



Original Article

The political economy of technology adoption: The case of Saharan salt mining

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ABSTRACT

Innovation is an important driver of economic growth and competitive advantage. A diverse literature in economics and management addresses a variety of questions about how to manage associated technological change. This paper explores the “opposite” question: Namely, what explains the absence of change? We apply existing theories of non-adoption to our case study, salt mining in the Sahara Desert, in order to generate new insights into barriers to technology adoption. We find that political organization establishes an environment for the formation of higher-order economic organizations, which in turn affect the direction and rate of technology adoption. Our setting seems exotic, but traditional methods of production persist in myriad impoverished settings, including those containing widespread artisanal and small-scale mining (ASM) activity. The study thus sheds light on the role of institutions in economic growth.

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1. Introduction

Technological innovation is an important driver of economic growth and competitive advantage. There is now a diverse literature that spans contexts and levels of analysis to examine the adoption of technology. This literature includes work explaining the timing and pattern of adoption of agricultural innovations by individual farmers (Griliches, 1957), and of manufactured goods (Rogers, 2003; Gort and Klepper, 1982; Klepper, 1996). However, at times, technologies are slow to be adopted, prompting explanations such as the “appropriateness” of technology in different economies (Basu and Weil, 1998; Acemoglu and Zilibotti, 2001) and cognitive obstacles to adoption. In this paper, we extend this latter line of inquiry to investigate the persistence of traditional technologies over the long term, despite the existence of more advanced technology.

Our setting is salt mining in the Taoudenni region of the Sahara Desert, which by most accounts has remained largely unchanged since at least the 14th century, and possibly as far back as the fifth century B.C. Located in northern Mali, the Taoudenni salt mine is the largest in the Sahara, and has been described throughout history, including accounts by Ibn Battuta in 1353, and Herodotus who mentioned salt mining in *Histories*. Salt is extracted using hand tools and, until recently, was transported by camel caravan to market towns on the edge of the desert. However, elsewhere, the history of salt production has been characterized by profound organizational and technological change, including large-scale production organized by the church in medieval Europe (Multhauf, 1978) and the rise of Midwestern firms in 19th century America (Roy, 1997). Why, then, is Saharan salt extracted by traditional technology when, everywhere else, technology has changed?

One concern about such an exotic setting is whether findings are generalizable. We would argue that Saharan salt mining is but one example of persistent traditional technology. Basu and Weil (1998) observe that crops are still harvested by sickle in India, and ASM, which occurs throughout Africa, Asia, and Latin America, is defined as “labour-intensive, low-tech mineral exploration and processing activities” (Hilson, 2011). A burgeoning literature explores why this arduous and informal activity is so widespread

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(Perks, 2011). We ask why it remains predominantly artisanal and low-tech.¹

To explore this question, we use a research design that tests candidate explanations against the facts on the ground. The theories are drawn from the economics and management literature and the factual details come from original ethnographic research (Gilberthorpe, 2013) on the economy and society of Taoudenni salt miners and the market towns of the salt trade.² Candidate theories include technological “appropriateness” given relative prices and worker skill, network effects of roads for wheeled transport, legal origins that could affect investment, and cognitive barriers to adapting to change. Explanations are organized into three categories: (1) theories that explain the choice of production technology, (2) theories that explain the choice of transportation technology, and (3) theories that explain “extinction”, or why technologies cease to be used.

To illustrate our research design, consider a theory on the role of specialized intermediaries in technological diffusion. Rosenberg (1963) argues that intermediaries spread information and provide expertise, and are thus necessary agents of technological diffusion. But in our case, we find that worker specialization occurs, and so we can reject Rosenberg’s theory that an absence of intermediaries explains persistence of traditional methods.

Applying this method, we reject quite a number of theories, and find that the most relevant literature is that which focuses on organization and hierarchy. For example, the small-scale mining operations of Taoudenni, and ASM more generally, are peculiar given the large-scale organization of salt production even historically, in medieval Europe and 19th century U.S. Several areas of research suggest that political organization is related to economic organization in complex ways. First, the history of the corporation indicates that this relationship may involve learning or unobserved heterogeneity, as corporations were originally created for political purposes, to form cities (Kuran, 2003, 2010; Lipartito, 2004), and subsequently used for commercial purposes, in this case for salt production. Second, high-quality political institutions seem to facilitate an increase in firm size. Libecap (1978) details the case of Nevada, where early mining practices closely resemble our salt mining context. California mining financiers helped to organize Nevada into a U.S. Territory, which, among other changes, transformed the legal framework from scattered, autonomously formed “mining district codes” to federal law (Clay and Wright, 2005). Large capital investments were made and, in a short period of time, ASM was replaced by some of the largest firms in the country (Hannah, 2008).

