

Price Behavior in Ancient Babylon¹

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This article analyzes the longest continuous price data from the ancient world, which come from ancient Babylon and stretch from almost 500 BCE to beyond 100 BCE. The analysis confirms the interpretation in Slotsky (1997) that they are market prices. It shows that the prices of agricultural goods moved in a random walk. They rose sharply after the death of Alexander the Great in 323 BCE and more gradually toward the end of the period. The author suggests that both price rises resulted from breakdowns in the ruling government. © 2001 Elsevier Science

The nature of ancient economies has been a topic of debate for decades. Disagreement and controversy have been encouraged by the scarcity of ancient economic data. Therefore, it was startling when Slotsky (1997) reported the existence of what appeared to be the longest extant series of ancient prices. This article analyzes these putative price series using time-series methods designed for the study of prices to divine their nature and reveal what they indicate about the economy of ancient Babylonia.

The primary issue in the study of the ancient economy has been the extent of markets. Polanyi (1944) argued that ancient markets were limited in scope and peripheral to most economic activity. Others, following Rostovtzeff (1957), have argued that markets were important or even central to ancient economies. This debate has been known as the primitivist/modernist debate or as the Finley debate, following his famous Sather lectures (Finley, 1973). This debate takes place mostly in ancient history journals, but it also has appeared in economic history journals in articles by Silver (1983) and Greene (2000).

One argument of the primitivists is that there is a paucity of ancient prices in the surviving records. Duncan-Jones (1982) and Rathbone (1997) collected prices for common articles in an agricultural economy, albeit one with many monuments and statues. Even though they found a large number of prices, the

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prices were spread over many commodities and even more years. One has only to look at the small number of observations found by these authors to realize that only the simplest of hypotheses can be tested. Hopkins (1978) reported what he called “the largest single series of prices over time which we have from the classical world” (p. 158). The series contained 700 prices that slaves paid for their freedom, spread over the last 200 years before the Common Era. Slaves, of course, were very diverse, and there were far fewer observations for any subsets of more similar slaves. Hopkins observed a rise in release prices over these years but could not test complex hypotheses.

In this context, Slotsky’s report of what appeared to be a series of monthly market prices for six agricultural commodities for 400 years in ancient Babylon appeared to provide much more evidence of ancient market activity than had been available earlier. But although Slotsky argued that her observations were market prices, her interests were primarily historical and philological rather than economic. This article pursues the economics of these observations to answer two questions. First, were they market prices? Second, if they were, then what can their behavior tell us about the economy of ancient Babylon?

This article progresses by first reviewing the evidence and its historical context. I then describe the hypotheses to be tested and the methods I use, which include comparison with more modern prices. Finally, I bring the data and tests together to generate conclusions about the Babylonian economy.

THE DATA

The price data come from a vast archive of astronomical cuneiform tablets from the ancient city of Babylon. This renowned site first gained importance during the beginning of the second millennium BCE and attained a preeminence in the ancient world that was to last for nearly 2000 years. During the last seven centuries of the first millennium BCE, clay tablets, of which about 1200 fragments are known, were filled with almost daily astronomical and other observations written in the Akkadian language by observers specifically trained and employed by the Temple of Marduk in Babylon. Each day, scribes made entries on small tablets, recording on a single tablet information for periods ranging from 1 or 2 days to a few months. This was possible because clay can be kept soft and inscribable for up to 3 months (e.g., by wrapping it in a wet cloth). At a later date, the scribes composed larger texts from these smaller ones, with the full-sized versions covering either an entire Babylonian calendar year or the first or last half of one (Sachs and Hunger, 1988, 1989, 1996).

A typical half-year “astronomical diary” has six sections, seven in an intercalary year (i.e., one with an extra month), each covering one lunar Babylonian month. Observations began with what was considered to be the beginning of the month—the first visibility of the new moon at sunset—and continued with the monthly progress of the moon among the stars and planets. Nightly and daily weather conditions were written down meticulously because they had an impact

on visibility. Eclipses, equinoxes and solstices, Sirius phenomena, and the appearance of comets (including Halley's comets of 234, 164, and 87 BCE) were recorded. At the end of the month, there was a final statement about the moon's last appearance and then a recapitulation of planetary positions at month's end, a list of the market values of six commodities that month, measurements of the changes in the water levels of the Euphrates River, and anecdotal historical information.

These tablets are unique among documents pertinent to the study of ancient history. They are unmatched in magnitude, sequence, and detail. Because of the astronomical content, any evidence extracted from these texts—astronomical, meteorological, economic, and historical—can be dated with certainty. And the market quotations always were expressed in the same terms, quantities that can be purchased for 1 shekel of silver. (A shekel was a weight measure, not a coin.) In addition, values of the same six commodities were listed in a set order: barley, dates, cuscuta (called mustard in the early translations of the diaries and here), cardamom (called cress originally and here), sesame, and wool.

