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Inventories, Sticky Prices, and the Propagation of Nominal Shock

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Abstract

Post-war business cycle fluctuations of output and inflation are remarkably persistent. Recent sticky-price monetary business cycle models, however, grossly underpredict this persistence. We assess whether adding inventories to a standard sticky-price model raises the persistence of output and inflation. For this addition, we consider three different frameworks: a linear-quadratic inventory model, a factor of production model, and a transaction costs model. We find that adding inventories increases the persistence of output and inflation, but that the increase is smaller for inflation. Overall, the transaction costs model explains more the persistence of output and inflation than the other models.

JEL classification: E22, E30

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1. Introduction

Post-war US business cycle fluctuations of output and inflation are remarkably persistent. A number of recent papers study the ability of sticky-price monetary business cycle models to explain this persistence (e.g. Andersen 1998, Ascari 2000, Chari, Kehoe, and McGrattan 2000, Christiano, Eichenbaum, and Evans 2001, Fuhrer and Moore 1995, Ireland 2001, Kiley 1996, and Nelson 1998). With the exception of Christiano, Eichenbaum, and Evans (2001), these papers show that existing monetary business cycle models with

The last two reasons suggest that the gradual adjustment of inventory stocks is an explanation for the sluggishness of both output and inflation changes. In the terminology of Ball and Romer (1990), inventories create a real rigidity. They write "Researchers have presented a wide range of explanations for wage and price rigidities: examples include implicit contracts, customer markets, social customs, efficiency wages, *inventory* models, and counter-cyclical markups" (page 183). In other words, the effects of money growth shocks on the real economy created by nominal rigidities become quantitatively important and persistent with inventories.

To achieve our objective, we compare the persistence of output and inflation in monetary business cycle models with and without inventories. We evaluate whether adding inventories raises the persistence by directly comparing the sample autocorrelations of output and inflation produced by the different models. In addition, we verify whether the models with inventories reproduce two features of the data: sales are less volatile than output and changes in inventories are procyclical.

model are positive only for the first six lags. In contrast, the autocorrelations of output computed from quarterly post-war US data are positive for the first 18 lags. Those of inflation are positive for the first 11 lags.

Sections 3, 4, and 5 verify whether adding inventories to the baseline model enhances the lasting effects of money growth shocks. In each of these inventories models, only producers hold inventories, while the retailer does not. Ramey and West (1999) document that, for 1995, about 37 percent of inventories were held in manufacturing and 52 percent were held in either retail or wholesale trade. We abstract from inventories in the retail sector for two reasons. First, we introduce the retailer only to simplify the exposition. Our approach is equivalent to one where the consumer purchases goods directly from producers. Second, we are interested in the interaction between inventories and pricing decisions of monopolistic producers. In doing so, we follow Blinder and Fischer (1981) and Hornstein and Sarte (1998).

Section 3 discusses the persistence of output and inflation in a monetary business cycle model with inventories that share several features with the linear-quadratic model of West (1990). In this model, producers manage an inventory stock of goods, but face costs of changing the level of production and costs of deviating from a ratio of sales to inventories. The first cost provides a production smoothing motive and the second represents stockout costs. Overall, we find that adding inventories raises the persistence of output, but not that of inflation. The linear-quadratic model generates autocorrelations of output that are positive for the first nine lags and that are larger than those produced by the baseline model. It also generates autocorrelations of inflation that are positive for the first four lags only. The increase in the persistence of output results only partially from the smoothing motive. That is, without the costs of changing the level of production, the autocorrelations of output are still larger than those produced by the baseline model. The linear-quadratic model, however, counterfactually predicts that sales are more volatile than output and that changes in inventories are countercyclical.

Section 4 discusses the persistence of output and inflation in a factor of production model that embodies a feature found in the model of duction. T

2.1 The Consumer

The representative consumer'

$$\frac{U_c(Z_t)}{\left[1 - \nu\left(\frac{I_t}{K_t} - \delta\right)\right]} = \beta E_t \left\{ \frac{U_c(Z_{t+1})}{\left[1 - \nu\left(\right.\right.}\right.$$

$$\alpha\, r_t^k k_{it} = (1-\alpha) w_t n_{it}, \tag{9.2}$$

$$(\theta - 1)p_{it}s_{it} - \lambda_{it}\left[\theta s_{it} - \phi_p\left(\frac{p_{it}}{\pi p_{it-1}} - 1\right)\frac{p_{it}}{\pi p_{it-1}} y_{it}\right] = E_t\left\{R_{t+1}^{-1}\lambda_{t+1}\phi_p\left(\frac{p_{it+1}}{\pi p_{it}} - 1\right)\frac{p_{it+1}}{\pi p_{it}} y_{it+1}\right\}, \tag{9.3}$$

where λ_i is the multiplier associated with constraint (7).

2.3 The Retailer

The competitive retailer's profits are

$$P_t G_t - \int p_{it}\, s_{it}\, di. \tag{10}$$

The retailer aggregates individual goods using the technology

$$G_t = \left[\int g_{it}^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}, \tag{11}$$

where $g_{it} = s_{it}$.

The retailer chooses inputs and output to maximize profits. The first-order necessary conditions of this problem imply the goods demand function displayed in equation (8). The demand functions for all goods and the retailer's zero-profit condition yield the aggregate price index

$$P_t = \left[\int p_{it}^{1-\theta} di\right]^{\frac{1}{1-\theta}}. \tag{12}$$

2.4 The Monetary Authority

The monetary authority is passive and provides nominal transfers according to

$$T_t = M_t - M_{t-1}. \tag{13}$$

The growth rate of money, $\mu_t = \ln(M_t/M_{t-1})$, evolves as

$$\mu_t = (1-\rho)\ln(\pi) + \rho\mu_{t-1} + \ _t, \tag{14}$$

where   is a mean zero random variable with variance σ_μ^2.

