect of female non-cognitive skills on adoption can be accounted for by differences in investments in farm family labor, non-labor inputs (fertilizer and pesticides), and specific knowledge on how to grow and sell tobacco. As a corollary, these findings suggest that the *de facto* resource constraints to adoption faced by households are a function of female non-cognitive skills.

3.3.3. Intrahousehold Bargaining Power and Health

We investigate two other possible mechanisms mediating the effect of female non-cognitive skills on adoption: intrahousehold bargaining power and health status. Low bargaining power vis-à-vis her husband can limit a woman's control over how their income is spent, which in turn can reduce their monetary (and thus extrinsic) incentives to pursue high-value cash crops. It is possible that female non-cognitive skills help shape the balance of power within the household: perseverance and optimism could provide the woman with the psychological aid needed to cope with the potential conflict that can ensue during intrahousehold bargaining. If so, the mechanism driving the effect of female non-cognitive skills on adoption might not be increased (intrinsic) personal motivation, but instead increased bargaining power, that in turn, raises her expected monetary rewards from adoption.

[14] The three main sources of advice are: (i) radio (58%), (ii) government agricultural extension service (21%), and (iii) neighbor/relative (10%).

We construct a proxy for female intrahousehold bargaining power that equals the sum of two dummy variables indicating whether the woman is involved in negotiating crop sales with buyers, and whether she is able to keep or decide what to do with the resulting income. Column 6 in Table 6 includes this measure of female bargaining power.[15] This measure is insignificant and does not affect the coefficient of interest. There is thus no evidence that improved intrahousehold bargaining ability explains the effect of female non-cognitive skills on adoption.

We also explore the possibility that improved health could mediate part of the effect of female non-cognitive skills on tobacco adoption. There is evidence that non-cognitive skills positively predict health outcomes [Conti *et al.* 2010], which in turn can have a positive impact on farm productivity and profits [Strauss 1986]. Good health can be especially important in the production of tobacco given its labor-intensive nature. We proxy for health status with a dummy for whether the respondent reports to suffer from a chronic illness (8% of the women and 9% of the men in our sample do). Column 7 of Table 6 shows that controlling for both spouses' health statuses does not affect the coefficient of interest on female non-cognitive skills. Improved health therefore also does not appear to explain the advantage of higher non-cognitive ability women.

4. Conclusion

Work on labor markets and outcomes in developed countries has shown that non-cognitive skills are important for, among other outcomes, occupational choice and earnings. And some of this work [Heckman *et al.* 2006] finds that the gradient of the effect of non-cognitive skills with respect to earnings is steeper for women. We provide evidence from a rural, developing country context that is consistent with this work. Among couples in Malawi, female non-cognitive skills are significantly associated with the adoption of

[15] By definition, this measure of female bargaining power is only identified for households that sell any produce (tobacco or any other crop). About 60% of the households in our sample do so. We recode the female bargaining power measure to zero for households that do not sell any produce, and in Column 6 of Table 6 use the full sample to examine the sensitivity of the coefficient of interest to inclusion of the recoded measure, conditional on a dummy for whether the household sells any produce.

tobacco, a highly profitable crop that is exclusively produced for selling in export markets. One main channel through which these non-cognitive skills seem to work is through the use of productive inputs including higher levels of labor, fertilizer and agricultural advice services.

These findings have clear implications for agricultural growth and poverty reduction. The adoption of high value crops is critical for agricultural growth and economic growth more broadly. Non-cognitive skills seem to play an important role in adoption and in procuring the necessary inputs for success. Thus, interventions that develop these skills are likely to have significant payoffs for both household incomes and agricultural productivity.

These findings also deepen our understanding of how gender matters for household outcomes. These are households where men and women farm together. When we control for both the husband and wife's non-cognitive skills, her skills are significantly correlated with farming tobacco, while his are not. This indicates that programs seeking to increase agricultural productivity need to take into account all farmers in the household, not just the titular household head. In addition, our finding that women's non-cognitive skills matter particularly in patrilocal communities, where women are at a relative social disadvantage suggest that these skills may matter more when local and social institutions are stacked against women's empowerment. This finding that is consistent with recent evidence in developed countries documenting a greater importance of non-cognitive skills for individuals with low socioeconomic backgrounds [Carneiro *et al.* 2011, Kuhen and Melzer 2016]. Given the structure of our data as well as the structure of agricultural production in Malawi, we cannot provide definitive evidence for this, but this indicates an intriguing area for future research.

