



The Adoption of Paper in the Middle East, 700-1300 AD

Maya Shatzmiller
The University of Western Ontario
maya@uwo.ca

Abstract

The adoption of paper in the Middle East changed literacy practices and improved economic performance, yet current accounts remain unhelpful for understanding why and how it happened. This paper offers a new analysis of the long-term factors behind the adoption of paper in the Middle East, combining insights from economic theory, economic history and evidence from quantitative studies. The paper establishes a long-term trend in the price of writing material and books in the Middle East, and suggests an explanation based on economic factors which led to a decline in the price of inputs in paper production.

Keywords

economic change – purchasing power – agrarian shift

Introduction

It is hard to exaggerate the significance of writing material to human civilization and literacy. Ancient societies in the Near East invented writing systems, including the alphabet, but used an array of writing surfaces which limited the diffusion of knowledge. These were potsherds, clay tables, bricks, stone and wood as writing surfaces: materials that were not easily transported, mass-produced or made to circulate. Awkward writing materials limited the scope of functional literacy, hindered the development of languages, reading

and writing skills, knowledge acquisition and efficient information storage. They hindered and delayed the dissemination scholarly explorations, technical innovations and inhibit skill development of the service professions. Papyrus and parchment, widely used in the Middle East, were easier to write on and to move around, but remained limited due to the scarcity of the raw material and the high manufacturing costs. The invention of paper in China in the second century BC added another writing surface which was easier to carry around, although it does not seem to have changed literacy rates in China, or lower the cost of production. The adoption of paper in the 8th century in the Middle East replaced papyrus and parchment with a product at least as good to write on while easier to produce which resulted in long-term social and economic change before it spread to Europe, centuries later. This 'Arab' or 'Islamic paper' as it came to be known facilitated the extensive use of documents and books, and helped in the standardization of the Arabic language, and the transition from oral to written culture. It promoted a rise in literacy rates, enabled the efficient storing and dissemination of complex systems of knowledge, and improved human capital formation. The use of paper documents in long-distance trade, in court administration and government bureaucracies reduced transaction costs, and increased efficiency and contract enforcement.

Despite the important role played by the adoption of paper in the Middle East, a proper analysis of how and why it was adopted is still missing. Existing accounts consist of synchronizing events, notably the transmission of Chinese papermaking techniques to the Middle East through Chinese prisoners and the decision to replace papyrus with paper by the Abbasid administration in Baghdad.¹ These accounts explain little. True, the existence of a 'want', namely the inadequacy of papyrus and parchment to supply growing demand for writing material, was doubtless a driving force behind the adoption of paper; however, it does not fully explain how an 'alternative product'

* The author wishes to thank Şevket Pamuk, Boğaziçi University, and Joseph Berechman, CUNY, for valuable comments on earlier versions, and four anonymous *JESHO* reviewers. I also thank Amar Jayaram for excellent research work.

¹ For accounts of the introduction of paper see J. von Karabacek, *Arab Paper*, tr. D. Baker and S. Dittmar (London: Archetype Publications, 2001); H. Loveday, *Islamic Paper. A study of the ancient craft* (London: Archetype publications, 2001); J. Bloom, *Paper before Print: The History and Impact of Paper in the Islamic World* (New Haven and London: Yale University Press, 2001); F. Richard, "The Writing Surface: Paper." In *Islamic Codicology* (London: Al-Furqan Islamic Heritage Foundation, 2006): 49-63.

came into existence. Moreover, the chronology suggested by this account is unlikely. A sizable paper industry, capable of supplying the needs of the administration and the reading public, could not have come into existence during the few years separating the decision taken by the Abbasid Caliph Harūn al-Rashīd and his death in 809 AD, when the transition to paper was supposedly completed.² Monopolies on papyrus production and forced sales to the Caliphs' administration indicate attempts to secure supply, but there is no empirical evidence that a major transformation in paper production followed.³ The complex set of factors and mechanisms required for a massive production, such as allocation of resources, manufacturing techniques, empire wide distribution networks, with short and long distance supply lines bringing raw material and product to markets, did not exist in these early stages. Even if we concede that papyrus-making techniques could have been adjusted to produce paper, there is simply no evidence that such was the case. A precise chronology as to when these infra-structures came into existence remain elusive.

This paper offers a different approach to the study of the adoption of paper in the Middle East, by combining insights from economic theory, economic history and analysis of statistical evidence.

1 Methodology and Data

An introduction to the methodology used here may be useful. Treatment of numerical evidence in statistical manipulations allows economic historians of pre-modern societies to investigate critical questions in economic history such as what was the historical rate of economic growth, or what were the standards of living in the societies they study and compare the results with those of other contemporary societies.⁴ A recent study of prices, wages and

² A. Grohmann, *From the world of Arabic papyri* (Cairo: Maaref press, 1952): 39-42; W. M. Malczykcki, "The Papyrus Industry in the early Islamic era." *Journal of the Economic and Social History of the Orient* 54 (2011): 189-194 and Appendix 1.

³ Loveday, *Paper*: 21.

⁴ M. Shatzmiller, "New Initiative: Medieval Islamic Economic Quantitative Data Collection in a Global Setting." *Al-Usur Al-Wusta. Bulletin of Middle East Medievalists* 21 (2009): 2-4. (Published in 2013); ead., "The Economic History of the Medieval Middle East: Strengths, Weaknesses and the Challenges Ahead." *International Journal of Middle Eastern Studies* 44(2012): 529-531; M. Shatzmiller, "Economic Performance and Econom-

purchasing power in the medieval Middle East from the 8th to the 15th century demonstrate the usefulness of collecting and exploiting numerical data.⁵ In this case price and wage data was retrieved from the Arabic sources and used to build a consumer price index and calculate purchasing power by correlating wages and prices of consumer goods. By compiling prices of single units of certain basic food items, linen cloth and rent, it was possible to estimate a subsistence level for medieval Muslims in Iraq and Egypt. By collecting data on wages, it was then possible to determine the income level needed to pay for it. Once subsistence level was established and the incomes generated, a clear idea of the income levels in the Middle East emerged for the first time. It was shown that the purchasing power of unskilled wages ranged between 2 to 3 times the subsistence level for most of the medieval period, suggesting that Middle Eastern incomes were high. When compared to the results of similar studies based on numerical data from Mesopotamia,⁶ Rome, Byzantium,⁷ and medieval Europe,⁸ it transpired that medieval Muslims enjoyed higher standards of living than their contemporaries.⁹ Another significant outcome of the wage data study was estimates of GDP, the first available for early Islamic societies.

As the benefits of numerical studies became more obvious, and following the pioneering work by Eliyahu Ashtor,¹⁰ a new database was compiled by myself and a team of research assistants.¹¹ It includes commodity prices, wag-

ic Growth in the Early Islamic World." *Journal of the Economic and Social History of the Orient* 54 (2011): 132-184.

⁵ Ş. Pamuk and M. Shatzmiller, "Plagues, Wages, and Economic Change in the Islamic Middle East, 700-1500." *Journal of Economic History* 74(2014): 198.

⁶ P. Földvári and B. van Leeuwen, "Comparing Per Capita Income in the Hellenistic World: The Case of Mesopotamia." *Review of Income and Wealth* 58 (2012): 550-68.

⁷ B. Milanovic, "An Estimate of Average Income and Inequality in Byzantium Around the Year 1000." *Review of Income and Wealth* 53 (2006): 449-70.

⁸ J. Goldstone, "Efflorescences and Economic Growth in World History: Rethinking the 'Rise of the West' and the Industrial Revolution." *Journal of World History* 13 (2002): 323-89; K. G. Persson and P. Sharp, *An Economic History of Europe. Knowledge, Institutions and Growth, 600 to the Present*. 2nd edition. (Cambridge: Cambridge University Press, 2015); D. C. North, *Structure and Change in Economic History* (New York and London: Norton & Co., 1981).

⁹ J. Bolt and J. L. van Zanden, "The Maddison Project: Collaborative Research on Historical National Accounts." *English Historical Review* 67 (2014): 627-51.

¹⁰ E. Ashtor. *Histoire des prix et des salaires dans l'Orient médiéval* (Paris: SEVPEN, 1969).

¹¹ Available on line <http://medievalislamicconomy.uwo.ca/>.

es and cost of living, national income accounting, coins and money, and weights and measures. It may be possible to construct such database from papyri documents of the early Arabic administration as papyrologists are continuously deciphering and publishing new material.¹²

Another new and important source of quantitative data used here is provided by the collection of Judeo-Arabic documents dating from the years between the 11th to the 13th centuries Egypt, referred to as the *Genizah*.¹³ The 350,000 *Genizah* documents, almost all on paper, originated in a specific segment of Middle Eastern population, the Jews of Fustāt-Cairo. The data they contain were used judiciously in studies of economic theory and will continue to provide data to be used in economic history.¹⁴ The project of putting the entire collection online continues, and their treasures of numerical data will soon be deployed.¹⁵ The statistical data used here is derived from all three sources mentioned above, while a comprehensive bibliography of studies on the Arab paper may be found in Bloom's *Paper Before Print*, or in the edited volume *Islamic Codicology*.