2.5 Market Clearing and Aggregation

Clearing of the bond, labor, capital, and goods markets requires

$$B(Z_t) = 0, \tag{15.1}$$

$$N_t = \int n_{it}\, di, \tag{15.2}$$

$$K_t = \int k_{it}\, di, \tag{15.3}$$

$$S_t = Y_t - \frac{\phi_p}{2}\left(\frac{P_t}{\pi P_{t-1}} - 1\right)^2 Y_t, \tag{15.4}$$

$$G_t = S_t, \tag{15.5}$$

$$C_t + I_t = G_t, \tag{15.6}$$

where aggregate quantities are given by $Y_t =$ [redacted] $y_{it}\, di$ and $S_t =$ [redacted] $s_{it}\, di$. Also, note that $n_{it} = N_t$, $k_{it} = K_t$, $y_{it} = Y_t$, $s_{it} = S_t$, $g_{it} = G_t$, and $p_{it} = P_t$ because all producers are identical. Finally, the aggregate production function is

$$Y_t$$

Kydland and Prescott (1982) and set $\beta = 0.99$. We also follow Ireland (2001) and use his estimated value of ϕ_p for the pre-1979 period: $\phi_p = 72.01$ (See Ireland Table 1). Our empirical results, however, are qualitatively similar if we use the estimate for the post-1979 period ($\phi_p = 77.10$). Finally, we use quarterly data on $M2$ to estimate ρ and σ_μ. The results are $\rho = 0.72$ and $\mu = 0.006$.

2.7 Empirical Results

Figure 1 displays autocorrelations of output and inflation for up to 20 lags. The autocorrelations in the post-war US sample are computed as the sample autocorrelations from the logarithm of output and the inflation rate over the 1959:1 to 2000:1 period (see Data Appendix). Output corresponds to per capita gross domestic product and the inflation rate to the first difference of the logarithm of the consumer price index. In the data, the logarithm of output displays an upward trend. For our computations, we remove the trend by regressing the logarithm of output on a constant, a linear trend, and a quadratic trend. The residual of this ordinary least squares regression is our definition for the cycle of the logarithm of output. Although the inflation rate does not possess a trend, we nevertheless remove one similarly to that of output. We do so for two reasons. First, we wish to treat inflation and the logarithm of output similarly. Second, we wish to account for the fact that post-war US inflation is on average much higher during the 1970s and early 1980s than during the 1960s and 1990s. This feature alone would suggest that inflation fluctuations are extremely persistent. It is doubtful, however, that it reflects a business cycle fluctuation of inflation. Our detrending method may not completely eliminate the influence of this period, but it is a step in the right direction. Overall, it is important to note that the sample autocorrelations obtained for both output and inflation are sensitive to the detrending method. For this reason, the Results Appendix shows autocorrelations computed from (the number of quarters of the post-war US sample).

A comparison between the autocorrelations computed from the post-war US sample and those predicted by the baseline model shows that the model grossly underpredicts the persistence of output and inflation. The autocorrelations of output and inflation predicted by the baseline model decline much more rapidly than those computed on the post-war US sample. The autocorrelations of output computed from the post-war US sample are positive for the first 18 lags, and negative after. Those of inflation are positive for the first 11 lags. The autocorrelations of output predicted by the baseline model are positive for the first 16 lags, but are very close to zero after the first nine lags. The autocorrelations of inflation are only positive for the first six lags.

Figure 2 displays the dynamic responses of output, inflation, and money growth in percent deviations from their steady-state levels computed from the baseline model. The [illegible] model generates real effects to the money growt[illegible]ses sh[illegible]ation le.

where x_i is the stock of inventories. Labor is used in three activities. The first term on the right side of equation (18) represents the time allocated to production. The second term reflects the labor used to change the level of production. Finally, the last term is a labor cost due to deviations of inventories from a fraction of sales. This term represents as well as equations (15.5) and (15.6). Aggregate quantities are as before, except for $n_{it} = n_t$ and $x_{it} = X_t$. Finally, the aggregate production function is

$$Y_t = \Gamma n_t^{\blacksquare} K_t^{1-\blacksquare}. \tag{22}$$

3.3 Calibration

Table 1 also reports the calibration of the linear-quadratic model. The calibration is similar to that of the baseline model. That is, we set β, σ, ω, χ, δ, Γ, α, ϕ_p, θ, ρ, and σ_μ to the same values. We also set ψ and ν so that hours worked are 30 percent of the time endowment and that the standard deviation of investment is 2.9 times that of output.

The linear-quadratic model has three additional parameters: ζ_1, ζ_2, and η. West (1990) estimates a cost function similar to that in equation (18). Although the exact specification differs, West's estimate offer a good benchmark (see West Table III). Estimates for ζ_1 range from $2{\times}0.344$ to $2{\times}0.366$ and estimates for ζ_2 range from $2{\times}0.111$ to $2{\times}0.145$. Accordingly, we set $\zeta_1 = 0.7$ and $\zeta_2 = 0.25$. West also provides estimates for η that range between -0.040 and -0.057, but argues that a value between 0.4 and 0.7 reflects the general concensus. We set $\eta = 0.68$ so that steady-state sales are 60 percent of available goods (output plus inventories) as in the post-war US sample.