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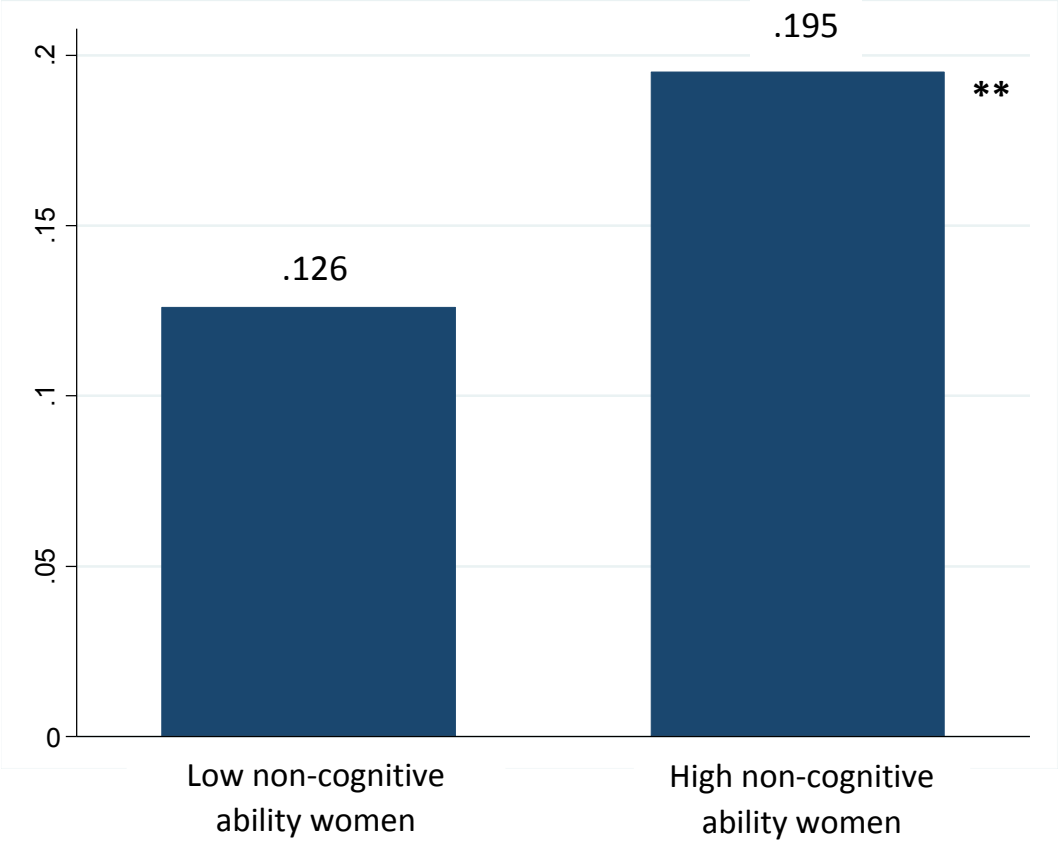
Figure 1. Percent of household farms producing tobacco



Notes: ** denotes significance at the 5% level. Low non-cognitive abiliy women refers to households mananaged by women with median or below median non-cognitive ability. High non-cognitive abiliy women refers to households managed by women with above median non-cognitive ability.

Table 1. Measuring Non-Cognitive Ability

Factor loadings of a one-factor model after direct quartimin rotation

Items	Factor loadings (1) Women	(2) Husbands
Perseverance		
I can think of many times when I persisted with work when others quit.	.561	.503
I continue to work on hard projects even when other oppose me.	.589	.519
It is important to me to do whatever I'm doing as well as I can even if it isn't popular with people around me.	.474	.487
My family and friends would say I am a very organized person.	.502	.540
I plan tasks carefully.	.478	.561
Passion		
I look forward to returning to my work when I am away from it.	.434	.505
The most important things that happens in life involve work.	.537	.545
Part of my enjoyment in doing things is improving my past performance.	.506	.578
Optimism		
In uncertain times I usually expect the best.	.460	.448
Overall I expect more good things to happen to me than bad.	.423	.529
I'm always optimistic about my future.	.473	.418

Notes: Data from 494 joint farm households. Factor loadings based on the exploratory factor analysis with direct quartimin rotation.