¹² <http://www.apd.gwi.uni-muenchen.de:8080/apd/project.jsp>

¹³ <http://cudl.lib.cam.ac.uk/collections/genizah/>; Bloom, *Paper*, 75.

¹⁴ On the importance of the *Genizah* documents to the study of institutions, see A. Greif, "Reputation and Coalition in Medieval Trade: Evidence on the Maghribi Traders." *The Journal of Economic History* 49 (1989): 857-82; A. Grief, "Contract Enforceability and Economic Institutions in Early Trade: The Maghribi Traders' Coalition." *The American Economic Review* 83 (1993): 525-48; A. L. Udovitch, "Reflections on the Institutions of Credits and Banking in the Medieval Near East." *Studia Islamica* 41 (1975): 5-22; P. I. Ackerman-Lieberman, *The Business of Identity* (Stanford: Stanford University Press, 2014). On the importance of the documents to economic history see S. D. Goitein, *A Mediterranean Society. The Jewish communities of the Arab world as portrayed in the documents of the Cairo Geniza*. Vol. 1, *Economic foundations* (Berkeley and Los Angeles: University of California Press, 1967); J. C. Garcin, "Le JESHO et la recherche sur l'histoire économique et sociale des pays musulmans." *Journal of the Economic and Social History of the Orient* 36 (1993): 139-53; K. Hopkins, "Taxes and trade in the Roman Empire (200 BC-AD 400)." *The Journal of Roman Studies* 70 (1980): 103, note 10. Ashtor, *Prix et salaires*: 10-11; J. Goldberg, *Trade and Institutions in the Medieval Mediterranean* (Cambridge: Cambridge University Press, 2012).

¹⁵ The Cambridge collection holds probably two-thirds of the world's *Genizah* items, about 200,000 pieces. Personal communication of Dr. Ben Outhwaite, director of the Taylor-Shechter collection, Cambridge University. The confusion about the size of the *Genizah* documents may be due to counting them differently, for instance, folios versus separate pieces, shelf marks versus folios, images versus pieces, etc.

The paper unfolds in four sections. In the first section we begin by asking: how 'expensive' was writing material, and who could afford it? No prices for paper in single sheets or rolls are available, but we establish the long-term trends in the price of ninth-century papyrus, the most common writing material in use. Next, we compare the average price of papyrus to the purchasing power of unskilled wages. The results suggest that while papyrus was indeed expensive, wages of unskilled and professional workers were sufficiently high to acquire it. In the second section, we proceed by calculating the average price of books, using a sizeable database of book prices, all written on paper, available from the *Genizah* documents, and again compare them to the purchasing power of wages. The results suggest that books became 'cheaper': book prices declined precipitously between the 11th and the 12th century, and modestly between the 12th and the 13th century. The average cost of a book was 2,80 dinars in 11th-century Egypt, 0.87 dinars in the 12th century and 0.52 dinars in the 13th century. When compared to daily wages, the decline in the price of books meant that an unskilled worker had to work 41 days in the 11th century to purchase a book, 14 days in the 12th century and 8 days in the 13th century.

In the third and fourth sections, we examine the causes for the changes we observed, and develop a chronological trajectory of paper adoption, production and consumption. We begin by analyzing changes in the structures of demand and link them to the evidence on the rise in wages and elasticity of demand. An early change in cultivation patterns in favor of textile plants suggests reduction in the demand for wheat in response to population decline and satisfying demand for fine clothes instead. In the next phase of macroeconomic change, a rise in productivity in the agrarian and manufacturing sectors led to commercialization of the economy in the 11th century. With it, the infrastructures of papermaking and the cost of inputs equally changed. The increase in flax cultivation, the rising productivity of the textile industry and the commercialization of the economy increased supply of paper's raw material without increasing the price of linen waste. (It is important to remind the reader at this point that Arab paper was made exclusively of linen rags, a byproduct of flax.) With increased movement along the trade routes, paper manufacturing techniques could be theoretically even diffused free of charge in the form of written manuals. The use of water power as a cheap energy source lowered further the cost of inputs of paper production. In the presence of evidence of growing demand for paper and books across the Middle East and the spread of their use, one might have expected the price of paper and books to rise. In fact, however, this did not happen. Instead, as we have shown, there is evidence of a decline in the price of

books. We advance that the reason was a drop in the costs associated with papermaking itself. Not only did it compensate for the effect of the rise of demand on prices, it also drove up the number of producers.

2 The Price of Writing Material and Purchasing Power in the Middle East

The calculation of an average price of writing material presents several challenges. While papyrus, paper and parchment were used side by side during the introductory period of the 8th-10th centuries, only papyrus prices were available, and only for the 9th century.¹⁶

Table 1 presents 14 papyrus prices from 9th-century Egypt and one observation from the 8th, for good measure. The numbers were gathered from Ashtor, *Prix et salaires*,¹⁷ and from Malczykcki, "The papyrus industry,"¹⁸ where we find prices collected by Von Karabacek and Grohmann from the papyri documents. Price observations in documents which come from orders of shipments of papyrus reflect prices more correctly while the prices cited by chroniclers often give prices in years when they are very high or very low. Since the silver content of the dirham changed frequently, and information of the exchange rate between dinar and dirham and the gold content of the dinar are more reliable, prices used in this paper were converted to dinars. The ratio of the dinar/dirham fluctuated during the 9th century in Egypt: Von Karabacek and Ashtor used 1:12 and Grohmann 1:24.¹⁹

¹⁶ In C. Roberts and T. C. Skeat, *The Birth of the Codex* (London: Oxford University Press, 1983), the authors wrote: "...attempts to establish the price of papyri during the Roman period were futile. "...the question is unanswerable and meaningless because there are no comparative prices for parchment", 7.

¹⁷ Ashtor, *Prix*: 60-61 (Iraq); 89-9 (Egypt).

¹⁸ Malczykcki, "The Papyrus Industry."

¹⁹ *Ibid.*: 190-191.

TABLE 1 *Papyrus prices in 9th century Egypt**(Dinar per Qirtās roll)*

Period	Size	Price in quote	Source
<i>8th Century</i>	Roll	0.25 Dinars	Ashtor (p. 89)
<i>9th Century</i>	Roll	0.25 Dinars	Karabacek (p. 10)
	Roll	1.50 Dinars	Malczycki (p.190) PER inv. AR.P.1714
	Roll	1.04 Dinars	Malczycki (p.193) P IV 1783
	Roll	0.25 Dinars	Malczycki (p.190) 709/P. World p.135-6, 1.3
	Roll	0.25 Dinars	Malczycki (p.190) 709/P. World p.135-6, 1.2
	Roll	0.25 Dinars	Malczycki (p.190) 2332
	Roll	0.25 Dinars	Malczycki (p.190) 9013
	Roll	0.19 Dinars	Malczycki (p.193) Inv. AR.P.1198
	Roll	7/48 Dinars	Malczycki (p.190) 707
	Roll	0.125 Dinars	Malczycki (p.192) p.146/PERF 826
	Roll	0.13 Dinars	Ashtor (p. 89)
	Roll	0.06 Dinars	Malczycki (p.193) Inv. Ar. P. 6954
	Roll	0.03 Dinars	Malczycki (p.193) P III/2 Inc. 237
	<i>Tumr</i>	1/8 Dinar minus 1/4 qirat	Ashtor (p. 89)

SOURCES: IN THE TABLE.

Further complicating the calculations is the fact that papyrus was sold in Iraq and Egypt in 3 1/2 loose leaves in *tūmār*, pl. *tawāmīr*, or a roll, a *qirtās*, consisting of 6 *tūmārs* of 21 separate sheets each. It was decided to proceed with the most common unit of papyrus, the roll, *Qirtās*.²⁰ The one price observation for paper dating from Egypt suggests that paper was sold not in rolls, but either one sheet at a time or in small bundles. Ashtor suggested quantities

²⁰ Ashtor, *Prix*: 89.

ranging from thirty to a hundred sheets in a bundle sold in both regions.²¹ We have no clear idea of paper prices before the 11th century when they become available through the *Genizah* documents, where prices are given for paper bundles not for a single sheet. The size of the bundle remains unclear.²² The price list presented in Table 1 suggests that the price of 0.25 dinars per roll, *Qirtās*, is most frequently cited and is adopted here as the average price of writing material.

We may now compare the average price of papyrus to those of basic food items and cloth, goods which together made a 'subsistence basket', and compare them to the purchasing power of wages.²³ Table 2 presents the average price of basic goods, a papyrus roll and unskilled wages for two benchmark years, 820 and 850, in Fustāt, Egypt.

TABLE 2 *Average wages and prices in Egypt during the 9th century*

Period	Unskilled Wage	Wheat	Beans	Meat	Olive Oil	Linen	Papyrus
	<i>Dinars/ Month</i>	<i>Dinars/Kilogram</i>				<i>Dinars/ Meter</i>	<i>Dinars/ Qirtas</i>
<i>Fustāt</i>							
820	0.75	0.0031	0.0048	0.036	0.03	0.05	0.25
850	1.2	0.004	0.0062	0.04	0.044	0.06	0.25

SOURCE: PAMUK AND SHATZMILLER, "PLAGUES, WAGES," TABLE 2 P. 202.