3.4 Empirical Results

Figure 3 shows sample autocorrelations of output and inflation for up to 20 lags. The autocorrelations are computed as before. Table 2 reports the relative volatility of sales to output, the relative volatility of changes in inventories to output, and the correlation between changes in inventories and output. As for the autocorrelations, these moments are computed from the post-war US sample and the model. In the post-war US sample, the relative volatility of sales is the ratio of the standard deviation of the logarithm of per capita sales to the standard deviation of the logarithm of per capita gross domestic product, where sales are computed from the data using equation (21.2). The relative volatility of inventories is the ratio of the standard deviation of changes in inventories to the standard deviation of the logarithm of output. Changes in inventories corresponds to the ratio of changes in private per capita inventories to per capita gross domestic product. The moments predicted by the model are averages over 1000 simulations of 164 periods. As for the autocorrelations, the different moments are computed from detrended variables.

The results for our benchmark calibration of the linear-quadratic model appear as output, and by depleting inventories. He must account for the cost of adjusting prices and the marginal cost of production, as well as for the cost of changing output and the cost of having inventories deviate from a fraction of sales. With the benchmark calibration, a producer adjusts price, output, and inventories to trade off all these costs. The reduction in inventories ensures that output does not increase as much as in the baseline model. It also ensures that the change in output is lasting to gradually replenish inventories.

We wish to verify the robustness of these results to the values of the additional parameters ζ_1, ζ_2, and η. To that end, we perform three experiments on the linear-quadratic model.

Our first experiment investigates the effects of the cost of changing production. This cost offers a production smoothing motive that may explain the increase in the persistence of output. For this experiment, we reduce this cost by lowering ζ_1 from 0.7 to 0.01. The results of this experiment appear as Low Smoothing in Figure 3 and Table 2. Diminishing the cost of changing output reduces the predicted autocorrelations of output, but these autocorrelations are still larger than those predicted by the baseline model. Clearly, the gradual adjustment of inventories adds to the persistence of output fluctuations. Otherwise, diminishing the cost of changing output has little effects. The autocorrelations of inflation are still small, sales are still more volatile than output, and changes in inventories are still countercyclical.

Our second experiment investigates the effects of the cost of having inventories deviate from a fraction of sales (the convenience yield cost). It might be possible to make changes in inventories procyclical by increasing this cost and forcing inventories to track sales more closely. For this experiment, we make the deviations more costly by raising ζ_2 from 0.25 to 4, while keeping $\zeta_1 = 0.01$. The results appear as & High Yield Costs. Raising this cost makes inventories procyclical and sales less volatile than output. It also severely reduces the predicted autocorrelations of output and inflation. By making inventories procyclical, a higher cost eliminates the need for the lasting increase in output required to replenish inventories.

Our last experiment investigates the effects of the steady-state level of the ratio of sales to all available goods. A large steady-state level of this ratio is associated with a low convenience of having inventories and a low steady-state level of inventories. For this experiment, we raise the steady-state ratio of sales to available goods from 0.6 to 0.82 by reducing η from 0.68 to 0.24. This value for the ratio is similar to that obtained in Bils and Kahn (2000). The results of this experiment appear as Low Convenience. The increase in the steady-state ratio of sales to available goods raises the autocorrelations of output, but has very little impact on the autocorrelations of inflation as well as on moments of sales and changes in inventories.

4. The Factor of Production Model

The factor of production model adds inventories to the baseline model by following Kydland and Prescott (1982). In particular, inventories are an input in production, because they reduce down time and help economize on labor. Our version of the factor of production model is different from that of Kydland and Prescott. Importantly, our producers are monopolistic competitors, while theirs are perfect competitors. Also, we consider only monetary growth shocks, while they consider only real technology shocks.

$$\alpha\, r_t^k k_{it} = (1-\alpha) w_t n_{it} (1-\ell) \left[\frac{k_{it}^{-\varepsilon}}{(1-\ell) k_{it}^{-\varepsilon} + \ell\, x_{it}^{-\varepsilon}} \right], \tag{24.2}$$

$$(\theta - 1)\, p_{it} s_{it} - \theta \lambda_{it} s_{it} + \lambda_{it} \phi_p \left(\frac{p_{it}}{\pi p_{it-1}} - 1 \right) \frac{p_{it}}{\pi p_{it-1}} y_{it} = E_t \left\{ R_{t+1}^{-1} \lambda_{it+1} \phi_p \left(\frac{p_{it+1}}{\pi p_{it}} - 1 \right) \frac{p_{it+1}}{\pi p_{it}} y_{it+1} \right\}, \tag{24.3}$$

$$\lambda_{it} = E_t \left\{ R_{t+1}^{-1} \left(\lambda_{it+1} + \lambda_{it+1} \left[1 - \frac{\phi_p}{2} \left(\frac{p_{it+1}}{\pi p_{it}} - 1 \right)^2 \right] (1-\alpha) \frac{y_{it+1}}{x_{it+1}} \ell \left[\frac{x_{it+1}^{-\varepsilon}}{(1-\ell) k_{it+1}^{-\varepsilon} + \ell\, x_{it+1}^{-\varepsilon}} \right] \right) \right\}, \tag{24.4}$$

where λ_i is the shadow price of inventories or the multiplier associated with equation (19).

4.2 Market Clearing and Aggregation

Clearing of the bond, labor, capital, and goods markets are as in equations (15.1), (15.2), (15.3), (21.2), (15.5), and (15.6). Aggregate quantities are as in the linear-quadratic model, except for $n_{it} = N_t$. Finally, the aggregate production function is

$$Y_t = \Gamma N_t^{\blacksquare} \left(\left[(1-\ell) K_t^{-\varepsilon} + \ell\, X_t^{-\varepsilon} \right]^{-1/\varepsilon} \right)^{1-\blacksquare}. \tag{25}$$

4.3 Calibration

Table 1 reports the calibration. As for the linear-quadratic model, we set percent of available goods, and that the steady-state capital stock is 9.2 times the output (as in the baseline model).