I study the data from 464 to 72 BCE, omitting one stray set of market values for 568 BCE. The data contain many missing values because of the many lost tablets and the large number that are damaged or broken. The commodity summary was inscribed close to the end of a monthly unit. The last month on a tablet was at the bottom of the tablet and in a particularly vulnerable position; there are many disconnected and broken passages, not to mention lost quotations. Tablet damage and loss was random from the point of view of prices. There are more than 3000 observations—nearly as many observations for each of the six commodities as Hopkins (1978) found for *all* slave freedom prices. The prices of barley and wool are shown in Figs. 1 and 2. Barley prices are measured in *qa* (close to a modern quart) per shekel (a standard weight of silver). Wool prices are measure in *mina* (close to a modern pound) per shekel.

Slotsky (1997) had no doubt that the market quotations were real market prices. The texts contained principally observed rather than predicted phenomena. The quotations appeared too irregular to have been computed according to some abstract principle. The pace of reporting commodity prices quickened and became erratic when they were volatile, and there were reports of interrupted or suspended commodity sales at these times. Slotsky, however, analyzed these putative prices in the manner of an ancient historian and philologist, although she did use some statistics. I have used the tools of economics to ask whether these magnitudes behave like real prices. If they do, then what can we learn from them about the economy of ancient Babylon?

Grainger (1999) and Van der Spek (2000) interpreted these prices as market prices. Grainger described long-run trends, and Van der Spek argued that prices rose during wartime. Grainger, however, based his argument on bar graphs, whereas Van der Spek cited isolated prices, restricting his observations to wartime and to the price of barley. Neither author subjected the data to any kind of formal tests.

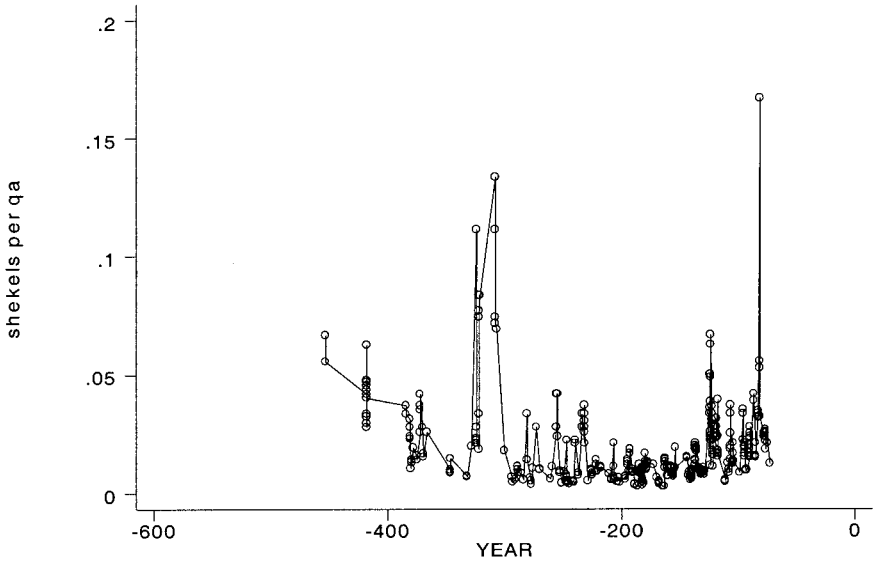


FIG. 1. The price of barley, 417 to 72 BCE (Slotsky, 1997).

To create a frame of reference, I compare these prices to the price of wheat in England during the Medieval and early modern periods. The price of wheat is a good standard of comparison for several reasons. The wheat prices are well