The results suggest that the cost of papyrus in this period was not trivial. It was much higher than one unit of wheat, beans, meat, olive oil and linen. For instance, one roll of papyrus cost the same as 81 kg of wheat, 52 kg of beans and 7 kg of meat. If we now use the daily wage of unskilled worker to measure his purchasing power we can say that his daily wage could buy twice, sometimes three times, the amount of the basic goods needed for subsistence. As a result, he needed to pay the equivalent of 5 to 8 days' wages to purchase one *Qirtās*, roll of papyrus.

Who would then consume writing material at this price? Papyrus was in-

²¹ Ibid.: 60-61, 89-90; Bloom, *Paper*: 79.

²² Goitein, *Mediterranean Society*: 81, to be discussed below.

²³ Pamuk and Shatzmiller, "Plagues,": 201-208, for discussion of the methodology used in estimate purchasing power of wages and subsistence level commodities. Calculations for Egypt and Iraq in Table 2, Figure 1 and Figure 2, show the results.

deed expensive but demand for it must have been strong since its price remained high. Government was certainly a customer. The number of surviving official papyri documents indicate that papyrus was regularly used by the administration, and more regularly than paper and parchment in the general population. 'Professionals' certainly had enough money to purchase papyrus. Wages paid to the 'skilled' workers were higher than those paid to unskilled workers, though our data is limited only to Iraq.²⁴ Wages of teachers and other skilled professionals there were particularly high. They ranged between 10 dirhams for teaching a course to 200 dinars a month, and salaries of administrators, doctors, religious scholars, translators, were even higher. A 'doctor to the caliph' commanded an average wage around 18.116 dinars/day, while a 'top level scientist' average wage was 14.493 dinars/day. Another 'doctor to the caliph' commanded an average wage in the range of 53.9 dinars/day, as did a 'supreme judge', whose average wage was 17.3 dinars/day, and a 'top level astronomer', whose average wage was 670.6 dinars/day. In addition to these extraordinary wages, which had to be omitted in the calculations of averages, some 25 skilled wage observations were available for Iraq. Presented in Table 3 they provide an average of 0.34 dinars a day for the 8th century, 1.32 for the 9th century and 0.99 for the 10th century.

TABLE 3 *Daily wages of skilled and unskilled labour, Egypt and Iraq, 8th-10th centuries*

(In gold dinars)

Time Period	Iraq – Skilled (Professionals)	Iraq – Unskilled	Egypt – Unskilled
8th Century	0.34	0.0073	0.02
9th Century	1.32	0.02	0.03
10th Century	0.99	0.05	0.05

SOURCES: <http://medievalislamicconomy.uwo.ca/>.

The evidence of high wages paid to professionals as well as those paid to unskilled workers, together with other indicators, such as consumption of fancy cloths and foods, paint a picture of a high-income environment which drove demand for luxury consumption. The long-term presence of high incomes stimulated a shift in consumers' tastes from one for basic goods to one for

²⁴ All wage observations of professionals are derived from Ashtor, *Prix*: 67-70.

luxury high-end items. While writing material may have been considered a fancy item, it was not alone. A whole slew of luxury goods was available for consumption in 9th-century Baghdad. It included imported spices, precious stones, fancy foods, exotic animals, fine clothing, dishes cooked with new ingredients, slave girls from every corner of the world and more. This was a new environment where high wages kept demand for writing material high, and contributed to the maintenance of its elevated price. At the same time, the pressure of consistent demand and high prices also drove the search for an alternative product. A transition to paper was under way.

3 The Decline in the Price of Books

By the beginning of the 11th century the first evidence of a major shift in papermaking becomes apparent. The *Genizah* letters speak of 28 ‘camel loads’ of one kind of paper sent to Egypt from Syria, together with 20 bales of a second kind and 10 bales of yet a third. Another shipment from Egypt to Tunis was valued at 250 dinars and included 5,000 sheets of thin paper and 1,000 sheets of ‘*talhi*’ paper.²⁵ While no numbers of single paper sheets are reported in the sources, we do find prices for single-book volumes. Indeed, the image of enormous quantities of paper sheets dispatched in ‘camel loads’ is matched by evidence on an increased number of books written on paper. Ibn al-Nadīm, a 10th-century bibliographer, for example, compiled a list of contemporary books, scripts, and regional makes of paper and inks.²⁶

Book prices are practically absent from our early sources, but by the 11th century they appear in large numbers: from the *Genizah* documents we find 45 book prices for the 11th century, 50 for the 12th and 74 for the 13th century.²⁷ The books in question belonged to Jewish owners, though were not all on Jewish subjects, nor were they written exclusively in Hebrew. Historians of the Jewish book confirm that development in book production followed

²⁵ Goitein, *Mediterranean Society*: 80-1 and note 2; M. Gil, *Texts from the Cairo Genizah*, vol. 2. (Tel Aviv: Tel Aviv University, 1997): 459-62.

²⁶ B. Dodge, ed. and tr. *The Fihrist of al-Nadim: A Tenth-Century Survey of Muslim Culture*. vol. 2. (New York: Columbia University Press, 1970). Unfortunately, he neglected to give book prices.

²⁷ N. Allony, *The Jewish Library in the Middle Ages—Book Lists from the Cairo Genizah* (Jerusalem: Hebrew University of Jerusalem, 2006).

closely that of Islamic/Arabic books.²⁸ Indeed, the Jews of Egypt switched to paper by the 10th century in everything but the Torah scrolls which remained on parchment,²⁹ and the records show that the earliest Hebrew book manuscript on paper was dated 1005.³⁰ Their books were written on locally produced paper or paper imported from another region, were in the shape of the codex, frequently bound in leather and could contain any number of volumes and large or small number of pages. The books found in the *Genizah* records were locally transcribed or imported as a finished product, whether a single title or a multi-volume set. Their prices were recorded in inventories of booksellers and scribes, records of estates and auctions. Books were of material or emotional value to their owners and were considered an asset, a valuable property. They were given as collateral, inventoried in lists and catalogues, listed per title, author, location and date of entry. In general, books were certainly holders of value but not exceptionally so.

TABLE 4 *Average prices of books in daily wages, Egypt, 11th-13th centuries*

(In gold dinars)

Time Period	Price of One Volume	Average Daily Wage for Unskilled Urban Worker	Days of Work to Buy One Volume	Number of Book Prices Used
11th Century	2.80	0.06	41	45
12th Century	0.87	0.06	14	50
13th Century	0.52	0.06	8	74

SOURCES: <http://medievalislamicconomy.uwo.ca/>.

Table 4 presents the results of calculations of average book price per century based on the *Genizah* book prices, placed next to an average daily wage of unskilled worker. The fourth column in Table 4 shows the number of days

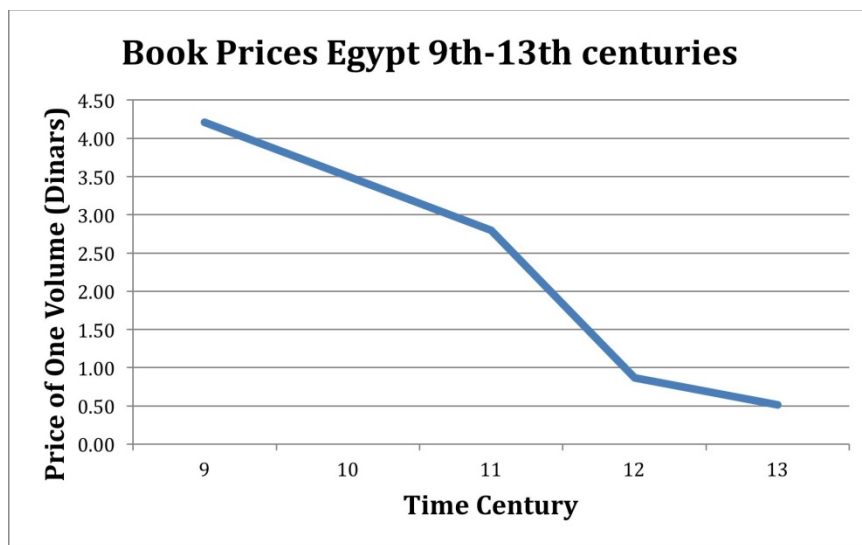
²⁸ R. Drory, *The emergence of the Jewish-Arabic literacy contacts at the beginning of the tenth century* (Tel Aviv: The Porter Institute for Poetics & Semiotics, Tel Aviv University, 1988).

²⁹ M. Haran, "Bible Scrolls in Eastern and Western Jewish Communities from Qumran to the High Middle Ages." *Hebrew Union College Annual* 36 (1985): 21-62.

³⁰ M. Beit-Arié, "The Oriental Arabic paper." *Gazette du livre médiéval* 28 (1996): 10. I thank Professor G. Hegedus for drawing my attention to this article.

needed to purchase a book when calculated in daily wages. Thus, an average book price was 2,80 dinars in 11th-century Egypt, 0.87 dinars in the 12th century and 0.52 dinars in the 13th century. An unskilled worker had to work 41 days to purchase a book in the 11th century, 14 days in the 12th century and only 8 days in the 13th century. Graph 1 displays the dynamics of the decline: book prices declined sharply between the 11th and the 12th century, and more moderately between the 12th and the 13th century.