4.4 Empirical Results

The results for the benchmark calibration appear in Figure 5 and Table 2. The sample autocorrelations shown in Figure 5 suggest that having inventories as an input raises the persistence of output beyond that predicted by both the baseline and linear-quadratic model. It also slightly increases the persistence of inflation. The autocorrelations of output predicted by the benchmark factor of production model are positive for the first ten lags, and larger than those predicted by the benchmark linear-quadratic model. The autocorrelations of inflation are positive for the first six lags, and also larger than those predicted by the benchmark linear-quadratic model. Otherwise, the factor of production model behaves similarly to the linear-quadratic model: changes in inventories are less volatile than output, sales are much more volatile than output, and changes in inventories are countercyclical.

Figure 6 displays the dynamic responses of output, inflation, and money growth produced by the benchmark factor of production model. As for the linear-quadratic model, the dynamic responses of the factor of production model differ from that of the baseline model because producers can vary inventories to respond to changes in demand. In the factor of production model, as in the linear-quadratic model, a producer meets a larger demand by increasing price and output, and by depleting inventories. In making his decisions, he accounts for the cost of adjusting prices and the increasing marginal cost of production. In this case, the short-run marginal cost of production depends on inventories. A reduction of inventories, r- weon , i s n ot n y ice n y s w substitutable which might generate procyclical changes in inventories. For our experiment, we reduce the elasticity by raising ε from 5 to 100. T

5.1 Producers

Producer i's expected discounted profits are described in equation (5). The production technology is given in equation (6) and the stock of inventories evolves as in equation (19). Producer i faces the demand

$$s_{it}^d = \left[\frac{P_t}{p_{it}}\right]^\theta G_t \gamma^{\theta-1} a_{it}^{\xi(\theta-1)}, \tag{26}$$

where $a_{it} = y_{it} + x_{it}$ is the stock of good i available.

The producer chooses labor, capital, inventories, and prices to maximize expected discounted profits. This problem yields the following necessary first-order conditions:

$$P_t w_t = (p_{it} - \lambda_{it})\,\xi(\theta-1)\frac{s_{it}}{a_{it}}\alpha\,\frac{y_{it}}{n_{it}} + \lambda_{it}\left[1 - \frac{\phi_p}{2}\left(\frac{p_{it}}{\pi p_{it-1}} - 1\right)^2\right]\alpha\,\frac{y_{it}}{n_{it}}, \tag{27.1}$$

$$\alpha\, r_t^k k_{it} = (1-\alpha) w_t n_{it}, \tag{27.2}$$

$$\begin{aligned}(\theta-1)p_{it}s_{it} - \lambda_{it}\left[\theta s_{it} - \phi_p\left(\frac{p_{it}}{\pi p_{it-1}} - 1\right)\frac{p_{it}}{\pi p_{it-1}} y_{it}\right] = \\ E_t\left\{R_{t+1}^{-1}\lambda_{it+1}\phi_p\left(\frac{p_{it+1}}{\pi p_{it}} - 1\right)\frac{p_{it+1}}{\pi p_{it}} y_{it+1}\right\},\end{aligned} \tag{27.3}$$

$$\lambda_{it} = E_t\left\{R_{t+1}^{-1}\left(\lambda_{it+1} + (p_{it+1} - \lambda_{it+1})\xi(\theta-1)\frac{s_{it+1}}{a_{it+1}}\right)\right\}, \tag{27.4}$$

where λ_i is the shadow price of inventories or the multiplier associated with equation (19).

5.2 The Retailer

The retailer's profits are depicted in equation (10). The retailer aggregates goods using the technology displayed in equation (11). The retailer finds it costly to purchase goods. The cost of purchasing s_{it} goods is $(1 - \gamma a_{it}^\xi)s_{it}$, such that

$$g_{it} = \gamma a_{it}^\xi s_{it}. \tag{28}$$

The representative retailer chooses inputs and output to maximize profits. For convenience, we split the representative retailer in two retailers. The first retailer purchases s_{it} at price p_{it} and sells g_{it} at price $\hat{p}_{it}$ to the second retailer. The zero profit condition of the first retailer is $\hat{p}_{it}g$

are much more volatile than output. This occurs because the volatility of both sales and output declines, but the reduction is larger for output (given the impact of both available goods and prices on sales). Over time, the producer gradually replenish its inventories and manages the demand by smoothly increasing output.

We wish to verify the robustness of these results to the values of the coefficient of risk aversion σ and the additional parameter ξ.

ever, fail to explain this persistence. Our objective is to determine whether adding inventories to a standard sticky-price monetary business cycle model raises the predicted persistence of output and inflation.

To fulfill this objective, we compare the persistence of output and inflation computed from three different models with inventories to the persistence computed in a model without inventories. Our three models with inventories are a linear-quadratic model, a factor of production model, and a transaction costs model. These models emphasize different roles for inventories. In the linear-quadratic model, producers manage inventories to avoid the costs associated with changing output and with having inventories deviate from a target fraction of sales. In the factor of production model, producers manage a stock of inventories that is an input in production. Finally, in the transaction costs model, producers manage inventories that affect the demand for its goods by making it easier for consumers to shop.

We find that the propagation properties of inventories depend on the role played by

Data Appendix

Our quarterly post-war US sample covers the 1959:1 to 2000:1 period. It comprises the following: *Gross Domestic Product:* Bureau of Economic Analysis, NIPA Table 1.2; *Change in Private Inventories:* Bureau of Economic Analysis, NIPA Tables 1.2, 5.11A, 5.11B; *Private Inventories:* Bureau of Economic Analysis, NIPA Tables 5.13A, 5.13B; *Consumer Price Index:* Bureau of Economic Analysis, NIPA Table 7.1; *Investment:* fixed investment, Citibase, mnemonic GIFQF; *Population:* Citibase, mnemonic P16; and *M2 Money Stoc S*

Results Appendix

Figures A1, A3, A5, and A7 display the autocorrelations of output and inflation, while Table A2 displays the relative volatility of sales, the relative volatility of changes in inventories, and the correlation between changes in inventories and output.