Table 2. Descriptive Statistics
Means, standard deviations reported in parentheses, p-values in brackets

	(1) Full sample	(2) Difference between women with above and below-median non-cognitive ability [p-value]
Panel A. Community characteristics		
Tobacco land suitability [score=1-100]	41.00	7.08
	(23.3)	[.001]
Tobacco club [yes=1]	.397	.081
	(.489)	[.066]
MFI/Commercial bank [yes=1]	.123	.077
	(.329)	[.009]
Paved road [yes=1]	.265	.036
	(.442)	[.360]
Bus service [yes=1]	.508	.020
	(.045)	[.654]
Matrilocal [yes=1]	.309	.133
	(.463)	[.001]
Panel B. Female characteristics		
Age	36.8	-.680
	(13.0)	[.688]
Years of schooling	5.18	1.36
	(3.73)	[.002]
Digit span test [score=0-7]	2.52	.278
	(1.16)	[.008]
Religion is christian [yes=1]	.893	-.045
	(.310)	[.107]
Panel C. Husband characteristics		
Age	42.9	-.321
	(14.6)	[.867]
Years of schooling	6.73	1.18
	(3.99)	[.011]
Above-median non-cognitive ability [yes=1]	.500	.326
	(.501)	[.000]
Digit span test [score=0-7]	2.90	.068
	(1.11)	[.498]
Panel D. Household characteristics		
Number of adults	3.29	.312
	(1.52)	[.107]
Number of children	2.53	-.308
	(1.58)	[.030]
Polygamous relationship [yes=1]	.089	.011
	(.285)	[.771]
Credit constrained [yes=1]	.541	.049
	(.499)	[.403]
Panel E. Farm characteristics		
Farm size [hectares]	2.10	.047
	(1.83)	[.820]
Elevation [meters]	941	-14.0
	(311)	[.191]
Annual precipitation [mm]	1,093	-.561
	(255)	[.923]
Soil quality [score=1-7]	4.81	.184
	(2.08)	[.198]
Observations	494	

Notes: The table shows summary statistics in our working sample based on 494 household farm observations. The panels relate to characteristics of the communities, the women, their husbands, households, and farms. Column 1 shows the mean of each characteristic with standard deviations reported in parentheses. Column 2 shows the difference between farms managed by women farmers with above and below-median non-cognitive ability, with the p-values obtained from an OLS regression reported in brackets. All p-values allow for robust standard errors. P-values in Panels B-E control for community fixed effects.

Table 3. Female Non-cognitive Skills and Adoption

Dependent variable =1 if household grows tobacco, =0 otherwise

OLS estimates, standard errors reported in parentheses

	(1)	(2)	(3)	(4)	(5)
Woman's non-cognitive skills	.047***	.045**	.048**	.053**	.054**
	(.015)	(.020)	(.021)	(.023)	(.023)
Woman's cognitive skills			-.001	-.003	-.002
			(.006)	(.020)	(.018)
Woman's years of education			-.000	.001	-.001
			(.006)	(.006)	(.006)
Husband's non-cognitive skills				-.014	-.011
				(.022)	(.022)
Husband's cognitive skills				-.029	-.021
				(.024)	(.023)
Husband's years of education				.003	-.000
				(.006)	(.006)
Log(farm size)					.209***
					(.049)
Community fixed effects	No	Yes	Yes	Yes	Yes
Woman controls	No	No	Yes	Yes	Yes
Family controls	No	No	No	Yes	Yes
Farm controls	No	No	No	No	Yes
R-squared	.017	.465	.466	.488	.514
Identified set for coefficient of interest: Woman's non-cognitive ability [Oster 2015]	-	[.044, .045]	[.046, .047]	[.053, .055]	[.054, .057]
Observations	494	494	494	494	494