GRAPH 1 *The decline in book prices, Egypt, 9th-13th centuries.*



SOURCES: <http://medievalislamicconomy.uwo.ca/>.

4 Population Decline and the Transition from Wheat to Flax

We begin with the assumption that changes in the cost of paper inputs brought down the cost of papermaking, chief among them, the cost of paper's raw material, the linen rags.

Arab paper was made from an exclusive material referred to by paper specialists as an 'Arab mix', different from a 'Chinese mix'. The exclusivity of the Arab mix was determined as early as the 19th century by the Viennese schol-

ars Wiesner,³¹ and Von Karabacek.³² Wiesner, a chemist, was able to perform the first chemical examination of Arab paper using documents of which 90 percent dated between 950-1050 and came from the Fayyum in Egypt.³³ He concluded that the documents he examined were written exclusively on paper made largely of flax fibers from linen rags,³⁴ “instead of bast fiber.”³⁵ This was an observation whose significance somehow escaped the attention of those interested in the origins of Arab paper. The ingredients of the Chinese mix paper were hemp, mulberry tree bark, raw fibers, pulp of bamboo and rosewood, and silk, as well as some rags.³⁶ This blend was shared by all pre-Islamic and early Islamic paper found in various locations throughout China, Korea, India, Central Asia, and the Dunhuang caves on the Silk Roads, as well as in the former Sogdian lands.³⁷ By the 7th century the Chinese introduced a new process to papermaking which allowed them to use pure bast fiber, an ingredient which could be made only in regions where mulberry plants were available. When submitted to microscopic examination, the early Arabic documents written between 721-722 and the 780s, recently uncovered in Tajikistan, revealed a Chinese rather than an Arab mix.

*The choice of fiber material of pure mulberry fibers and the technology used in sheet formation to create layers of crossing fibers document that Chinese paper was available through export and that this paper was used as a writing material for the Arabic manuscript.*³⁸

³¹ J. Wiesner, "Mikroskopische Untersuchung der Papiere von El-Faijûm " (Microscopic Examination of the Faijûm Papers). Originally published in *Mittheilungen aus der Sammlung der Papyrus Erzherzog Rainer*, Wien, 1887. Translated into English by Gudrun Aurand. Ed. with an introduction by Jack C. Thompson (Fenwick: Caber Press, 1986).

³² Von Karabacek, *Arab Paper*: 1-7: 14-18.

³³ Bloom, *Paper*: 74.

³⁴ *Ibid.*: 11: 74.

³⁵ *Ibid.*: 12.

³⁶ *Ibid.*: 29-45. Enough samples of Chinese paper from before and after the date that the Middle East survive to indicate that Muslim papermakers did not produce Chinese mix paper.

³⁷ *Ibid.*: 41-42.

³⁸ H. Ofir, M. Shenkar and S. Kurbanov, "The Earliest Arabic manuscripts written on paper: Three letters from Sanjar-Shah (Tajikistan)." *Jerusalem Studies in Arabic and Islam* 43 (2016): 215.

Even though paper was available to Muslims for some time, either imported or stored and used in Arabic documents, production could not have increased because of the lack of raw material. As becomes clear from the Mugh mountain Arabic documents, not even the presence of water, mills and Chinese papermaking techniques in Samarqand were sufficient for an increase in paper production levels.³⁹ Furthermore, there is no evidence that paper industry sprung up in Iraq, either in the 8th or the 9th century. There is a mention of a Baghdadi paper mill in AD 795 and there is a mention that the Abbasid Caliph al-Mu^ctasim, 833-842, attempted to cultivate the papyrus plant and to manufacture papyrus in 9th century Samarra.⁴⁰ These references should be considered as indications that shortages of writing material continued to plague the administration, not of an expansion of paper manufacturing. The 8th-century Arabic documents from Afghanistan were written on parchment,⁴¹ and 9th-century documents retrieved from Samarra include 2 papyri and 4 written on paper.⁴² Bloom suggests that paper was already cheaper than papyrus by the mid-ninth century in Egypt, but that it was still not cheap enough and was saved for 're-use.'⁴³ The first bookmaking manual, by al-Rāzī, dates from the 9th century, and refers to three kinds of writing material—papyrus, parchment and paper.⁴⁴

By the 10th century the references to flax and linen rags in paper making begin to multiply. Al-Biruni, 973-1048, referred to the "the pounding of flax for paper," and not to bast.⁴⁵ A refuse heap dug up in Fustāt near the paper-making spot was revealed to comprise 95% of linen rags of various quality.⁴⁶ Chinese paper could theoretically still be imported and used in book making,

³⁹ Ofir et al. "The Earliest," 214-215. The difference between the Chinese mix and the Arab mix and its significance for understanding the adoption of paper is explained below.

⁴⁰ Bloom, *Paper*: 27; Loveday, *Paper*: 22.

⁴¹ G. Khan, *Arabic Documents* (London: Nour Foundation, 2007). Parchment was preferred in legal documents related to property, taxes and legal issues and thus may have been the case here.

⁴² M. Van Berkel, "Reconstructing Archival Practices in Abbasid Baghdad." *Journal of Abbasid Studies* 1 (2014): 9.

⁴³ Bloom, *Paper*: 48: 79.

⁴⁴ M. Zaki, "Early Arabic Bookmaking Techniques as Described by al-Rāzī in His Recently Discovered *Zinat al-Katabah*." *Journal of Islamic Manuscripts* 2 (2011): 223-234. Al-Rāzī d. in 313/925. References are to removing ink stains from all.

⁴⁵ Bloom, *Paper*: 56 (on the side panel.)

⁴⁶ *Ibid.*: 76-77.

but, as Bloom determined, “Chinese paper was made from fibers entirely different from those used in Islamic papers shows them to have been made predominantly of rag fibers, with the occasional admixture of raw fibers”.⁴⁷

How did the transition to linen rags in paper making occur, and in what circumstances? Meyerson and Bloom suggested that there was a link between Arab papermaking and an agricultural shift from wheat to flax, but left it at that.⁴⁸ As for parchment, it took hundreds of years to replace papyrus in codex making and there is no evidence that there was an attempt to use it for daily transactions.⁴⁹ Instead, the roots of the change were to be found in a structural shift in the agrarian sector from intensive grain cultivation to textile plants, which emerged in response to demand for alternative textiles. To illustrate the shift, we begin with the examination of wheat prices and compare them to those of flax.

TABLE 5 *Average prices of wheat, Egypt and Iraq, 8th-12th centuries*

(Per kg, in gold dinars)

Time Period	Egypt	Iraq
8th Century	0.0021	0.0009
9th Century	0.0036	0.0029
10th Century	0.0082	0.0103
11th Century	0.0143	0.0079
12th Century	0.0143	0.0083

SOURCES: PAMUK AND SHATZMILLER, “PLAGUES,” P. 202, TABLE 2.

<http://medievalislamicconomy.uwo.ca/>.

Table 5 shows that average prices of wheat were low in 8th-10th-century Iraq and Egypt but that they rose in the 11th and 12th centuries. The reason for the lows during the first three centuries of Islamic rule may be attributed to little demand triggered by population decline following the Justinian plague of

⁴⁷ Ibid.: 8-11: 45; 56-57: 70; 71-74.

⁴⁸ P. Mayerson, “The Role of Flax in Roman and Fatimid Egypt.” *Journal of Near Eastern Studies* 56(1997): 201-7.

⁴⁹ Roberts and Skeat, *The Birth*: 5-10, on the prices of parchment and papyrus in antiquity.

541.⁵⁰ Given the debate raging currently over the severity of the population decline and rate of devastation, we cite in support of major population decline evidence from archeological surveys of settlements in rural and urban Iraq and in Egypt.

The main archeological study of settlement in Iraq remains that by Adams which has shown that agricultural lands in the Sawād, east of the Tigris River, which were densely settled in the Sasanid period, contracted sharply when faced by Muslims after the conquest in the mid 7th century.⁵¹ The pattern was repeated in Egypt. Only 4 out of the 16 cities previously occupied between the 4th and the 7th centuries remained settled, while the rest were either abandoned or exhibited signs of decline.⁵² The incoming Muslim administration in the 8th century tried unsuccessfully to settle Arab tribes on the abandoned land, and forced fugitives to return to their villages and assume land tenure.⁵³ Low demand for wheat in Egypt was exacerbated by an end to the wheat shipments to Constantinople probably due to population decline in the Byzantine Empire as well.⁵⁴ The return of the plague in the 7th and 8th centuries prevented the population from recovering so that the downward pressure on wheat prices continued.⁵⁵ However, while decrease in population size resulted in labour shortages, it also resulted in high wages paid for urban labour. The rising income levels launched a shift in consumer preferences. Prices of agricultural commodities plummeted in relationship to manufactured goods, as demand for basic foods declined. Demand for expensive and fine garments rose, stimulating textile plants cultivation and the extension of the textile industry.

⁵⁰ L. K. Little, ed. *Plague and the End of Antiquity* (Cambridge: Cambridge University Press, 2007); Pamuk and Shatzmiller, "Plagues, Wages"

⁵¹ R. McC. Adams, *Land Behind Baghdad: A History of the Settlement on the Diyala Plains* (Chicago and London: The University of Chicago Press, 1965): 97-102.