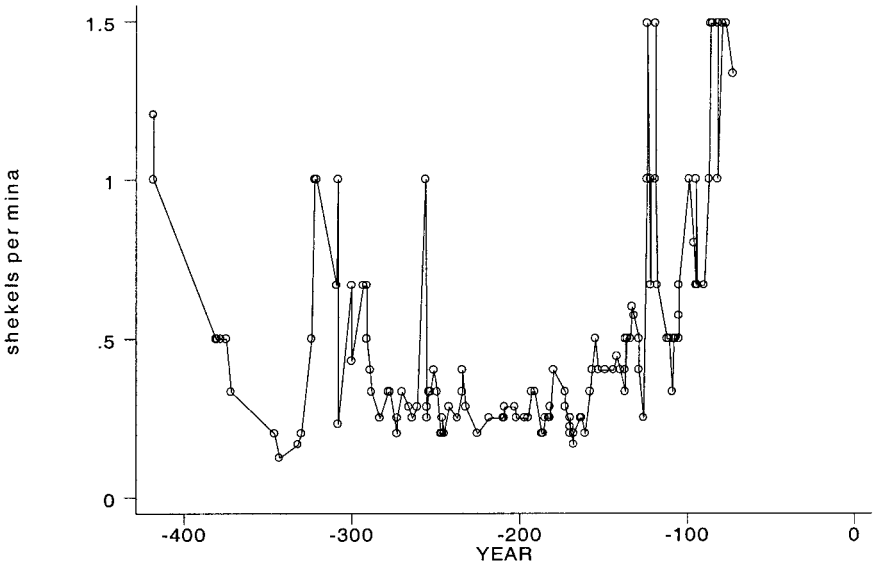


FIG. 2. The price of wool, 417 to 72 BCE (Slotsky, 1997).

attested and continuous for centuries, comparable to the Babylonian prices. They are the prices of an agricultural commodity from a primarily agricultural economy, as are the Babylonian prices. And they clearly were set in relatively free market conditions.

THEORY AND METHODS

The first question is whether these are market prices. To answer that question, I need to consider what else they might be. The alternative is some sort of administered prices that indicate nonmarket activity such as tax collections or royal exactions of some other sort. If these prices indicated such an administrative activity, then they would have been generated by some rule and would have followed a uniform pattern like the celestial movements also recorded on the tablets. Market prices, by contrast, move freely in response to changing conditions and would have exhibited a far more random pattern.

Therefore, I can test for market prices by looking for random movements in the data. I distinguish five types of movements to be examined.

1. *Annual variation.* I measure the year-to-year variation by examining yearly prices. Only the year in which prices were reported is relevant here, not the month. As can be seen from Figs. 1 and 2, the price series exhibit substantial annual variation. Prices, as we know from the modern world, also exhibit autocorrelation. In fact, they typically can be described as a random walk.

2. *Long-run variation.* I examine trends over time to see whether prices exhibited persistent trends over the four centuries I observe. Administered prices could remain constant over time, but market prices are more likely to exhibit inflation or deflation over this long period. Grainger (1999) inferred long-run trends from bar graphs but could not test for significance in light of the short-run variation.

3. *Short-run variation.* Market prices react to unexpected events. Alexander the Great returned to Babylon in 324 BCE and then died suddenly in 323, giving rise to lasting dynastic conflicts. These were events of great magnitude. If these observations are market prices, then they may well have shown some effects. Changes in the supply of silver and any scarcity of goods resulting from Alexander's death both could have caused prices to rise. Van der Spek (2000) interpreted a price rise at this time as the effect of war rather than the effect of other events.

4. *Relative variation.* The scribes recorded prices for six commodities. If the prices were administered, then they should have preserved their relative magnitudes. It is a hallmark of administered prices even in modern times that they do not vary against each other (Berliner, 1976). Market prices, by contrast, often diverge as there are changes in individual markets. Five of the prices I have are for crops, whereas wool is an animal product. If these are market prices, then the price of wool could have moved differently from the price of crops.

5. *Seasonal variation.* Agricultural prices tend to have patterns that reflect growing conditions, both seasonal variation within years and yearly variations from weather changes. Crops were harvested at different times of the year in ancient Babylon, and there might not be uniform seasonal patterns. In addition, there may have been good and bad years for agriculture as a whole.

I examine the first kind of variation through regressions of the following form:

$$\text{LogPrice}_i(t) = \alpha + \beta_i^{\text{Lag}(t)} \text{LogPrice}_i(t - 1) + \varepsilon(t). \quad (1)$$

For modern prices with annual observations, $\text{Lag}(t) = 1$ for all years, and it normally is not expressed. I calculated the price as the inverse of the volume or weight measure of each commodity described earlier. I use the log of the price in the following regressions to reduce the variance of the prices and the influence of outliers in the data. Because the Babylonian observations come at random intervals, it is necessary to adjust for the length of each interval to estimate autocorrelation. I compare the autocorrelation in agricultural prices from Babylon in and around the Hellenistic period with that in Medieval and early modern English wheat prices to see whether the degree of autocorrelation is the same.