Notes: *** denotes significance at 1% level, ** at 5% level, * at 10% level. All columns estimated by OLS, with robust standard errors in parenthesis. The dependent variable in all columns is a dummy equal to 1 if the household produces tobacco, and 0 otherwise. Community fixed effects are 145 enumeration area dummies. Woman controls include her age, digit span test score, and years of education. Family controls include her husband's age, his measure of non-cognitive skills, digit span test score, and years of education, number of adult in the household, number of children in the household, a dummy for whether the household is liquidity constrained, and a dummy for whether the household is polygamous. Farm controls include log of farm size, the soil quality score, log of elevation, and log of annual precipitation. The second to last row reports the identification bounds on the coefficient of interest on the measure of female non-cognitive skills in the presence of omitted variable bias. These are computed following Oster [2015]. For the computation of the bounds: (i) the coefficient of proportionality between selection on observables and selection on unobservables is assumed to be one, and (ii) the maximum R-squared is assumed to be 1.3 times the R-squared from the corresponding regression with the full set of control variables.

Table 4. Heterogeneous Impacts within Communities

Dependent variable =1 if household grows tobacco, =0 otherwise
OLS estimates, standard errors reported in parentheses

	(1)	(2)
Woman's non-cognitive skills	.054**	.070**
	(.023)	(.031)
Woman's non-cognitive skills X Age	.003	
	(.017)	
Woman's non-cognitive skills X Spousal mismatch		-.028
		(.037)
Woman's age	-.021	
	(.049)	
Spousal mismatch [yes=1]		-.008
		(.040)
Community fixed effects	Yes	Yes
Woman, family, farm controls	Yes	Yes
R-squared	.513	.512
Observations	494	494

Notes: *** denotes significance at 1% level, ** at 5% level, * at 10% level. All columns estimated by OLS, with robust standard errors in parenthesis. Spousal mismatch is a dummy for whether the absolute value of the difference between the spouses' non-cognitive ability measures are above median. Community fixed effects are 145 enumeration area dummies. Woman controls include her age, digit span test score, and years of education. Family controls include her husband's age, his measure of non-cognitive skills, digit span test score, and years of education, number of adult in the household, number of children in the household, a dummy for whether the household is liquidity constrained, and a dummy for whether the household is polygamous. Farm controls include log of farm size, the soil quality score, log of elevation, and log of annual precipitation.

Table 5. Heterogeneous Impacts across Communities

Dependent variable =1 if household farm grows tobacco, =0 otherwise
OLS estimates, standard errors reported in parentheses

	(1)	(2)	(3)
Woman's non-cognitive skills	.059**	.057**	.059**
	(.024)	(.025)	(.024)
Woman's non-cognitive skills X Matrilocal community	-.080**	-.077**	-.068**
	(.032)	(.034)	(.032)
Matrilocal community [yes=1]	-.072**	-.044	-.047
	(.034)	(.043)	(.042)
Woman, family, farm controls	Yes	Yes	Yes
Region fixed effects	No	Yes	Yes
Community controls	No	No	Yes
R-squared	.177	.180	.233
Observations	494	494	494

Notes: *** denotes significance at 1% level, ** at 5% level, * at 10% level. All columns estimated by OLS, with robust standard errors in parenthesis. Woman controls include her age, digit span test score, and years of education. Family controls include her husband's age, his measure of non-cognitive skills, digit span test score, and years of education, number of adult in the household, number of children in the household, a dummy for whether the household is liquidity constrained, and a dummy for whether the household is polygamous. Farm controls include log of farm size, the soil quality score, log of elevation, and log of annual precipitation. Region fixed effects are 3 dummies for North, Center, and South. Community controls includes the log of the tobacco suitability index, log of number of households, and dummies denoting the presence of a tobacco club, MFI/bank, paved road, and bus service in the community.

Table 6. Accounting for the Effect of Female Non-Cognitive Skills on Adoption

Dependent variable =1 if household farm grows tobacco, =0 otherwise

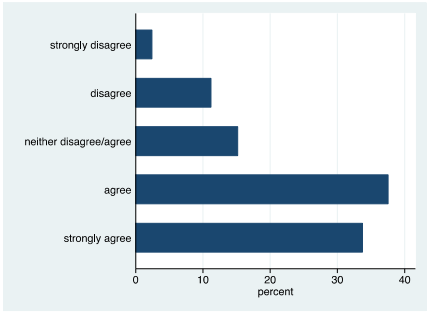
OLS estimates, standard errors reported in parentheses