⁵² R. Alston, "Urban Population in Late Roman Egypt and the End of the Ancient World." In *Debating Roman Demography*, ed. Walter Scheidel (Leiden: Brill, 2001): 169, Table 2.

⁵³ G. Frantz-Murphy, "Land-Tenure in Egypt in the First Five Centuries of Islamic Rule (Seventh-Twelfth Centuries AD). In *Agriculture in Egypt: From Pharaonic to Modern Times*, ed. Alan K. Bowman and Eugene Rogan (Oxford: Oxford University Press, 1999): 237-66.

⁵⁴ J. L. Teall, "The Grain Supply of the Byzantine Empire, 330-1025." *Dumbarton Oaks Papers* 13 (1959): 87-139.

⁵⁵ C. McEvedy and R. Jones, *Atlas of World Population History* (New York: Penguin Books, 1980): 151: 226.

The changes in the agrarian sector related to the introduction of new plants were first suggested by Andrew Watson.⁵⁶ Short of demonstrating conclusively that the new plants were responsible for the rise in agricultural productivity, Watson's short book was thought-provoking and innovative. Authors of recent studies of 'agricultural revolutions' eventually substantiated his thesis without acknowledging it. Two studies on specific textile plants, cotton and flax, illustrated the change in a regional specific context. Richard Bulliet studied the expansion of cotton cultivation in Iran/Iraq,⁵⁷ and Gladys Frantz-Murphy flax cultivation in Egypt.⁵⁸

Unlike flax, Old World cotton was a newly introduced plant and its cultivation expanded in Iraq/Iran in the 9th century, facilitated by *qanat* irrigation, a technique used in the region for tapping underground water using vertical shafts.⁵⁹ By the 9th century cotton was commercially grown in Iran/Iraq in sufficient quantities to satisfy demand for the new fibers and for the fine cottons manufactured in Baghdad.⁶⁰ Cotton did not play any role in paper making, its fibers produced a soft surface which absorbed the ink and was unsuitable for writing—but its story is relevant here for the similarities it offers to that of flax.⁶¹ Flax was already cultivated in Egypt when the Muslims arrived, but cultivation and production have soon begun on industrial scale. Egypt's new masters, the Tūlūnids, led a slow conversion of fields from wheat to flax, improved the irrigation system and invested the tax money they col-

⁵⁶ A. M. Watson, *Agricultural Innovation in the Early Islamic World*. (Cambridge, UK: Cambridge University Press, 1983): 31-42.

⁵⁷ R. Bulliet, *Islam: The View from the Edge* (New York: Columbia University Press, 1994): 67-79 and Bulliet, *Cotton, Climate, and Camels* (New York: Columbia University Press, 2009).

⁵⁸ G. Frantz, *Saving and Investment in Medieval Egypt* (Ann Arbor, MI: PhD dissertation, University of Michigan, 1978); G. Frantz-Murphy, "A New Interpretation of the Economic History of Medieval Egypt: The Role of the Textile Industry." *Journal of the Economic and Social History of the Orient* 24 (1981): 254-567; 868-1171; Mayerson, "The Role".

⁵⁹ Watson, *Agricultural*: 31-42.

⁶⁰ H. J. Cohen, "The Economic Background and the Secular Occupations of Muslim Jurisprudents and Traditionalists in the Classical Period of Islam (until the Middle of the Eleventh Century)." *Journal of the Economic and Social History of the Orient* 13 (1970): 16-61; M. Shatzmiller, *Labor in the Medieval Islamic World* (Leiden: Brill, 1994): 118-123; 240-249.

⁶¹ See the elaborate discussion devoted to the 'myth of cotton paper' Von Karabacek, *The Arab Paper*: 36-41 and Bloom, *Paper*: 56-57.

lected locally instead of sending it to Baghdad.⁶² Commercial linen weaving expanded in the countryside, contributing to the development in urban centers in the Fayyum.⁶³

Both cotton cultivation in Iran/Iraq and flax cultivation in Egypt occurred in response to the same economic mechanism of supply and demand, and both illustrate the economic transition in agriculture in the Middle East. Facilitating the transition was a change in political elites. The fragmentation of the Abbasid Empire produced local dynasties ruling semi-independent states in Iran, Iraq and Egypt, and allowed the new masters to implement economic policies geared to strengthening the local economies.⁶⁴

5 Textile Production and Commercialization

By the 11th century the accounts of the *Genizah* merchants attest to a well-organized flax cultivation and linen garment production geared to export to local and international markets. Flax was grown in central Egypt, and harvested and bundled in Būsīr, from where it was transported on the Nile to Cairo and Alexandria. From Alexandria, flax and other manufactured commodities and raw materials were shipped to Tunisia, Sicily and other destinations on the Mediterranean shores. Table 6 presents flax prices in different locations in Egypt gathered from the *Genizah* records.⁶⁵

Transportation costs, agents' fees, labour disruptions, wages and weather conditions contributed to the cost.

⁶² On the Abbasid budgets S. A. Al-Ali, "A New Version of Ibn al-Mutarrif's List of Revenues in the Early Times of Harun al-Rashid." *Journal of the Economic and Social History of the Orient* 14 (1971): 303-10.

⁶³ Y. Rāgīb, *Marchands d'étoffes du Fayyūm au III^e/IX^e siècle d'après leurs archives*. Actes et Lettres. (Cairo: Institut Français d'Archéologie Orientale, 1982).

⁶⁴ Lenient taxation offered by the new Arab political masters, substitutes of the Persian landowners, the *dihqans*, in the case of cotton. Bulliet, *Cotton*: 5. "The estimable theologian or mystic whose great-grandfather converted to Islam because he could better support his family by growing cotton for an Arab landlord than by harvesting wheat for a Zoroastrian village chief."

⁶⁵ M. Gil, "The Flax Trade in the Mediterranean in the Eleventh Century A.D. as seen in Merchants' Letters from the Cairo *Genizah*." *Journal of Near Eastern Studies* 63 (2004): 81-96; N. A. Stillman, "A Case of Labor Problems in Medieval Egypt." *International Journal of Middle East Studies* 5 (1974): 194-201. It is assumed that cotton prices in 9th-century Iraq would confirm the trend.

TABLE 6 *Average price of flax, Egypt, nth century**(In gold dinars)*

Region	Dinars per kg
Alexandria	0.17
Būsīr	
(Low)	0.05
(High)	0.10
Cairo	
(Low)	0.0992
(High)	0.1543

SOURCES: STILLMAN, "THE ELEVENTH CENTURY MERCHANT HOUSE OF IBN 'AWKAL"; GIL, "THE FLAX," PP. 224-9.

Egypt's flax was the main product traded internationally by the *Genizah* merchants, but it was far from being the only item traded; nor were the Jews the only traders, or the Mediterranean the only destination.⁶⁶ Indicators of commercialization multiplied everywhere in the Middle East. A larger share of the textile net production, threads, cloth, or finished garments was traded in urban markets, and a larger proportion of the population used markets to satisfy a greater proportion of their needs. As new commercial arteries developed, old and new maritime sea-lanes linking the Mediterranean and India with Egypt strengthened.⁶⁷ International export and import markets in-

⁶⁶ Goitein, *Mediterranean Society*; N. A. Stillman, "The Eleventh Century Merchant House of Ibn 'Awkal: A *Genizah* Study." *Journal of the Economic and Social History of the Orient* 16 (1974): 15-88; Gil, "The Flax Trade." Commercialization in the Medieval Middle East, including that of textile production, still awaits a monograph and quantitative treatment. Studies based on the *Genizah* documents provide a starting point. See Goldberg, *Trade and Institutions*.

⁶⁷ Goitein, S. D. and M. A. Friedman, *India Traders of the Middle Ages. Documents from the Cairo Geniza ('India Book')* (Leiden and Jerusalem: Brill, 2008). M. Shatzmiller, "Transcontinental Trade and Economic Growth in the Early Islamic Empire: The Red Sea Corridor in the 8th-10th centuries" In *Connected Hinterlands. Proceedings of the Red Sea Project IV held at the University of Southampton, September, 2008*, ed. by L. Blue et al. Bar International Series 2052, Society for Arabian Studies, Monographs No. 8 (Oxford, 2009): 119-130; T. Power, *The Red Sea from Byzantium to the Caliphate: AD 500-1000*. (Cairo; New York, American University in Cairo Press, 2012); H. Margariti, *Aden and the Indian*

creased in number and in size. The *Genizah* documents show that when it came to textile products, the urban network grew denser, with Cairo functioning as the central distribution depot and Alexandria as the largest export port of the Mediterranean. The appearance of Qus and Qusayr al-Qadim as the Red sea ports were signs of an increase in urbanization, following the second wave of Islamic urbanization represented by the foundation of Cairo in 969 AD. The expansion of the sea-lanes to India made Aden into a new commercial hub and a market for finished Egyptian textiles. At the same time, Mediterranean international hubs such as Qairawan and Sicily assumed larger shares in finishing Egyptian textile products.⁶⁸

Commercialization, in particular that of the textile industry, was instrumental to paper production by lowering the cost of paper's raw material, the linen rags. Commercialization benefitted from more efficiency in transportation, market organization and rising urbanization, each helping make linen rags available almost everywhere in the Middle East and North Africa. Table 6 demonstrates that flax prices remained higher than those of wheat, even after population levels recovered to pre-plague levels.⁶⁹ Thanks to commercialization flax offered consistently better returns to land owners who chose to remain in flax cultivation and guaranteed that the supply of flax remained stable and with it linen cloth and linen rags.