I employ descriptive regressions of the price of each commodity over time to examine the next two types of variation. The results of estimating Eq. (1) show whether contemporaries could have predicted future prices; descriptive regressions can tell later observers what actually happened. The first such regression evaluates the long-run trend of prices. It models the relationship between each commodity's log price and the year, year squared, year cubed, and three dummy variables for different intervals:

$$\text{LogPrice}_i = \alpha + \beta_1 \text{Year} + \beta_2 \text{Year}^2 + \beta_3 \text{Year}^3 + \beta_4 \text{Dum1} \\ + \beta_5 \text{Dum2} + \beta_6 \text{Dum3} + \varepsilon, \quad (2)$$

where the subscript of the log price refers to the commodity being observed. The first dummy variable, Dum1, controls for years between 323 BCE (−322) and 314 BCE (−313). This 10-year window is isolated to see whether the death of Alexander had an effect on prices. The length of the window to account for any market disruptions in the wake of Alexander's death is arbitrary. To allow for a possible longer disruption to markets, two other dummy variables (Dum2 and Dum3) control for 10-year windows from 313 BCE (−312) to 304 BCE (−303) and from 303 BCE (−302) to 294 BCE (−293). These added dummy variables are included in the regression to discover whether prices returned to their level before 323 BCE or whether prices continued to be higher than normal 10 and 20 years after the initial shock. The year-squared and year-cubed variables allow the path of prices to curve over the years. Any polynomial is an approximation to the arbitrary path of prices over time; a third-order polynomial allows a reasonably good characterization of the time path. Slotsky also used a cubic equation to allow for an accurate representation of the prices' patterns over four centuries.

If the results of Eq. (1) show autocorrelation, this implies that Eq. (2) will have

it as well. It is harder to correct Eq. (2) for autocorrelation, and I have not done so. The problem is that the data come at irregular intervals, whereas time is measured uniformly. Standard errors are incorrect as a result, and any significance tests need to be regarded as only approximate. I use a 1% confidence limit throughout to minimize the possibility of accepting an erroneous hypothesis.

To see whether there was relative variation (i.e., whether the trends for the prices of different commodities differed from each other), I pooled the regressions for individual commodities to provide tests of significance for the trends of individual commodities. I expect market prices for agricultural commodities to have moved together because changes in supply and demand would have been similar for each crop. Wool, however, might have moved differently from the agricultural commodities because the production of wool is quite distinct from raising a crop. To determine empirically whether the change of each price was significantly different from the change of other prices, I use a regression model of pooled commodity log prices that examines simultaneously the path of the six log prices over the years from 473 BCE to 72 BCE. The regression used is

$$\begin{aligned} \text{LogPrice} = & \alpha_1 + \beta_{11}\text{Year} + \beta_{12}\text{Year}^2 + \beta_{13}\text{Year}^3 \\ & + \beta_4\text{Dum1} + \beta_5\text{Dum2} + \beta_6\text{Dum3} \\ & + \sum_i \delta_i(\alpha_i + \beta_{i1}\text{Year} + \beta_{i2}\text{Year}^2 + \beta_{i3}\text{Year}^3) + \varepsilon, \end{aligned} \quad (3)$$

where δ_i represents the dummy variable for the i th commodity. Dates are the omitted commodity. Dum1, Dum2, and Dum3 are the dummy variables for the three 10-year windows from 323 BCE to 294 BCE used in Eq. (2). Equation (3) determines the effect of time on each price. The extent to which trends of individual commodities differed is shown by the magnitude and significance of the α and β coefficients.

To capture seasonal variations in commodity log prices, it is necessary to model the relationship of seasons and years with log prices. Market prices could have shown consistent variation in seasons, whereas government-determined prices would not have a clear pattern of variation. I incorporate dummy variables for winter, summer, and fall into the regressions for individual commodities. The dummy variable for spring (months 1–3) is omitted. The seasonal regression is

$$\begin{aligned} \text{LogPrice}_i = & \alpha + \beta_1\text{Year} + \beta_2\text{Year}^2 + \beta_3\text{Year}^3 + \beta_4\text{Dum1} \\ & + \beta_5\text{Dum2} + \beta_6\text{Dum3} + \beta_7\text{Winter} \\ & + \beta_8\text{Summer} + \beta_9\text{Fall} + \varepsilon. \end{aligned} \quad (4)$$

The year and commodity dummies are defined as in Eqs. (2) and (3). The dummy variables for seasons show the relative effect that each season has on prices. The scribes collected information on the height of the Euphrates River, and it can be added to or substituted for seasonal dummies. I also test for correlation of the errors in Eq. (2) to see whether there were good and bad years for agriculture as a whole.

TABLE 1
Regressions of Log Prices on Last Year's Prices

	Barley	Dates	Mustard	Cress	Sesame	Wool
Intercept	0.00047 (0.0012)	-0.149 (0.301)	0.00027 (0.00036)	0.0029 (0.0030)	0.0031 (0.0036)	0.010 (0.022)
LogPrice ₋₁	0.988* (0.0064)	0.988* (0.0025)	0.978* (0.0025)	0.979* (0.0052)	0.983* (0.0040)	0.996* (0.0031)
DW	2.08	2.28	2.69	2.69	2.74	2.55
Observations	127	120	99	104	109	99

Note. Standard errors are in parentheses.