There are two main computational differences between these statistics and those shown in Figures 1, 3, 5, and 7, and in Table 2. The first difference is that, for both the postwar US sample and the models, all variables are detrended by the Hodrick-Prescott filter

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Table 1: Benchmark Parameter Values

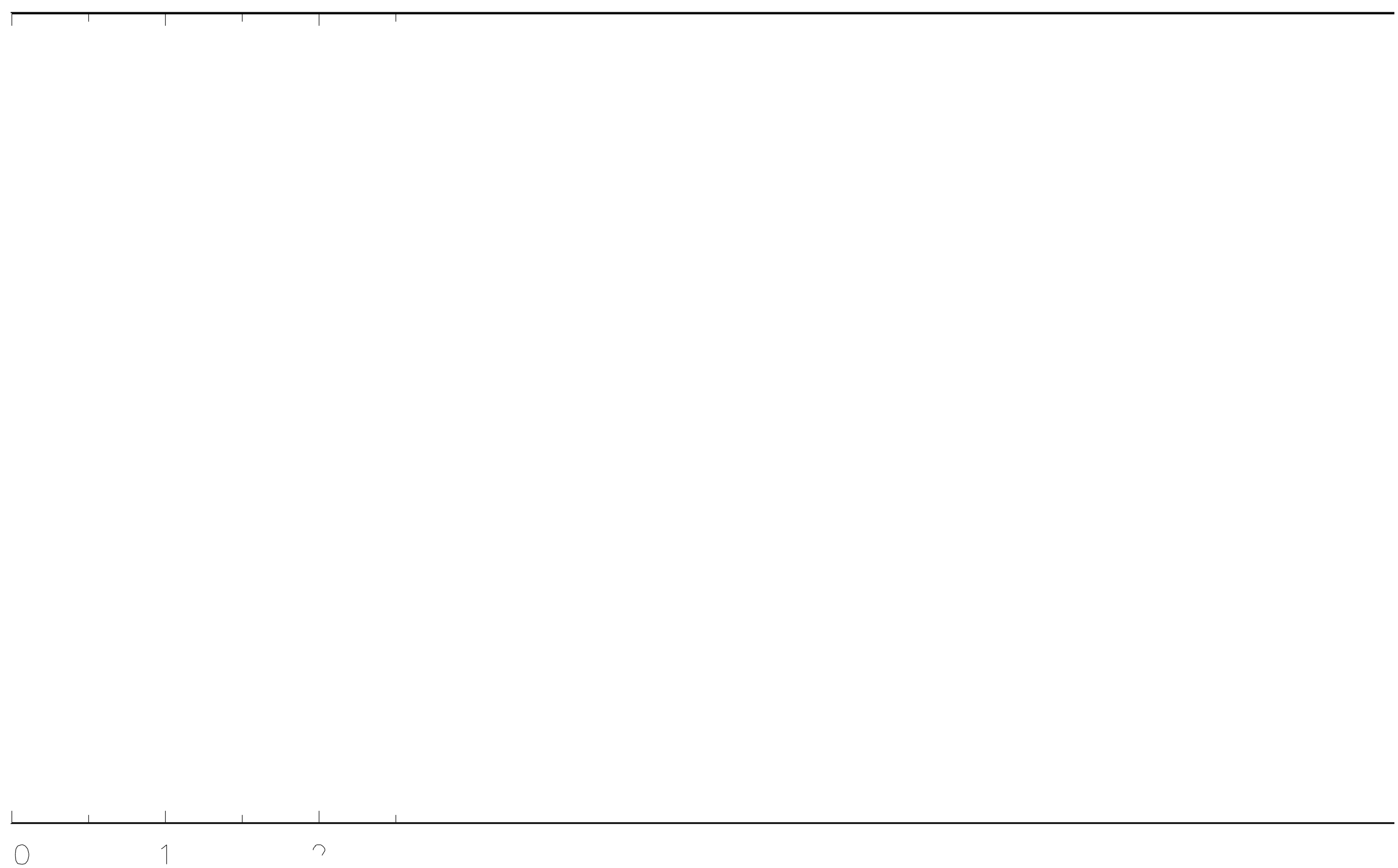
The Baseline Model	
Consumers	$\beta = 0.99$, $\sigma = 1$, $\omega = 0.94$, $\chi = 0.39$, $\psi = 1.7119$, $\delta = 0.025$, $\nu = 5.71$
Producers	$\Gamma = 1$, $\alpha = 0.64$, $\phi_p = 72.01$
Retailers	$\theta = 10$
Monetary Authority	$\rho = 0.72$, $\sigma_\mu = 0.006$
The Linear-Quadratic Model	
Consumers	$\beta = 0.99$, $\sigma = 1$, $\omega = 0.94$, $\chi = 0.39$, $\psi = 1.6967$, $\delta = 0.025$, $\nu = 14.6$
Producers	$\Gamma = 1$, $\alpha = 0.64$, $\phi_p = 72.01$, $\zeta_1 = 0.7$, $\zeta_2 = 0.25$, $\eta = 0.68$
Retailers	$\theta = 10$
Monetary Authority	$\rho = 0.72$, $\sigma_\mu = 0.006$
The Factor of Production Model	
Consumers	$\beta = 0.99$, $\sigma = 1$, $\omega = 0.94$, $\chi = 0.39$, $\psi = 1.7028$, $\delta = 0.025$, $\nu = 19.4$
Producers	$\Gamma = 1$, $\alpha = 0.64$, $\phi_p = 72.01$, $\ell = 0.3 \times 10^{-7}$, $\varepsilon = 5$
Retailers	$\theta = 10$
Monetary Authority	$\rho = 0.72$, $\sigma_\mu = 0.006$
The Transaction Costs Model	
Consumers	$\beta = 0.99$, $\sigma = 1$, $\omega = 0.94$, $\chi = 0.39$, $\psi = 1.7345$, $\delta = 0.025$, $\nu = 54.52$
Producers	$\Gamma = 1$, $\alpha = 0.64$, $\phi_p = 72.01$
Retailers	$\theta = 10$, $\gamma = 0.9906$, $\xi = 0.0168$
Monetary Authority	$\rho = 0.72$, $\sigma_\mu = 0.006$