	Baseline (1)	Farm labor (2)	Information (3)	Non-labor inputs (4)	Farm tools (5)	Bargaining power (6)	Health (7)
Woman's non-cognitive skills	.054**	.042*	.032	.029	.029	.028	.031
	(.023)	(.022)	(.022)	(.022)	(.022)	(.022)	(.022)
Log(Total family labor in hours)		.098***	.093***	.096***	.096***	.077***	.077***
		(.022)	(.021)	(.021)	(.021)	(.021)	(.022)
Non-family farm labor [yes=1]		-.013	-.029	-.046	-.046	-.037	-.036
		(.041)	(.041)	(.041)	(.041)	(.040)	(.041)
Advice grow/sell tobacco [yes=1]			.144***	.144***	.002	.155***	.159***
			(.048)	(.048)	(.034)	(.048)	(.048)
Fertilizer [yes=1]				.159***	.159***	.147***	.148***
				(.048)	(.046)	(.045)	(.045)
Pesticide [yes=1]				.202***	.201***	.181**	.183**
				(.073)	(.074)	(.075)	(.073)
Log(Number of farm tools)					.000	-.014	-.016
					(.004)	(.035)	(.035)
Farm sells produce [yes=1]						.156***	.156**
						(.048)	(.062)
Female bargaining power						-.032	-.031
						(.033)	(.033)
Woman has chronic illness [yes=1]							-.042
							(.060)
Husband has chronic illness [yes=1]							-.075
							(.054)
Community fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Woman, family, farm controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.514	.551	.566	.585	.599	.611	.610
Observations	494	494	494	494	494	494	494

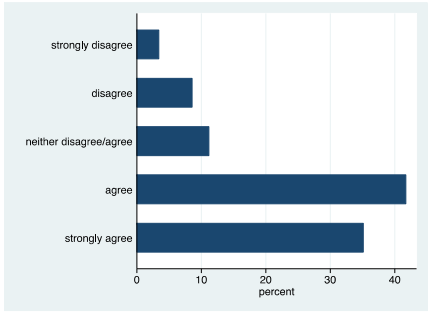
Notes: *** denotes significance at 1% level, ** at 5% level, * at 10% level. All columns estimated by OLS, with robust standard errors in parenthesis. Community fixed effects are 145 enumeration area dummies. Woman controls include her age, digit span test score, and years of education. Family controls include her husband's age, his measure of non-cognitive skills, digit span test score, and years of education, number of adult in the household, number of children in the household, a dummy for whether the household is liquidity constrained, and a dummy for whether the household is polygamous. Farm controls include log of farm size, the soil quality score, log of elevation, and log of annual precipitation.

Figure A1. Histograms of Items Related to Perseverance, Optimism, and Passion: Women

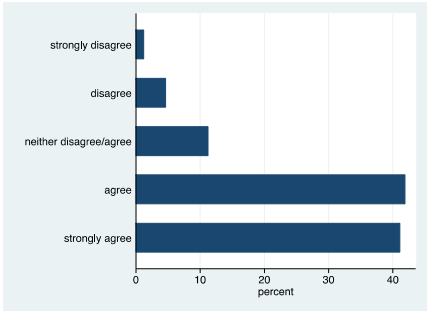
"I can think of many times when I persisted with work when others quit."



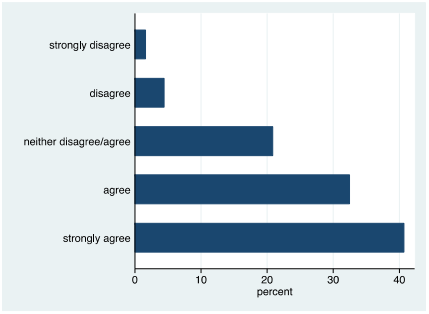
"I continue to work on hard projects even when other oppose me."



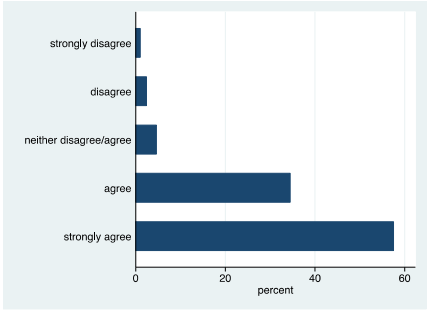
"It is important for me to do whatever I'm doing as well as I can even if it isn't popular with people around me."