* Significantly different from zero at 1% probability.

ESTIMATION RESULTS

The results of estimating Eq. (1) for each of the six commodities are shown in Table 1. In each case, the constant is not significantly different from zero, nor is the coefficient on the lagged price different from 1. These prices describe a random walk very much like that of modern prices. The analogous regression for wheat prices from 1260 to 1914 is

$$\text{LogPrice}_w(t) = -0.042 + 0.942 \text{LogPrice}_w(t-1) + \varepsilon(t). \quad (5)$$

(0.15) (0.014)

The price of wheat for early modern Britain shows exactly the same kind of autocorrelation as do the ancient Babylonian prices. (Lag(t) has been suppressed because it always takes the value of 1 in this regression.) The price of wheat after 1500 is shown in Fig. 3, using only part of the modern price series to approximate the time interval of the ancient one. The graph looks very similar to Figs. 1 and 2.

The existence of this stochastic process is a clear marker for market prices. The ancient prices behave like Medieval and early modern prices, which in turn share the time-series properties of prices today. Administered prices could not possibly have these properties. They would stay at or near some fixed level or at a level that changed deterministically over time; they would not behave as a random walk. The data in Table 1, therefore, document clearly the market nature of agricultural prices in Babylon before and during the Hellenistic period.

This conclusion can be strengthened by analysis of the path of these market prices over time. As can be seen in Table 1, the number of observations for each commodity fell from the observed 500 or so to 100 or slightly more. This was the result of collapsing the data into annual observations and allowing for lags. As can be seen, the remaining observations are quite sufficient to demonstrate the time-series properties of the ancient data. However, I used all of the observations for the descriptive regressions, Eqs. (2) through (4). The resulting equations have autocorrelated errors, as anticipated earlier, but the irregular occurrence of the

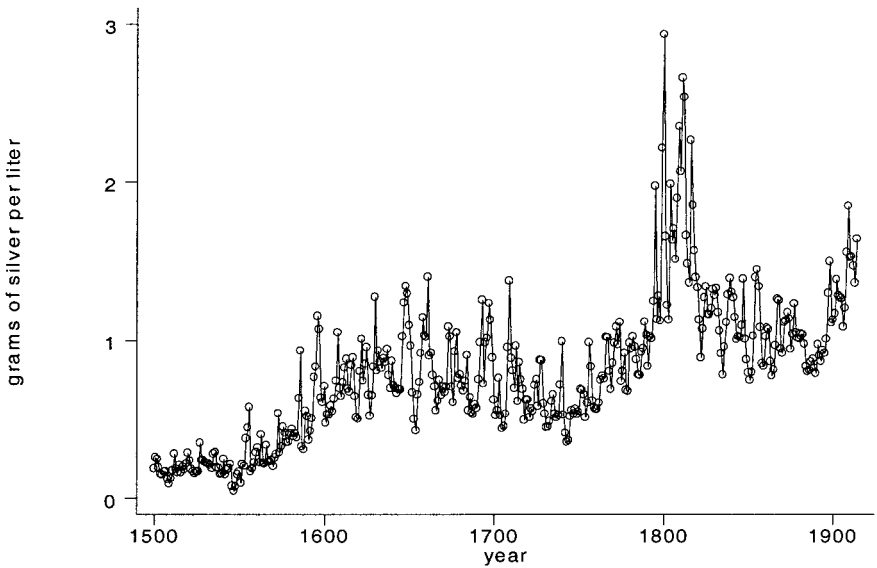


FIG. 3. The price of wheat in England, 1500 to 1914 (Allen, 2001).

data made it impossible to correct these equations for autocorrelation in any moderately accurate way. These regressions are designed simply to expose patterns shown in Figs. 1 and 2 in any case.

The results of estimating Eq. (2) for each of the six commodities are shown in Table 2. All of the time variables in the regressions are significantly greater than zero at the 1% significance level, indicating that a cubic equation helps to capture the curvature of the price series. The presence of all positive coefficients appears to indicate steadily rising prices, but dealing with years before the Common Era is tricky. The years are negative, increasing from -463 to -71 . The time derivative of Eq. (2) is

$$D(\text{LogPrice})/dt = \beta_1 + 2\beta_2\text{Year} + 3\beta_3\text{Year}^2. \quad (6)$$

The first and third terms are positive, but the middle term is negative. When β_2 is large enough, dp/dt will be negative for early years. When β_3 is large enough, dp/dt will be positive for even earlier years, producing a classic cubic shape. As the years progress, getting closer to zero, the size of the middle term diminishes and prices turn upward. The prices of three commodities—cress, mustard, and dates—rose initially and then fell until shortly after -200 , when they began to rise again. The prices of wool, sesame, and barley fell from the earliest years observed until reaching a minimum between -250 and -200 , after which they too rose. Prices moved in various ways during early years, but they all rose with increasing speed after 150 BCE.