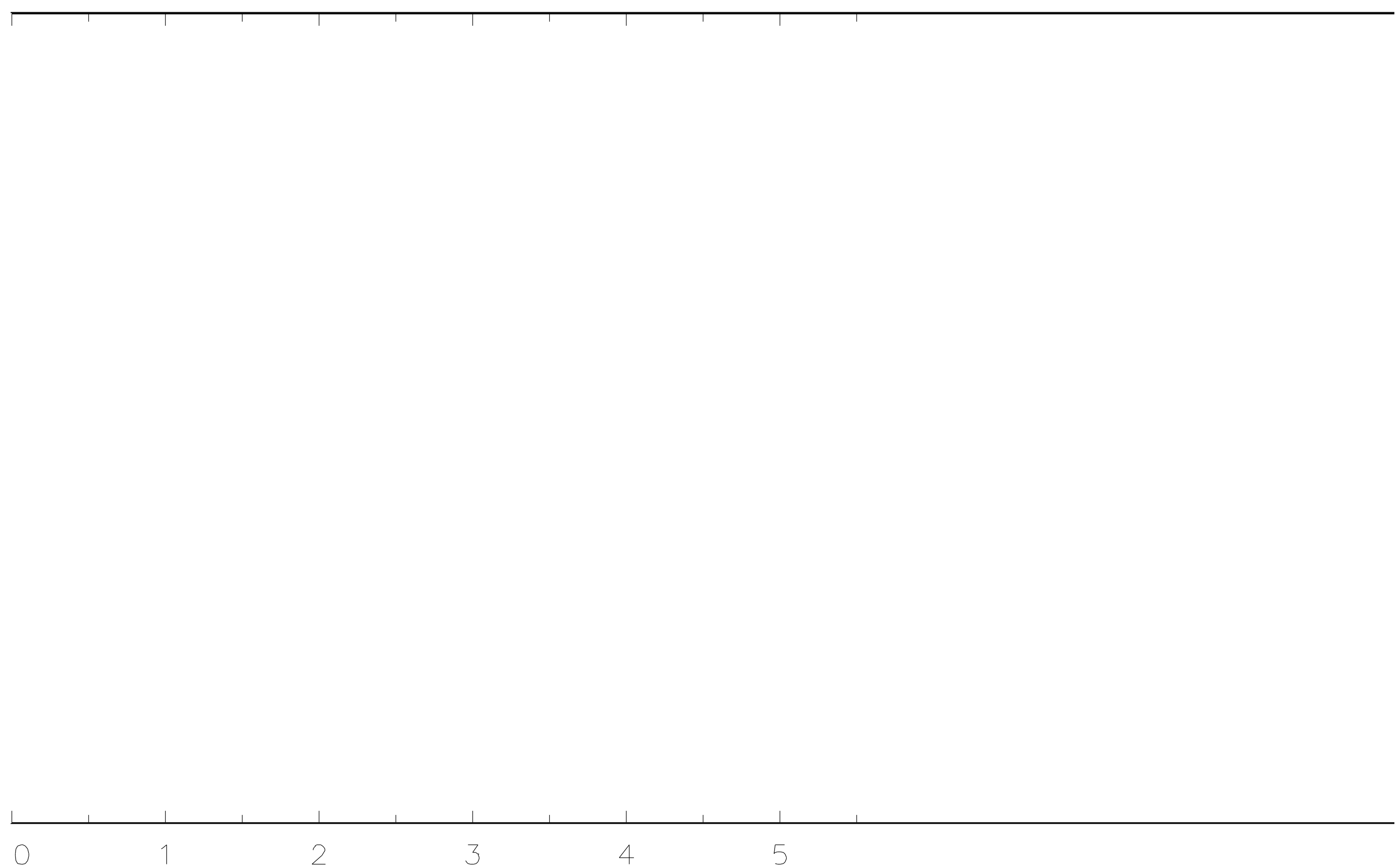
Note: Several parameters are set endogenously. The values for ψ and ν ensure that hours worked are 30 percent of the time endowment in the steady state and that the ratio of the standard deviations of the logarithm of investment and the logarithm of output is 2.9. The values h pNfr s m θ 006p - d l