Table 7 provides a list of garments established from hundreds of items mentioned in the *Genizah* records with their prices, to illustrate the new dimensions of garment production.

TABLE 7 *Average prices of garments, Egypt, 11th-13th centuries*

(In gold dinars)

Item (Ashtor)	Price	Item (Stillman)	Price
Simple <i>thaub</i> (cloth)	1-2	<i>Thawb</i>	6.20
Elegant <i>thaub</i> (cloth)	3-4	<i>Jukāniyya</i>	3-37

Ocean. 150 Years in the Life of a Medieval Port (Chapel Hill: University of North Carolina Press, 2007).

⁶⁸ Paper was not manufactured in Aden and the *Genizah* merchants repeatedly request that paper for private use be sent along with other merchandise. Goitein and Friedman, *India Traders*: 60-61.

⁶⁹ Bloom, *Paper*: 76: 83-84 on the side panel. Jonathan Bloom suggested that food shortages were a plausible outcome of the conversion of wheat fields to flax.

Item (Ashtor)	Price	Item (Stillman)	Price
Simple <i>ghilāla</i> (cloth)	1 1/2	<i>Mindil</i>	3.04
Elegant <i>ghilāla</i> (cloth)	4	<i>Mukallaf</i>	2.72
Simple <i>jukāniya</i> (cloth)	1/2	<i>Niqab</i>	1.25
Elegant <i>jukāniya</i> (cloth)	1-3	<i>Radda</i>	2.18
Simple <i>mindil</i> (scarf)	1/3-1/2		
Elegant <i>mindil</i> (scarf)	1-2		
Simple <i>wasat</i> (waist wrap)	1-1 1/2		
Elegant <i>wasat</i> (waist wrap)	2 1/2-3		
Simple <i>mal'a</i> (outer wrap)	1		
Elegant <i>mal'a</i> (outer wrap)	3-4		
Simple <i>milhafa</i> (coat)	1		
Elegant <i>milhafa</i> (coat)	2-3		
Simple <i>ridā</i> (cloak)	1		
Elegant <i>ridā</i> (cloak)	3		
<i>Makhtūma</i> (dress)	5 at least		
<i>Khil'a</i> (robe of honour)	10-15		
Turban	2-3		
Elegant mi'jar (head-cover)	2-3		
Simple skullcap	1		
Elegant skullcap	2		
Head cover	1		

SOURCES: MEASURING THE MEDIEVAL ISLAMIC ECONOMY; *STILLMAN*, FEMALE.

The Ashtor list is a list of basic wardrobe items for men and women,⁷⁰ the second, mostly elegant apparel for women, collected by Y. Stillman from the

⁷⁰ Ashtor, *Prix*: 173.

Genizah trousseau lists.⁷¹ As indicated by the average price even the so called 'basic wardrobe' could be manufactured to a higher standard. Average price of a garment varied between 1/3 dinar for an inexpensive item and 15 dinars for a luxurious, high quality one. The price of the two most common items, "thawb" and "jukaniyya", basic outfits respectively for men and women, could fluctuate between 1 dinar and 6.20 dinars depending on the quality of cloth used and labour invested in making it. Prices of garments were determined by the quality of the cloth, the raw material, the pigments and dyes used to stain it, the amount of work, embroidery or gilding, or the elaborate decorations on the borders. Clearly, with commercialization the degree of specialization and labour investment in textile industry deepened.

It is interesting to compare the prices of garments to those of books, as both were contemporaries, items which inhabited the same social and economic space of *Genizah* society. When compared, the average price of garments was usually higher than that of books. For instance, by the 11th century, when the average price of a book was 2.79 dinars, it was lower than most elegant garments. By the 12th century, when the price of books declined further, the average book price of 0.86 dinars was even below the average prices of simple inexpensive textile items in Egypt. By the 13th century, when the average book price reached the lowest level of 0.51 dinars, it was broadly equal to the price of a cheap garment. We may conclude that garments were considered a deposit of wealth, much more than books.

Increase in commercialization benefitted paper also by creating demand for it. The *Genizah* documents demonstrated that the management of trade increasingly required more and more paper.⁷² In fact, one can say that with a constant stream of documents the use of paper became a necessity. With the circulation of paper documents and books, literacy was increasingly used in trade transactions, and the ease with which paper travelled guaranteed better application of instructions. But manufacturing techniques could also easily travel when transmitted in writing. For instance, manuals for paper making could transfer technology across regions and from one urban center to

⁷¹ Y. Stillman, *Female Attire in Medieval Egypt: According to the Trousseau Lists and Cognate Material from the Cairo Genizah* (Philadelphia: Unpublished PhD Dissertation, University of Pennsylvania, 1972).

⁷² See request for paper and books in the letters from Aden, Goitein and Friedman, *India*: 60-1.

another. It meant that the diffusion of manufacturing technology was made at no extra cost, followed by an increase in the number of producers.

With commercialization paper could be manufactured everywhere, including in regions where flax was not grown, if water and paper making techniques were available. For instance, cities in Iraq,⁷³ Syria,⁷⁴ Iran and Central Asia,⁷⁵ Egypt,⁷⁶ Muslim Spain,⁷⁷ and even in the Maghreb, where the usage of parchment remained more entrenched, manufactured specialized brands of paper.⁷⁸ Among all descriptions attributed to papermaking, the one describing Samarqand is most illuminating: ‘doors, roofs and doors of paper makers, were covered with drying paper’.⁷⁹

Among the factors contributing to lower cost of inputs was efficient technology. While the basic processing technology was available through ‘local knowledge’, reports of early river-mounted paper mills mention Baghdad in 794-95 and Samarra in 836 as well as 9th-century Syria.⁸⁰ But the new raw material, the linen rags, presented a challenge. Processing the rags and reducing them to a pulp required physical strength and endurance. Multiple soakings, lifting the wet pulp and beating it repeatedly were required, before starching, tinting and drying. These tasks required paper mills, trip hammers, and water flow strong enough to make them work efficiently. For instance, the reason why paper mills were concentrated in Fustât and not in Cairo was the flow of the river Nile, faster at Fustât and slower around Cairo.⁸¹ Above all, water power provided cheap energy, and the technology of water lifting wheels, which circumvented a weak current by using animal power, may

⁷³ Bloom, *Paper*: 47-56.

⁷⁴ *Ibid.*: 56-61.

⁷⁵ *Ibid.*: 61-74

⁷⁶ *Ibid.*: 74-85.

⁷⁷ *Ibid.*: 85-89.

⁷⁸ *Ibid.*: 47-89. On the movement of artisans, M. Shatzmiller, “Human Capital Formation in Medieval Islam”. In *Workers of the World—International Journal on strikes and social conflict. Special issue: Global History* vol. 1 (2013): 49-71. (<http://www.workeroftheworldjournal.net/>)

⁷⁹ Bloom, *Paper*, 62.

⁸⁰ *Ibid.*: 57.

⁸¹ *Ibid.*: 76. On the industries in Fustât, M. Shatzmiller, “Industries, Manufacturing and Labour.” In *A Cosmopolitan City: Muslims, Christians and Jews in Old Cairo*, eds. Tasha Vorderstrasse and Tanya Treptow (Chicago: The Oriental Institute of Chicago, 2015): 49-52.

have been used here as well.⁸² The paper factory, *matbakh*, located near the paper mills in 10th-century Fustāt with remnants of linen and paper waste may be cited as evidence.⁸³ One nagging question remains that of trip hammers: no archeological evidence of such hammers exists.⁸⁴ Jonathan Bloom suggested that the spread of Chinese-style rice dishes in the Middle East implies the existence of Chinese style trip hammer technology used for pounding rice, and therefore for paper making as well. Samarqand is reported to have had a hydraulic power hammer like that used in de-husking rice. Indirect evidence for the existence of mills and trip hammers may also come from the sophisticated engineering manuals showing irrigation devices, including those of water clocks and waterworks, regardless.

Could the decline in the price of books be attributed to other factors than the decline in the price of paper inputs? Decline in demand, for example, which would mean that books were a preserve of literate elites? This is unlikely. What we currently know of the state of literacy, libraries and reading and writing practices does not support such conclusion. Despite a high rate of medieval manuscript loss, the large number of Arabic and Hebrew book manuscripts which survived suggests a high level of book production.⁸⁵ A recently-published library catalog from 12th-century Damascus relates that the library owned 2000 book volumes.⁸⁶ Reading practices among middle class Muslims, artisans, soldiers and shopkeepers have surfaced in the sources and are documented in the literature.⁸⁷ Writing practices expanded as well, to the point that paper could be offered free of charge to the poor

⁸² A.Y. Al-Hasan and D. R. Hill, *Islamic Technology: An Illustrated History* (Cambridge: Cambridge University Press, 1986): 192-7; J. Pedersen, *The Arabic Book*, tr. G. French (Princeton: Princeton University Press, 1984): 64-6; Th. Schiøler, *Roman and Islamic Waterlifting Wheels* (Odense: Odense university Press, 1973).