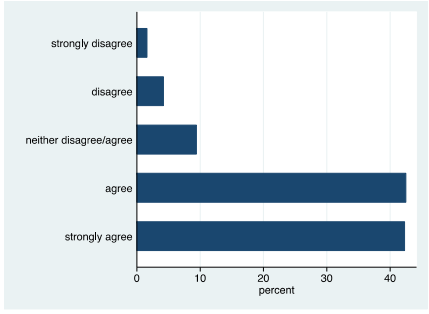
"My family and friends would say I am a very organized person."



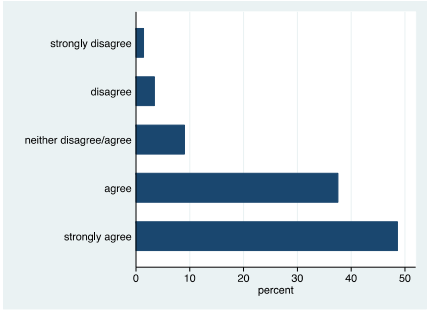
"I plan tasks carefully"



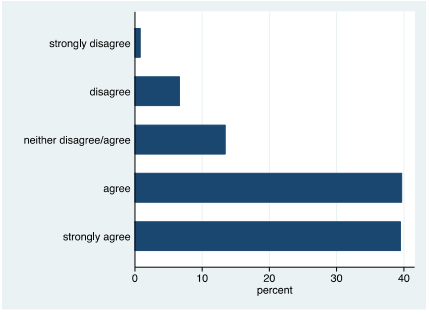
"Overall I expect more good things to happen to me than bad"



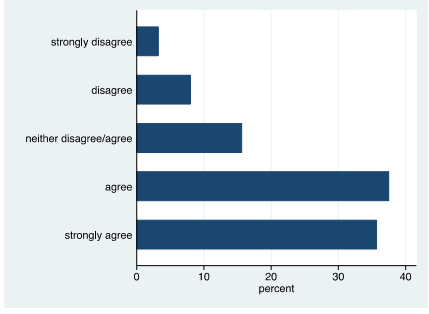
"I'm always optimistic about my future"



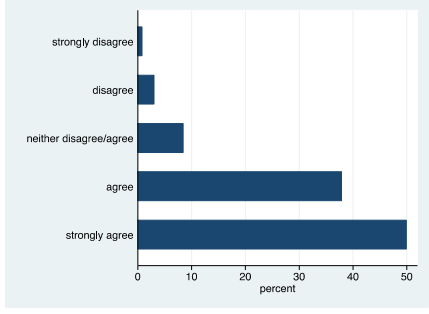
"In uncertain times I usually expect the best."



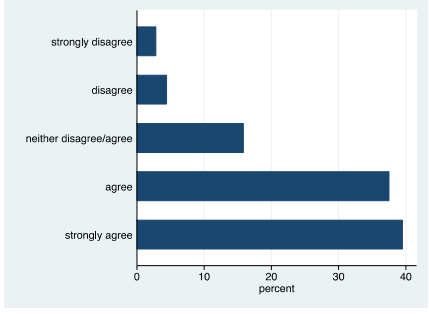
"I look forward to returning to my work when I am away from work."



"The most important things that happens in life involves work"



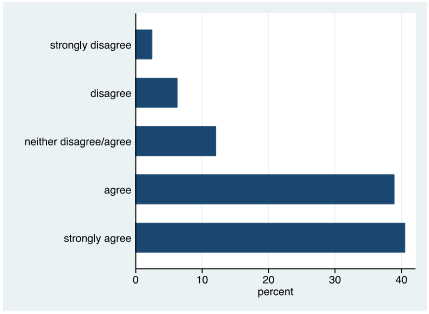
"Part of my enjoyment in doing things is improving my past performance"



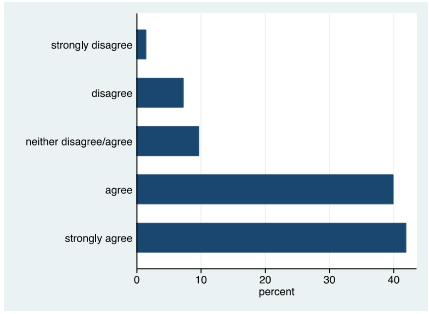
Notes. Data from 494 joint farm manager couples.