Table 2. Empirical Results: Sales, Inventories, and Output

	Volatility Relative to Output	*Correlation with Output*
	Sales	

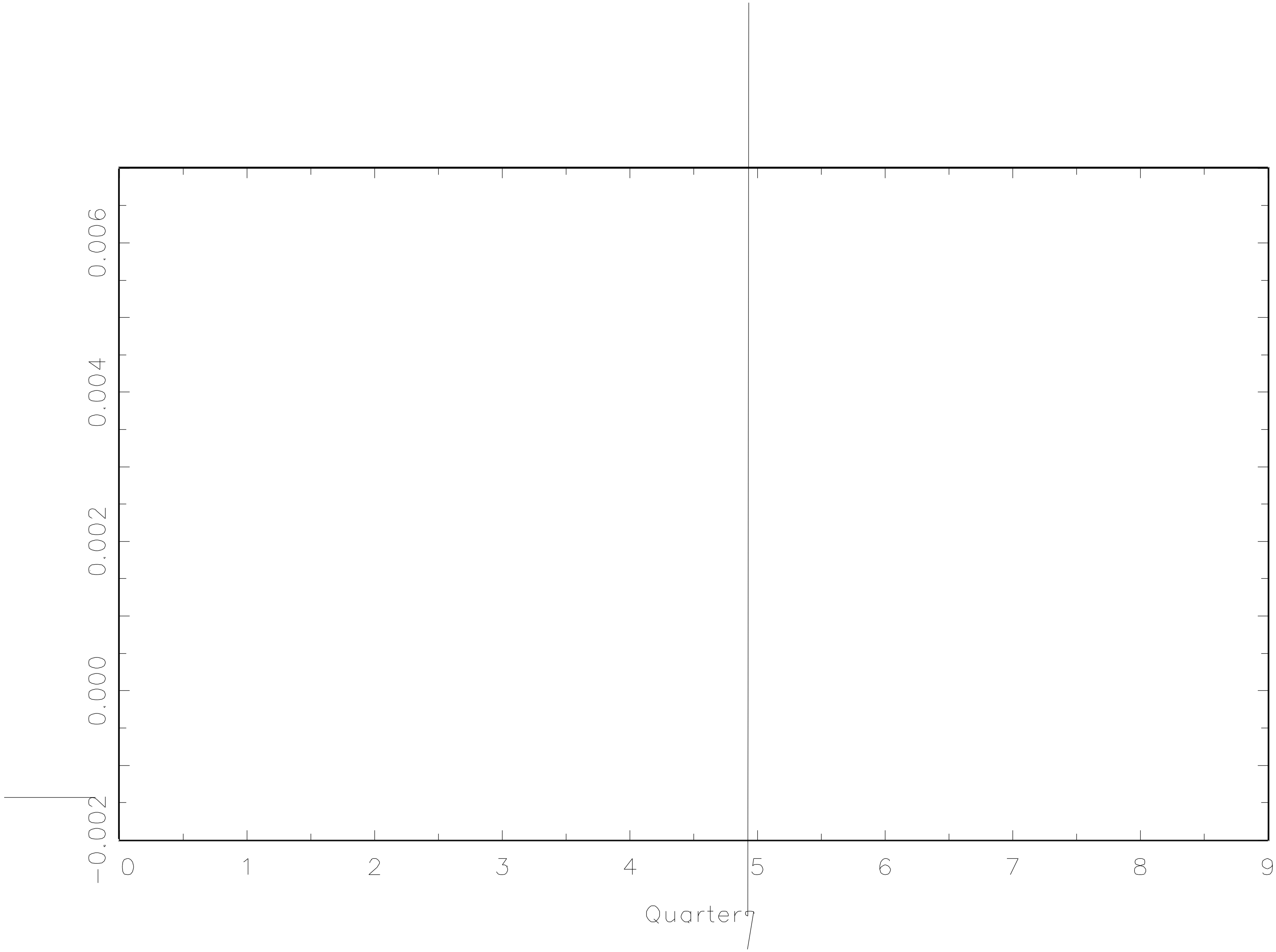

0
2
4
6
8
10
12
14
16
18


0
1


0
1
2
3
4
5


0 2 4 6 8 10 12 14 16 18


0 2 4 6 8 10 12 14 16 18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0.004
0.002
0.000
−0.002
0
1
2
3
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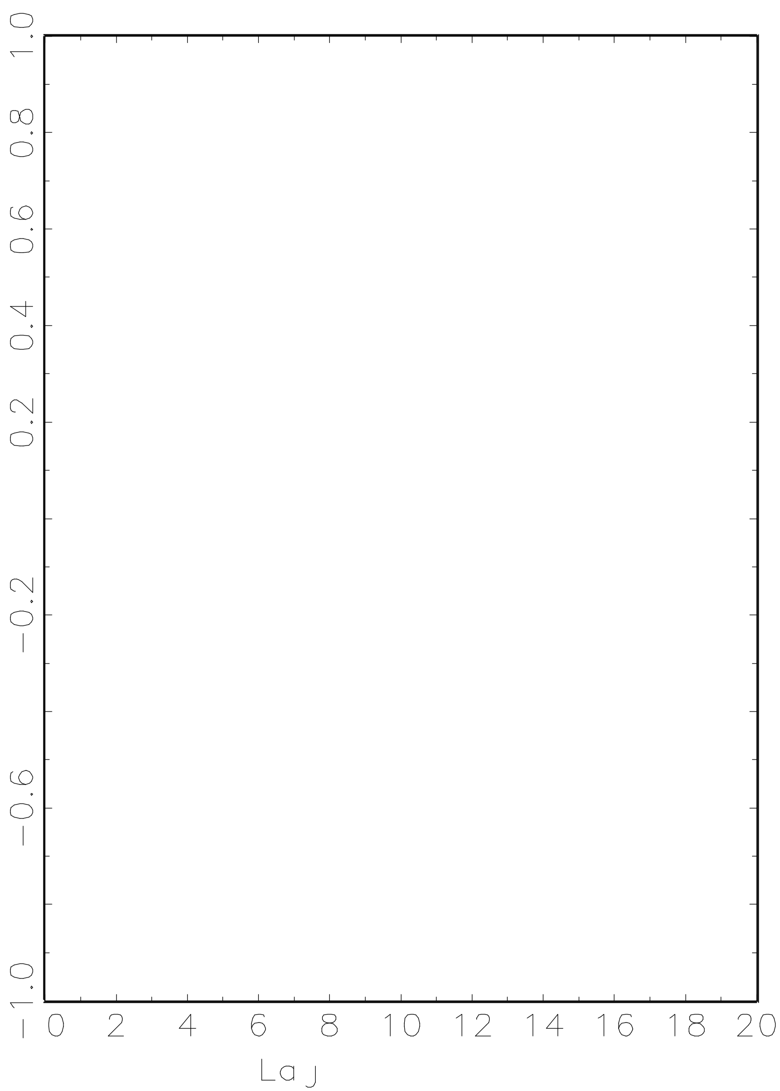
7
8
9
Quarter

