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Math skills and market and non-market outcomes: Evidence from an Amazonian society of forager-farmers

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ABSTRACT

Research in industrial nations suggests that formal math skills are associated with improvements in market and non-market outcomes. But do these associations also hold in a highly autarkic setting with a limited formal labor market? We examined this question using observational annual panel data (2008 and 2009) from 1121 adults in a native Amazonian society of forager-farmers in Bolivia (Tsimane'). Formal math skills were associated with an increase in wealth in durable market goods and in total wealth between data collection rounds, and with improved indicators of own reported perceived stress and child health. These associations did not vary significantly by people's Spanish skills or proximity to town. We conclude that the positive association between math skills and market and non-market outcomes extends beyond industrial nations to even highly autarkic settings.

1. Introduction

Economists have long highlighted the importance of individual skills in labor market outcomes, and there is abundant evidence of the increasing importance of cognitive skills in the labor market of industrial countries (Ishikawa & Ryan, 2002; Murnane, Willett, & Levy, 1995). However, much less is known about the importance of cognitive skills in developing nations (Glewwe, 2002). While there is some evidence that culturally appropriate math pedagogy improves math skills acquisition, increases in math skills in non-western settings have rarely been examined for their relation with personal and community outcomes (Nasir, Hand, & Taylor, 2008). Human capital theory suggests that cognitive skills increase labor productivity, and therefore income and wealth. If cognitive skills are associated with important outcomes in industrial and developing nations, investments to develop cognitive skills might well be a policy priority.

In comparison to what we know about the importance of school attainment or cognitive skills like reading or writing, less is known about the importance of formal math skills, particularly in rural societies of developing nations. Estimates in industrial nations suggest that individuals with better math skills receive higher earnings (McIntosh & Vignoles, 2001; Murnane et al., 1995). Here,

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we examine whether the relation of formal math skills with market and non-market outcomes found in industrial nations also hold in a rural setting with a limited formal labor market.

We address two questions: Are formal math skills associated with market (income and wealth) and non-market (nutrition and health) outcomes in a highly autarkic rural society? Are these associations larger as people gain a stronger foothold in the market economy? We address these questions using annual panel data collected in 2008 and 2009 from 1121 adults in a native Amazonian society of forager-farmers in Bolivia, the Tsimane'. We measured formal math skill by scores on tests that required people to use computational skills. We find that math skills are positively associated with the value of durable market goods and total wealth. Math skills are also associated with better indicators of own and child reported health among the Tsimane'. Our results suggest there is no differential association for math skills in relation to fluency in Spanish (Bolivia's national language) or to village proximity to towns or roads.

Our findings have several strengths. First, because there is very limited or no formal job market for Tsimane' workers, we could rule out the association of math skills and economic outcomes from solely having a diploma as opposed to having skills. Second, common confounders such as ethnic or cultural heterogeneity, school type, or residential segregation, are absent among the small-scale, relatively homogenous, and egalitarian Tsimane' society. Third, we used a relatively large sample of adults compared with the sample sizes used in previous related studies in developing nations. Fourth, we used instrumental variables to reduce measurement error.

2. Background and expectations

2.1. Math skills in developing countries

Taken together, previous research in developing countries points to a positive association between math skills and market and non-market outcomes, but the evidence draws for the most part on small cross-sectional samples of formally employed urban workers, and focuses mainly on market outcomes. For example, Glewwe (1996) studied 389 workers in Ghana (1988–1989) and found that an increase of one point in math skills improved wages in the public sector by 2.3–2.8%, but not in the private-sector. Also in Ghana, Jolliffe (1998) found that an increase of one standard deviation in mean and maximum household math score resulted in 8.6% and 4.9% higher household off-farm income, but had no effect on farm income ($n = 1388$). Vijverberg (1999) found no effects of math skills on self-employment in Ghana. Using data from urban and rural workers in South Africa ($n = 133$; collected 1993), Moll (1998) found that each extra point in math test scores resulted in 21–30% higher wages; the wage elasticity of math skills was 0.4. Aslam, Bari, and Kingdon (2012) analyzed the returns to math skills in urban and rural Pakistan ($n = 4907$; collected 2006–2007). They found (weak) evidence that, among men, math skills increased the probability of having a lucrative occupation, and reduced the likelihood of female unemployment (only after reaching a threshold of 4.8 and 5.6 out of 12 points in a math test). Using data from Pakistan (1998–1999 and 2000–2001), Kingdon and Söderbom (2008) found that math skills were associated with an increase in a male worker's probability of being self-employed (~2.8% increase for young men and ~6.7% for older men), a decrease in the chances of being out of the labor force (~2.8% decrease for young men and ~4.5% for older men), and higher agricultural earnings. Last, Boissiere, Knight, and Sabot (1985) examined data from primary and high-school graduates in Kenya ($n = 205$) and Tanzania ($n = 179$), and found significant returns to literacy and math (~1.3–1.7%, and 0.8–1.2% increase in pre-tax earnings in Kenya and Tanzania).

Godoy, Karlan, Rabindran, and Huanca (2005) estimated earning functions in a comparative study of four foraging-horticultural societies in the Bolivian lowlands (Tsimane', Yuracaré, Mojeño, and Chiquitano). Formal math skills bore no association with wages, imputed farm income, or total personal income (imputed + monetary), but did bear a significant positive association with monetary income among the sub-sample of participants ($n = 244$) who reported monetary earnings. A one-point improvement in math score (range: 0–4) was associated with a 13.5% increase in monetary earnings ($p = 0.03$). The study found no significant interaction effects between math skills and town propinquity, with the exception of higher imputed farm income.

Last, research in developing countries suggests a positive association between math skills and health outcomes (Grigorenko, Jarvin, Kaani, Kapungulya, Kwiatkowski, & Sternberg, 2007). Other studies have shown an association between mother's math skills and child health, possibly because math skills facilitate mothers' ability to acquire health knowledge on their own (Glewwe, 1999; Glewwe & Desai, 1999).

2.2. Math skills among the Tsimane'

The Tsimane' live in the tropical rain forest of the department of Beni, Bolivia. Recent estimates suggest that they number about 12,000 people living in approximately 100 villages of at least eight households (typically around 20 households), with about 6 people per household. Subsistence centers on farming and foraging. Contact with the outside is limited to the sporadic sale of local goods and to occasional work as rural laborers in cattle ranches or logging camps. Tsimane' society is relatively egalitarian, and displays much sharing and reciprocity. Mean daily monetary income per capita (wages + sales) reaches only about US$0.96 (2008–2009).

Most Tsimane' villages have schools covering the first five grades and, since 2005, a few larger villages have built middle schools. School attendance is in practice voluntary, and classes have traditionally been taught in Tsimane'; Spanish is taught as a second language. Tsimane' (and other native Amazonians in Bolivia) might be gaining math and other cognitive skills owing to the recent implementation of government programs, including adult schooling (e.g., *Yo sí puedo; Centros de Educación Técnico-Humanística*