Figure A2. Histograms of Items Related to Perseverance, Optimism, and Passion: Men

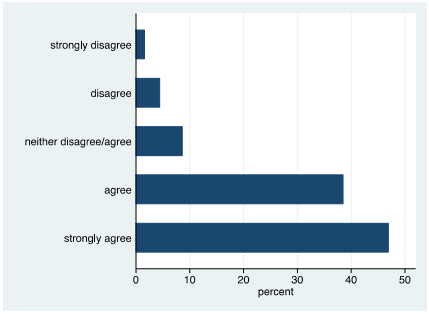
"I can think of many times when I persisted with work when others quit."



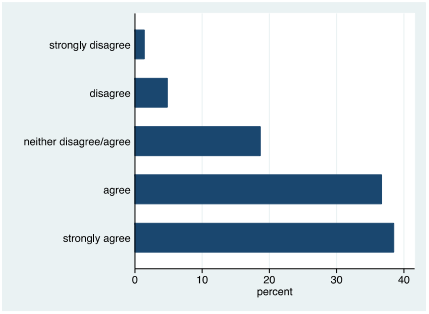
"I continue to work on hard projects even when other oppose me."



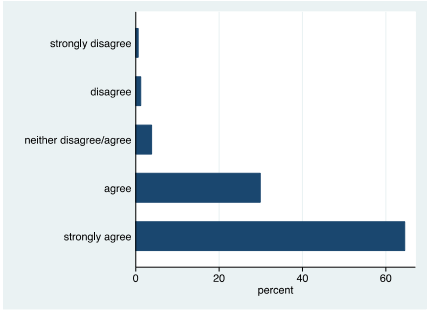
"It is important for me to do whatever I'm doing as well as I can even if it isn't popular with people around me."



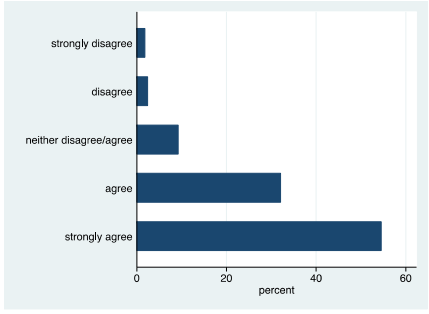
"My family and friends would say I am a very organized person."



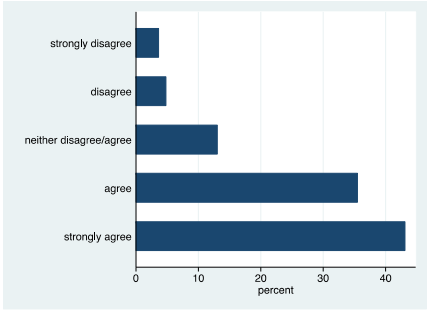
"I plan tasks carefully"



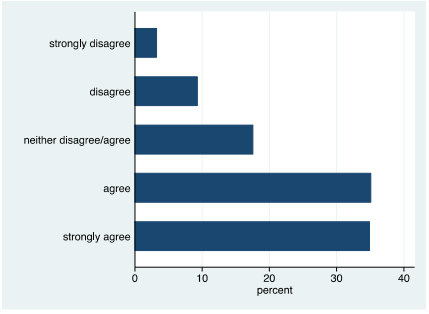
"Overall I expect more good things to happen to me than bad"



"I'm always optimistic about my future"



"In uncertain times I usually expect the best."



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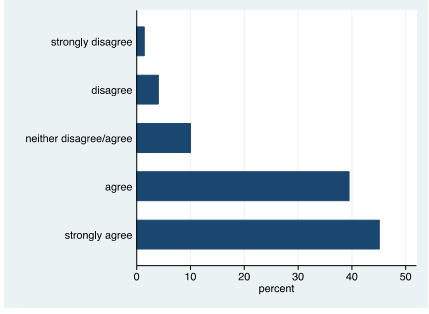