Grainger (1999) attributed this inflation to the breakdown of the Seleucid state.

TABLE 2
Regressions of Log Prices on Time

	Barley	Dates	Mustard	Cress	Sesame	Wool
Intercept	-1.71* (0.314)	-0.149 (0.301)	-3.62* (0.276)	1.25* (0.377)	-0.345 (0.243)	2.46* (0.191)
Year	0.0316* (0.00472)	0.0694* (0.00456)	0.0328* (0.00422)	0.0652* (0.00561)	0.0269* (0.00355)	0.0362* (0.0029)
Year ²	9.62×10^{-5} * (2.12×10^{-5})	2.90×10^{-4} * (2.06×10^{-5})	1.383×10^{-4} * (1.915×10^{-5})	2.52×10^{-4} * (2.52×10^{-5})	6.98×10^{-5} * (1.55×10^{-5})	1.01×10^{-4} * (1.35×10^{-5})
Year ³	7.14×10^{-8} * (2.88×10^{-8})	3.51×10^{-7} * (2.83×10^{-8})	1.63×10^{-7} * (2.60×10^{-8})	2.88×10^{-7} * (3.45×10^{-8})	3.71×10^{-8} * (2.06×10^{-8})	7.06×10^{-8} * (1.85×10^{-8})
Dum1	1.47* (0.216)	0.980* (0.168)	0.203 (0.152)	0.640* (0.139)	1.31* (0.108)	1.12* (0.096)
Dum2	2.07* (0.186)	1.56* (0.262)	0.173 (0.290)	0.191 (0.339)	N/A	0.515* (0.134)
Dum3	-0.592 (0.246)	0.242 (0.336)	1.55* (0.289)	0.694 (0.339)	0.675* (0.156)	0.704* (0.119)
Adjusted R ²	0.427	0.474	0.285	0.378	0.499	0.697
Observations	639	584	503	551	612	562

Note. Standard errors are in parentheses. Dum1 = $(-322 \leq \text{Year} \leq -313)$; Dum2 = $(-312 \leq \text{Year} \leq -303)$; Dum3 = $(-302 \leq \text{Year} \leq -293)$; NA = not applicable.

* Significantly different from zero at 1% probability.

A lack of public order could impede trade and make goods scarce. But this argument about the demand for goods ignores the supply of money. An abundance of silver also could cause commodity prices in silver units to rise. We do not know much about the supplies of silver during this period because most of our information comes from examining coins. Commerce in Babylonia was based not on coins but rather on standard weights of silver. When Alexander introduced coins, they were weighed rather than counted (Powell, 1996; Vargyas, 2000). It is very hard to know how many coins were circulating, and it was even harder to estimate the volume of silver in use.

Alexander established a mint in Babylonia around 330 BCE when he first arrived. He then went to Persia and beyond, returning with treasure in 324, presumably including silver. But we do not know how he financed his expedition, and there is no evidence that the Persian treasure was made into coins (Mørkholm, 1991, pp. 48–49). Conventional wisdom is that Rome was taking silver from the East in taxes and tribute. The Roman Republic was expanding its use of silver coinage during these years, and “silver drained out of Spain and the Greek world” to Italy and Rome after 200 BCE (Harl, 1996, p. 39). It is unlikely as a result that there was an increasing supply of silver in Babylon. In addition, when Augustus reformed the Roman currency a century after the Babylonian price series ended, his coins embodied a gold:silver ratio of 12:1, valuing silver higher relative to gold than it would be valued later (Greene, 1986, p. 49). This evidence does not suggest an abundance of silver in Rome at the end of our period, making a prior expansion of silver supplies in Babylon even more unlikely. Grainger’s suggestion, therefore, appears to be a reasonable one.

Most of the coefficients on the dummies for years after Alexander's death are positive, large, and significantly different from zero. The significance of Dum2 and Dum3 in many regressions shows that prices took about a generation to return to their normal trend. This price rise, clearly visible in Figs. 1 and 2, reveals the market nature of these prices given that episodic price rises are hallmarks of free markets. As with the later, more gradual price rise, the cause of this rise can be inferred only indirectly. It appears to be the effect of Alexander's unexpected death and the dynastic conflicts that followed.