⁸³ Goitein, *Mediterranean Society*: 81, note 2, p. 410.

⁸⁴ Watson, *Agricultural*: 77-136. Al-Hasan and Hill, *Islamic Technology*.

⁸⁵ Compare E. Buringh, *Medieval Manuscript Production in the Latin West* (Leiden: Brill, 2011).

⁸⁶ K. Hirschler, *Medieval Damascus. Plurality and Diversity in an Arabic Library* (Edinburgh: Edinburgh University Press, 2016). No prices are available in the catalog.

⁸⁷ Literacy and book consumption among artisans could be evidenced based on attendance in reading circles registered in the mosques. K. Hirschler, *The Written Word in the Medieval Arabic Lands: A Social and Cultural History of Reading* (Edinburgh, Edinburgh University Press, 2012).

who wanted to make notes while visiting the library.⁸⁸ The large amount of paper documents found in the *Genizah* archives also point to wide use of reading and writing. Literacy rates were not in the double digits, but book production fed book sellers' boutiques and libraries in every city.

Conclusion

The adoption of paper in the Middle East may be described as revolutionary, if only for its impact on knowledge accumulation, transmission and dissemination in the form of books. But the effect of the new literacy tool on the economy was nothing short of groundbreaking. Paper documents boosted literacy and human capital formation, efficient conduct of long distance trade, and enforcement of legal and economic transactions. Discovering that it owes its origins to changes in the economy is indeed befitting what we are slowly discovering about the early Islamic Middle East economic performance.

To investigate the question of how and why paper was adopted in the Middle East we used the mechanisms supplied by economic theory, chief among them laws of supply and demand, and applied to them evidence derived from quantitative study. A newly constructed database provided the statistics and the conclusions were correlated and associated with qualitative evidence furnished by the Arabic sources. Thus, it was made possible to identify the long-term changes in economic structures in the early Islamic Middle East, and link them to the various factors affecting paper production and consumption. First and foremost, it was a change in standards of living in the Middle East, which was crucial in stimulating demand for more efficient writing material. The rise in standards of living which was triggered by the increase in urban wages, also meant rise in demand for luxury goods, including fine garments and writing material. It was a complex process which led first to transformation in agrarian structures and then in manufacturing. Rise in demand for fine clothes ran parallel to weakening in demand for grains, generated by long-term population decline in the aftermath of the Justinian Plague and recurrences. Farmers and landowners responded by limiting

⁸⁸ In Mosul in 995. Grohmann, "Libraries and Bibliophiles in the Islamic East." In *Education and Learning in the Early Islamic World*, ed. Claude Gilliot (Aldershot UK: Ashgate Variorum, 2012)

wheat cultivation in favor of textile plants, cotton and flax. Increased production of raw material in the countryside transformed the textile industry in the cities and strengthened the overall commercialization of the economy. The movement in agriculture and manufacturing was replicated in the service sector, epitomized by the upswing in the size of paper consuming bureaucracies.

The changes in the macroeconomic dynamism of the Middle East facilitated change in the infrastructures of papermaking. First came the change in paper's raw material from plant fibers, as in the Chinese mix, to a pulp of processed textile product, the linen rags. More importantly, while paper production could not expand before the changes in the supply components materialized, once change occurred, massive amounts of commercially distributed raw material became available. Papermaking techniques were likely in evidence, either introduced from outside, as in the 'Chinese prisoners' theory, or circulated around Samarkand, or yet adopted from 'local knowledge' of papyrus making and readjusted. With the spread of paper use and literacy, written instructions became available in manuals, which commercialization helped widely and inexpensively diffuse. With commercialization, paper could be manufactured wherever linen rags, running water and techniques were available, practically everywhere in the Middle East. And there were changes in secondary factors, too. Decentralization of political power and local increases in capital accumulation exercised their influence. When examined in this setting, it is easy to see why the papyrus industry could not compete: limited by the availability of raw materials and plagued by fluctuations in labour supply and high transportation costs, price control, speculation and monopolies, it was not geared to answer the rise in demand for writing material.

One last observation may be made here about the adoption of paper and Islamic society. The trajectory of paper adoption represents the idiosyncratic character of the economic development in the Middle East. In his book devoted to technological change and rise in standards of living, *The Lever of Riches*, Joel Mokyr reflected that, "Technological innovation will not occur in a society, which is malnourished, superstitious or extremely traditional with tight social constraints preventing it from being open to diversity and tolerance."⁸⁹ Early Islamic society represented just the reverse: Its members bene-

⁸⁹ J. Mokyr, *The Lever of Riches. Technological creativity and economic progress* (Oxford: Oxford University Press, 1990): 12.

fitted from a rise in incomes and high standards of living. Islamic society reached into a pool of existing cultural heritage and knowledge and developed tools to exploit local and international scholarly traditions. It was an ethnic mix which displayed tolerance of diversity, a condition necessary for technological innovation to occur. Together, these were infrastructures that made Islamic society more disposed to adopt, implement, benefit and generate technological innovation on its own.

Bibliography

- <http://medievalislamicconomy.uwo.ca/>.
- <http://www.apd.gwi.uni-muenchen.de:8080/apd/project.jsp>
- <http://cudl.lib.cam.ac.uk/collections/genizah>,
- Ackerman-Lieberman, Philip I. 2014. *The Business of Identity. Jews, Muslims, and Economic Life in Medieval Egypt*. Stanford: Stanford University Press.
- Adams, Robert McC. 1965. *Land Behind Baghdad: A History of the Settlement on the Diyala Plains*. Chicago and London: The University of Chicago Press.
- Al-Ali, Saleh A. 1971. A New Version of Ibn al-Mutarrif's List of Revenues in the Early Times of Harun al-Rashid. *Journal of the Economic and Social History of the Orient* 14: 303-10.
- Al-Hasan, Ahmad Y. and Donald R. Hill. 1986. *Islamic Technology: An Illustrated History*. Cambridge: Cambridge University Press.
- Allony, Nehemya. eds. 2006. *The Jewish Library in the Middle Ages—Book Lists from the Cairo Genizah*, ed. Miriam Frenkel and Haggai Ben-Shammai with the participation of Moshe Sokolow. Jerusalem: Hebrew University of Jerusalem.
- Alston, Richard. 2001. Urban Population in Late Roman Egypt and the End of the Ancient World. In *Debating Roman Demography*, ed. Walter Scheidel. Leiden: Brill: 161-204.
- Ashtor, Eliyahu. 1969. *Histoire des prix et des salaires dans l'Orient médiéval*. Paris: SEVPEN.
- Beit-Arié, Malachy. 1996. The Oriental Arabic paper. *Gazette du livre médiéval* 28: 9-12.
- Bloom, Jonathan M. 2011. *Paper Before Print: The History and Impact of Paper in the Islamic World*. New Haven and London: Yale University Press.
- Bolt, Jutta, and Jan Luiten van Zanden. 2014. The Maddison Project: Collaborative Research on Historical National Accounts. *English Historical Review* 67: 627-51.
- Bulliet, Richard W. 1994. *Islam: The View from the Edge*. New York: Columbia University Press.
- Bulliet, Richard W. 2009. *Cotton, Climate, and Camels*. New York: Columbia University Press.

- Buringh, Eltjo. 2011. *Medieval Manuscript Production in the Latin West*. Leiden: Brill.
- Cohen, Hayyim. J. 1970. The Economic Background and the Secular Occupations of Muslim Jurisprudents and Traditionalists in the Classical Period of Islam (until the Middle of the Eleventh Century). *Journal of the Economic and Social History of the Orient* 13: 16-61.
- Dodge, Bayard. ed. and tr. 1970. *The Fihrist of al-Nadim: A Tenth-Century Survey of Muslim Culture*. New York: Columbia University Press.
- Drory, Rina. 1988. *The Emergence of Jewish-Arabic Literary Contacts at the Beginning of the Tenth Century*. Tel-Aviv: The Porter Institute for Poetics & Semiotics, Tel-Aviv University.
- Földvári, Péter, and Bas van Leeuwen. 2012. Comparing Per Capita Income in the Hellenistic World: The Case of Mesopotamia. *Review of Income and Wealth* 58: 550-68.
- Frantz, Gladys M. 1978. *Saving and Investment in Medieval Egypt*. Ann Arbor, MI: PhD dissertation, University of Michigan.
- Frantz-Murphy, Gladys M. 1981. A New Interpretation of the Economic History of Medieval Egypt: The Role of the Textile Industry. *Journal of the Economic and Social History of the Orient* 24: 254-567, 868-1171.
- Frantz-Murphy, Gladys M. 1999. Land-Tenure in Egypt in the First Five Centuries of Islamic Rule (Seventh-Twelfth Centuries AD). In *Agriculture in Egypt: From Pharaonic to Modern Times*, ed. Alan K. Bowman and Eugene Rogan, Oxford: Oxford University Press: 237-66.
- Garcin, J. C. 1993. Le JESHO et la recherche sur l'histoire économique et sociale des pays musulmans. *Journal of the Economic and Social History of the Orient* 36: 139-153
- Gil, Moshe. 1997. *Texts from the Cairo Genizah*. Vol. 2. Tel-Aviv: Tel-Aviv University.
- Gil, Moshe. 2004. The Flax Trade in the Mediterranean in the Eleventh Century AD as seen in Merchants' Letters from the Cairo Genizah. *Journal of Near Eastern Studies* 63: 1-96.
- Goitein, S. D. 1967. *Mediterranean Society: The Jewish Communities of the Arab World as Portrayed in the Documents of the Cairo Genizah*. Vol. 1. Berkeley and Los Angeles: University of California Press.
- Goitein, S. D. and M. A. Friedman. 2008. *India Traders of the Middle Ages. Documents from the Cairo Geniza ('India Book')*. Leiden and Jerusalem: Brill.
- Goldberg, Jessica L. 2012. *Trade and Institutions in the Medieval Mediterranean*. Cambridge: Cambridge University Press.
- Goldstone, Jack. 2002. Efflorescences and Economic Growth in World History: Rethinking the 'Rise of the West' and the Industrial Revolution. *Journal of World History* 13: 323-89.