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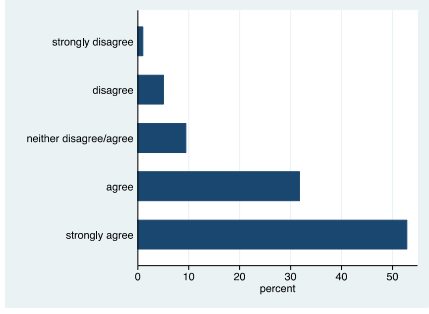
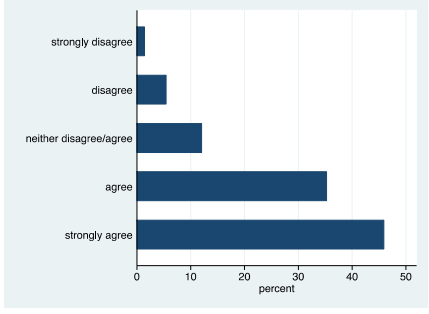
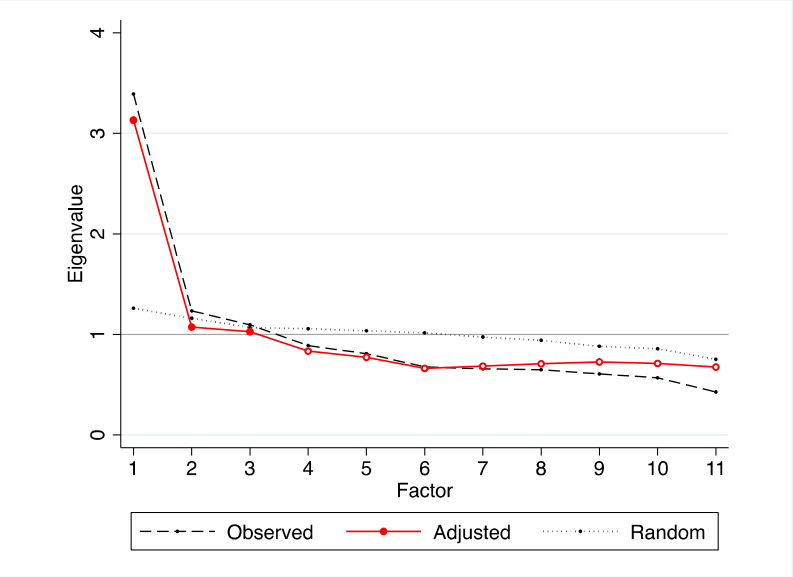


"Part of my enjoyment in doing things is improving my past performance"



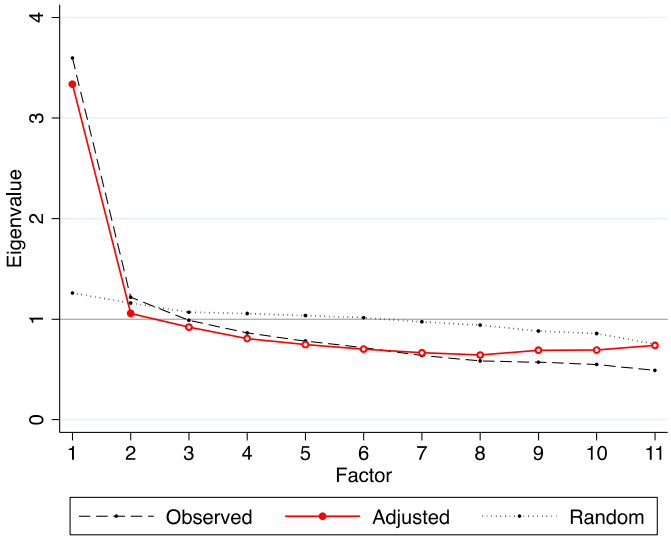
Notes. Data from 494 joint farm manager couples.

Figure A3. Number of Factors: Women
Eigenvalues from Horn's [1965] Parallel Analysis



Notes: Eigenvalues adjusted for sampling error were computed using 5,000 randomly generated datasets with the 11 items and 494 observations each. They correspond to the 95th percentile eigenvalues from the random data.

Figure A4. Number of Factors: Men
Eigenvalues from Horn's [1965] Parallel Analysis



Notes: Eigenvalues adjusted for sampling error were computed using 5,000 randomly generated datasets with the 11 items and 494 observations each. They correspond to the 95th percentile eigenvalues from the random data.