If this was the case, then what was the mechanism? Prices could rise either because agricultural goods were scarce in Babylon or because the stock of silver suddenly rose. Alexander brought back with him extensive plunder in 324 BCE. He did not coin this treasure, as noted above, but one modern author argued that he "released [his treasure] into circulation," dramatically increasing the supply of money (Patterson, 1972). It is likely, however, that Alexander did not by himself give rise to this short, sharp inflation. Instead, competing claimants to power probably paid their soldiers from Alexander's treasure during the dynastic struggles that followed his death. Stolper (1994) described the political history of these years, showing that the dynastic conflicts continued for a long time. It is the continuation of these struggles that explains why prices stayed high for a generation after Alexander's sudden death. Of course, the inference that an increased supply of money caused prices to rise assumes that the prices in question were market prices determined in reasonably well-functioning markets.

The regressions in Tables 1 and 2 show that agricultural prices in Babylon moved randomly from year to year, fell and rose again over the long run, and experienced severe market disruption after the death of Alexander. These conclusions imply more general conclusions about ancient Babylon. There clearly were markets for agricultural goods that were operating continuously and giving rise to market prices. This suggests that there was a market economy in ancient Babylon. To reach a stronger conclusion about the economy as a whole, we would need evidence on the spread and influence of other markets as well as the ones analyzed here. I have argued elsewhere that there was a market economy in the early Roman Empire by examining the nature of markets for commodities, land, capital, and labor (Temin, 2001). We lack this knowledge of the extent of market behavior in pre-Hellenistic and Hellenistic Babylon. Therefore, we can only be sure that there was a functioning free market in agricultural commodities.

The movements of these prices over time suggest conclusions about the politics of ancient Babylon as well. The severe disruption of prices after the death of Alexander confirms the views of those historians who have seen his death as the end of an era. The regressions tell us that it took nearly a generation to restore stability to the agricultural markets in Babylon. They inform us that it was not a simple thing to restore order after a sudden shock like Alexander's death. The succession may have been decided quickly, but life did not return to normal for many years.

After order was restored with the establishment of the Seleucid dynasty, prices

appear to have stabilized. But during the last two centuries before the Common Era, prices began to rise. As discussed earlier, this inflation may indicate a gradual breakdown of the government's ability to maintain stability as the Seleucid Empire gradually disintegrated. This price evidence, like that for the later Roman Empire, suggests that political and economic stability were becoming harder to achieve as time went on.

The results of estimating Eq. (3) revealed that the coefficients on the year variables for different commodities did in fact differ from each other. There were trends in relative prices as well as trends in the price level as a whole. This again reveals agricultural markets in action. Only administered prices maintain their relative prices over long stretches of time. Wool in particular followed a unique time path, as suggested by the contrast between Figs. 1 and 2.

During the years around 100 BCE, the price of wool rose when the price of agricultural crops did not. There were high wool prices during several years, spaced over a few decades, although there also were some lower wool prices interspersed. These high observations affect regression trends, although they also may have represented a more short-run movement. It appears that there was some kind of wool shortage or disruption of the wool market at the end of the observed period. The statistical work reported here cannot identify the cause of this disruption; it can only identify the existence of something unusual in the wool market.

The seasonal dummies in Eq. (4) revealed a complex pattern, which I describe without reproducing the full regression results. Dates were delivered during the fall, and date prices were lower during the following half year than during the half year before the harvest. Barley was delivered during the spring, and it was more expensive during the preceding few months. But although mustard was delivered during the fall like dates, it was more expensive at the same time. The other three prices did not have seasonal patterns that can be recovered from the data with confidence. Approximately 200 observations on the height of the Euphrates River have survived, but only about 100 of them overlapped price data on each commodity. Regressions of log prices on years and the height of the Euphrates did not reveal a significant effect of the river height on any of the six prices. The seasonal evidence, therefore, is ambiguous. There is some evidence that fits a model of an agricultural economy, but there also is seasonal evidence that does not.

Although the seasonal dummies reveal a mixed pattern and there are not enough observations of the Euphrates River's height to yield significant results, there is a way to identify good and bad years. If these are market prices, then we expect that a good year would produce bountiful harvests of most crops and, therefore, lower prices. A bad year, by the same reasoning, would result in high prices. As a result, the errors in the individual price regressions shown in Table 2 would be correlated. Zellner's technique of "seemingly unrelated regressions" tests for any correlations and uses the additional information in the correlations to improve the estimates.