We examine additional interactions between political and economic organizations. Importantly, we find that commercial corporations do not form where political corporations have not formed: foreign mining corporations operating in sub-Saharan Africa, therefore, have not “replaced” ASM. Instead, ASM persists alongside foreign-owned large-scale mining operations (Dondyene et al., 2009; Van Alstine and Afonis, 2013; Geenen, 2014). Such organizational shortcomings, both political and economic, contrast

starkly with the relatively smooth functioning of markets in our setting. Product markets are reliable, with stable prices and quality standards; debt contracts are used regularly; and workers specialize, becoming, *inter alia*, blacksmiths at the mine, and mechanics who accompany trucks with tools and spare parts in tow (Scheele, 2012). Markets for technology also appear to function, as satellite phones and GPS make truck journeys safer.

Our findings, though derived from a specific, even extreme, case, move the focus away from a search for market failure and instead draw attention to the relationship between political and economic institutions and their role in catalyzing technological change and economic growth. The analysis also raises new questions for future research, such as: *Why* are some societies organized politically in a way that promotes economic organization while others are not? and *Why* is the incorporation of municipalities for political purposes a precondition for the formation of hierarchical firms?

2. Case study: the Taoudenni salt trade

Journalist Michael Benanav’s 2006 account of his journey to the Taoudenni salt mines describes a 40-day trek with two experienced salt miners—cousins, who served as his guides across a stark and featureless landscape of shifting sand (Benanav, 2006). The trip begins with one cousin and a handful of camels; the other cousin is met several days later at one of the wells that dot the route across the desert. Not only are the cousins able to find each other sight unseen on either side of a large sand dune, but the navigation from one well to the next is repeated daily without the benefit of stars (they travel during the day) or GPS navigation.

While Benanav (2006) provides a valuable first-hand account, Rombe-Shulman’s extensive ethnographic fieldwork provides a wealth of perspectives, including findings from 70 in-depth interviews with salt merchants, transporters, miners, and consumers. As part of a “participant observation” method common to anthropological research, Rombe-Shulman lived among her subjects in a rented house, and hired three assistants to help identify interviewees and conduct (and translate for) the in-depth interviews using a comprehensive list of open-ended questions. Together they also conducted dozens of shorter interviews. Details about the mine and mining practices are drawn from these interviews.

The mine itself is a former seabed where high quality salt is carved out of the ground in rectangular slabs using simple tools. Several layers of lower-quality salt must be gone through to reach the pure white salt for which Taoudenni is known. Historically, all of the lower grades of salt have also been extracted in slabs and traded as well, except *wara*, the top-most layer of salt, which must be removed to reach the lower, more valuable layers. Because it is so hard, *wara* is laborious and time-consuming to remove and typically involves the cooperation of other miners (Rombe-Shulman, 2013; Clauzel, 1960). However, it serves as a good building material for constructing the mine and shelter structures. Thus, the otherwise ubiquitous corrugated iron, used to make “tin roofs” throughout Africa (Edgerton, 2006, p. 41) is not used here. It is now also sold, the only type in rock form rather than slab form.

The size and shape of the slabs are consistent with early descriptions and have practical origins. Specifically, camels can carry two 35-kg slabs on each side (150 lb per side). The standard size and shape of slabs facilitate transactions, historically and presently, because salt was and continues to be a form of currency. According to lore, salt was traded for gold—and worth its weight in that precious metal—and is still sold in the same market towns as in ancient times, including Timbuktu

¹ The literature identifies many reasons for the persistence of ASM. The low skill required makes ASM possible for most able-bodied workers. Moreover, it argues that earnings are more consistent than farming (Hilson, 2010; Bryceson and Jonsson, 2010) and that mine work is complementary to agriculture, which is typically undertaken seasonally (Kamlongera, 2011; Okoh and Hilson, 2011). In some cases, mine income is used for capital and human capital investments (Hilson and Garforth, 2013; Hilson and van Bockstael, 2012; Maconachie, 2011).

² Rombe-Shulman’s immersion into the Taoudenni salt industry began with a six-week examination of Timbuktu in mid-June to early August of 2006. A more lengthy residence began there in November 2008 and concluded in February 2010, and included time spent in the major market towns of Bamako and Mopti, as well as Bobo-Dioulasso, the second largest city in Burkina Faso, and formerly home to prominent salt trading families. Bobo-Dioulasso still serves as a trade and transportation hub for salt.

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