- Greif, Avner. 1989. Reputation and Coalition in Medieval Trade: Evidence on the Maghribi Traders. *The Journal of Economic History* 49: 857-82.
- Greif, Avner. 1993. Contract Enforceability and Economic Institutions in Early Trade: The Maghribi Traders' Coalition. *The American Economic Review* 83: 525-48.
- Grohmann, Adolph. 1952. *From the world of Arabic papyri*. Cairo: Maaref press.
- Grohmann, Adolph. 2012. Libraries and Bibliophiles in the Islamic East. In *Education and Learning in the Early Islamic World*, ed. Claude Gilliot. Formation of classical Islamic world, vol. 43. Aldershot: Ashgate Variorum.
- Haran, Menachem. 1958 Bible Scrolls in Eastern and Western Jewish Communities from Qumran to the High Middle Ages. *Hebrew Union College Annual* 36: 21-62.
- Hirschler, Konrad. 2012. *The Written Word in the Medieval Arabic Lands: A Social and Cultural History of Reading*. Edinburgh: Edinburgh University Press.
- Hirschler, Konrad. 2016. *Medieval Damascus. Plurality and Diversity in an Arabic Library*, Edinburgh Studies in Classical Islamic History and Culture. Edinburgh, Edinburgh University Press.
- Hopkins, Keith. 1980. Taxes and trade in the Roman Empire (200 BC-AD 400). *The Journal of Roman Studies* 70: 101-125.
- Khan, Geoffrey. 2007. *Arabic Documents from Early Islamic Khurasan*. London: Nour Foundation, Azimuth editions.
- Little, Lester, K. ed. 2007. *Plague and the End of Antiquity*. Cambridge: Cambridge University Press.
- Loveday, Helen. 2001. *Islamic Paper. A Study of the Ancient Craft*. London: Archetype publications.
- Malczykcki, W. Matt. 2011. The Papyrus Industry in the Early Islamic Era. *Journal of the Economic and Social History of the Orient* 54: 185-202.
- Margariti, Roxani, E. 2007. *Aden and the Indian Ocean. 150 years in the life of a medieval port*. Chapel Hill: University of North Carolina Press.
- Mayerson, Philip. 1997. The Role of Flax in Roman and Fatimid Egypt. *Journal of Near Eastern Studies* 56: 201-7.
- McEvedy, C. and R. Jones. 1980. *Atlas of World Population History*. New York: Penguin Books.
- Milanovic, Branko. 2006. An Estimate of Average Income and Inequality in Byzantium Around the Year 1000. *Review of Income and Wealth* 53: 449-70.
- Mokyr, Joel. 1990. *The Lever of Riches, Technological Creativity, and Economic Progress*. Oxford, Oxford University Press.
- North, Douglass C. 1981. *Structure and Change in Economic History*. New York and London: Norton & Co.
- Ofir, H., M. Shenkar and S. Kurbanov. 2016. The Earliest Arabic Manuscripts Written on Paper: Three letters from Sanjar-Shah (Tajikistan). *Jerusalem Studies in Arabic and Islam* 43: 181-237.

- Pamuk, Şevket and Maya Shatzmiller. 2014. Plagues, Wages, and Economic Change in the Islamic Middle East, 700-1500. *Journal of Economic History* 74: 196-229.
- Pedersen, Johannes. 1984. *The Arabic Book*, tr. by G. French. Princeton, Princeton University Press.
- Persson, K. G. and P. Sharp. 2015. *An Economic History of Europe. Knowledge, Institutions and Growth, 600 to the Present*. 2nd edition. Cambridge, Cambridge University Press.
- Power, Timothy. 2012. *The Red Sea from Byzantium to the Caliphate: AD 500-1000*. Cairo and New York, American University in Cairo Press.
- Ragib, Yūsuf. 1982. *Marchands d'étoffes du Fayyoun au III^e/IX^e siècle d'après leurs archives (Actes et Lettres)*. I : Les actes des Banū cAbd al-Mu'min. Cairo : Institut Français d'archéologie orientale.
- Richard, F. 2006. *The Writing Surface: Paper. Islamic Codicology*. London: Al-Furqan Islamic Heritage Foundation: 49-63.
- Roberts, C. and T. C. Skeat. 1983. *The Birth of the Codex*. London: Oxford University Press.
- Scheidel, Walter and Steven Friesen. 2009. The Size of the Economy and the Distribution of Income in the Roman Empire. *Journal of Roman Studies* 99: 61-91.
- Scheidel, Walter. 2010. Real Wages in Early Economies: Evidence for Living Standards from 1800 BC to 1300 CE. *Journal of the Economic and Social History of the Orient* 53: 425-62.
- Schiøler, Thorkild. 1973. *Roman and Islamic Waterlifting Wheels*. Odense: Odense university Press.
- Shatzmiller, Maya. 1994. *Labor in the Medieval Islamic World*. Leiden: Brill.
- Shatzmiller, Maya. 2009a. Transcontinental Trade and Economic Growth in the Early Islamic Empire: The Red Sea Corridor in the 8th-10th centuries. In *Connected Hinterlands. Proceedings of the Red Sea Project IV held at the University of Southampton, September 2008*. Ed. Lucy Blue et al. Society for Arabian Studies, Monographs No. 8. Oxford: Bar International Series 2052: 119-130.
- Shatzmiller, Maya. 2009b. New Initiative: Medieval Islamic Economic Quantitative Data Collection in a Global Setting. *Al- 'Usur Al-Wusta. Bulletin of Middle East Medievalists* 21/1-2: 2-4 Published in 2013.
- Shatzmiller, Maya. 2011. Economic Performance and Economic Growth in the Early Islamic World. *Journal of the Economic and Social History of the Orient* 54: 132-184.
- Shatzmiller, Maya. 2012. The Economic History of the Medieval Middle East: Strengths, Weaknesses and the Challenges Ahead. *International Journal of Middle Eastern Studies* 44/3: 529-531.
- Shatzmiller, Maya. 2013. Human Capital Formation in Medieval Islam. *Workers of the World—International Journal on Strikes and Social Conflict. Special Issue: Global Labour History*. Vol. 1: 49-71.

- Shatzmiller, Maya. 2015. Industries, Manufacturing and Labour. In *A Cosmopolitan City: Muslims, Christians and Jews in Old Cairo*. Ed. Tasha Vorderstrasse and Tanya Treptow. Chicago University of Chicago Press: 49-52.
- Stillman, Norman A. 1974a. A Case of Labor Problems in Medieval Egypt. *International Journal of Middle East Studies* 5: 194-201.
- Shatzmiller, Maya. Stillman, Norman A. 1974b. The Eleventh Century Merchant House of Ibn 'Awkal: A Genizah Study. *Journal of the Economic and Social History of the Orient* 16: 15-88.
- Stillman, Yedida. 1972. *Female Attire in Medieval Egypt: According to the Trousseau Lists and Cognate Material from the Cairo Genizah*. Philadelphia: Unpublished PhD Dissertation, University of Pennsylvania.
- Teall, John L. 1959. The Grain Supply of the Byzantine Empire, 330-1025. *Dumbarton Oaks Papers* 13: 87-139.
- Udovitch, Avrom, L. 1975. Reflections on the Institutions of Credits and Banking in the Medieval Near East. *Studia Islamica* 41: 5-22.
- Van Berkel, Maaïke. 2014. Reconstructing Archival Practices in Abbasid Baghdad. *Journal of Abbasid Studies* 1: 7-22.
- Von Karabacek, Joseph. 2001. *Arab Paper*, tr. D. Baker and S. Dittmar. London: Archetype Publications.
- Watson, Andrew M. 1983. *Agricultural Innovation in the Early Islamic World*. Cambridge, Cambridge University Press.
- Wiesner, J. 1986. Mikroskopische Untersuchung der Papiere von El-Faijûm. Originally published in *Mittheilungen aus der Sammlung der Papyrus Erzherzog Rainer*, Wien, 1887. Translated into English by Gudrun Aurand. Ed. Jack C. Thompson. Fenwick: Caber Press.
- Zaki, Mahmoud. 2011. Early Arabic Bookmaking Techniques as Described by al-Rāzī in his recently rediscovered *Zinat al-Katabah*. *Journal of Islamic Manuscripts* 2: 223-34.