TABLE 3
Seemingly Unrelated Regressions of Log Prices on Time

	Barley	Dates	Mustard	Cress	Sesame	Wool
Intercept	-1.66 (0.781)	-0.165 (0.768)	-4.34* (0.578)	2.12* (0.580)	-0.596 (0.567)	3.16* (0.389)
Year	0.0341* (0.0123)	0.0750* (0.0121)	0.0196 (0.00909)	0.0726* (0.00913)	0.0216 (0.00892)	0.0455* (0.0061)
Year ²	1.07×10^{-4} (5.69×10^{-5})	3.11×10^{-4} * (5.6×10^{-5})	7.1×10^{-5} (4.21×10^{-5})	2.63×10^{-4} * (4.23×10^{-5})	3.88×10^{-5} (4.13×10^{-5})	1.34×10^{-4} * (2.83×10^{-5})
Year ³	8.07×10^{-8} (7.76×10^{-8})	3.63×10^{-7} * (7.64×10^{-8})	6.59×10^{-8} (5.75×10^{-8})	2.81×10^{-7} * (5.77×10^{-8})	1.38×10^{-8} (5.64×10^{-8})	1.05×10^{-7} * (3.86×10^{-8})
Dum1	1.74* (0.486)	0.662 (0.478)	0.515 (0.360)	0.700 (0.361)	1.266* (0.353)	1.05* (0.242)
Observations	90	90	90	90	90	90

Note. Standard errors are in parentheses. Dum1 = $(-322 \leq \text{Year} \leq -313)$.

* Significantly different from zero at 1% probability.

There are some costs to this procedure. The regression can be done only for years in which there are observations of all prices in order to calculate correlations among the residuals. The regression coefficients will be estimated less precisely as a result, and Dum2 and Dum3 cannot be included at all for lack of timely observations. The results of seemingly unrelated regressions will be more efficient but will use far fewer observations.

The Breusch-Pagan test of independence of the regressions for different crops yields a chi-square with 15 degrees of freedom of 406. This is significantly different from zero at any conceivable level of significance. The errors of the equations in Table 2 clearly are correlated; the prices behave just the way in which market prices of agricultural prices in a local area are expected to act.

The results of estimating seemingly unrelated regressions are shown in Table 3. These results are comparable to those in Table 2. The coefficients are nearly the same, confirming the results in Table 2. The standard errors are much larger, however, and not all coefficients are significant. This is due partly to the better estimation technique and partly to the reduced number of observations. Because the number of observations in each regression falls from more than 500 to 90, the results in Table 2 are more reliable. Of course, all of the errors are subject to the autocorrelation shown in Table 1, and the trends shown in Tables 2 and 3 should be taken as purely descriptive rather than as evidence of an underlying price formation process. That process is shown in Table 1.

Dum1, the only dummy that can be estimated in seeming unrelated regressions, is large and significantly different from zero in half of the crops. Given the short time span of the window, the reduction in the number of observations probably is to blame for the reduction in significance. The correlation between the residuals for individual crops shows the effect of market forces in ancient Babylon.

CONCLUSIONS

Taking all of these observations together, I reach two conclusions. First, careful analysis of these prices using time-series techniques confirms the conclusion in Slotsky (1997) that these prices were market prices. They moved with a great deal of randomness, and they varied over time. These agricultural prices moved like the random walk of modern prices, and they varied together in response to weather that affected all crops. These changes are understood clearly within a market framework; they are impossible to understand within an administrative one. I conclude, therefore, that the scribes recorded prices set in functioning markets.

Second, the pattern of prices informs us of economic conditions in Babylon before the Common Era. Prices fluctuated a lot. The return and subsequent death of Alexander led to a major shock to the supply of money and, therefore, to prices, and this shock was sustained for a generation or more. Prices rose sharply and stayed high; normal conditions did not return for more than 20 years. This price disruption indicates how hard it was for political and economic stability to return. It shows how hard it was to reestablish peaceful conditions where foodstuffs were available cheaply. People living in Babylon during this transition must have had a very difficult time. It appears that food was twice as expensive as usual in the city of Babylon, and it is unlikely that many urban dwellers had assets that enabled them to offset the scarcity of food. Farmers, by contrast, might not have been affected if the prices they received for their produce rose as much as the prices of products they bought.

Prices rose during the last two centuries before the Common Era, gradually at first and then with increasing speed. This inflation suggests a gradual weakening of the political structure in Babylon during the final centuries before the Common Era given that there does not appear to have been a shock to the money supply during these years. A gradual inflation does not indicate as much hardship for ordinary people as did the sudden price rise of years before 300 BCE. Wool became expensive relative to other products at the end of the period, with prices that rose beyond the rise of other prices. This may have been a hardship for many people and possibly a boon for a few. Only future research can discover the cause of this price inflation and its possible effects on the lives of ordinary people.

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