Table A2. Empirical Results of Hodrick-Prescott Filtered Data

	Volatility Relative to Output		*Correlation with Output*
	Sales	Inventories	Inventories
Post-war US	0.85	0.28	0.60
Baseline	1.00	—	—
Linear-Quadratic			
Benchmark	1.60	0.98	-0.31
Low Smoothing	1.34	0.45	-0.63
& High Yield Costs	0.99	0.02	0.61
Low Convenience	1.57	0.96	-0.28
Factor of Production			
Benchmark	2.00	1.25	-0.58
Low Elasticity	1.67	0.93	-0.48
Low Convenience	1.56	0.76	-0.56
Transaction Costs			
Benchmark	5.31	6.03	0.76
High Risk Aversion	3.46	2.53	-0.91
& Low Convenience	3.33	2.41	-0.89

Note: The variables are as **m** &e les are as **m** e **l** *i* Note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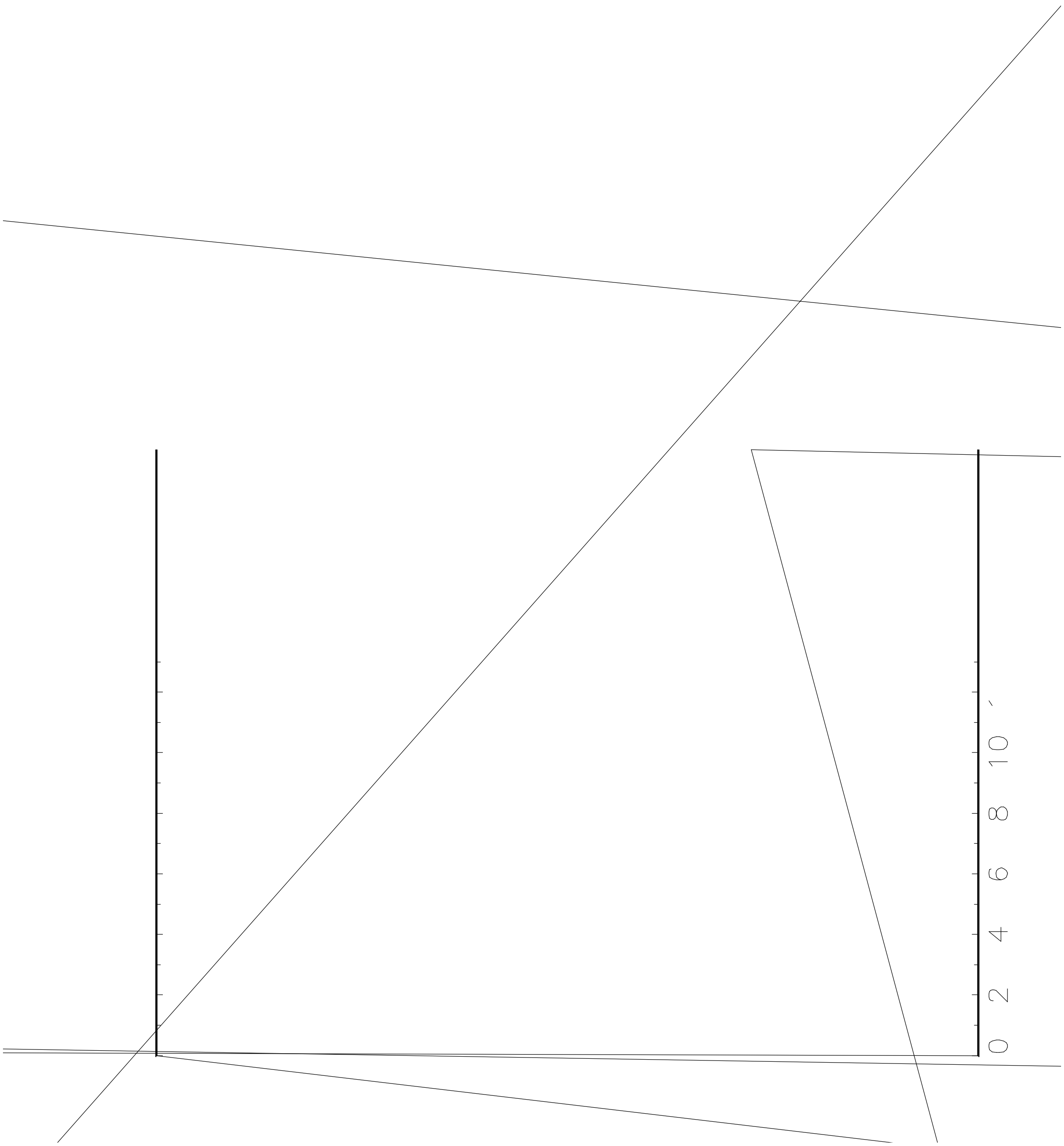
0.4
0.2
-0.2
-0.6
-1.0
0
2
4
6
8
10
12
14
16
18
20
Lag


0 2 4 6 8


0
2
4
6
8
10
12
14
16
18
20


0 2 4 6 8 10 ′