Estimating Anticipated and Nonanticipated Demand Elasticities for Cigarettes in Spain

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This paper will test whether tobacco consumption generates addiction in Spanish people. If this is the case, can such addiction be explained in the context of rational addiction theory? Elasticities are also obtained in the cases where price variations can be anticipated or, by contrast, where they cannot. The results first reveal the addictive and rational character of Spanish tobacco consumption. With respect to estimated demand elasticities, we find the expected results, namely that the anticipated values are higher than the nonanticipated values and that the long-run effects are also higher than the short-run effects. (JEL D11, D12)

Introduction

Although the first works that analyzed the consumption of addictive goods assumed such consumption was derived from irrational behavior [Elster, 1979; Winston, 1980], subsequent studies have raised the possibility that the behavior of agents who consume addictive goods could be considered as rational, in the sense of involving forward-looking maximization with stable preferences [Becker and Murphy, 1988; Becker et al., 1991, 1994; Chalopukpa, 1991; Waters and Sloan, 1995; Olekalns and Bardsley, 1996; Grossman and Chalopukpa, 1998; Suranovic et al., 1999]. In this context, the rational addiction model proposed by Becker and Murphy [1988] is based on a behavior that maximizes the utility obtained during the total lifetime of individuals. This model incorporates the dependence between the current and the past consumption of addictive goods, which implies that recognition is given to the existence of notions of tolerance, reinforcement, and withdrawal. Tolerance suggests that a given level of consumption yields less satisfaction, as past cumulative consumption is higher. Reinforcement implies a learned response to past consumption, and withdrawal refers to a negative physical reaction and other reductions in utility associated with the cessation or interruption of consumption.

This paper will estimate the intertemporal model of rational addiction proposed by Becker and Murphy [1988], using Spanish time series on tobacco during the period 1964-95, with the objective of obtaining different anticipated and nonanticipated demand

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elasticities, which allows for characterizing the behavior of individuals with respect to tobacco consumption. To that end, we should first test whether this consumption generates addiction in Spanish people. If this is the case, can such addiction be explained in the context of rational addiction theory? In other words, we should first examine if the consumer falls into addiction after a maximization process of the utility that was obtained during his total lifetime, taking into account the future consequences of current decisions or, by contrast, if the consumer becomes addicted because he does not evaluate the future consequences of current choices.

In this context, we consider a nonseparable intertemporal utility function in which tobacco addiction incorporates the dependence between current decisions and past decisions, thus permitting the inclusion of the earlier-cited notions of tolerance, reinforcement, and withdrawal. The maximization of such a utility function, subject to the corresponding budget restriction, allows for obtaining a demand function in which current consumption depends on lag and lead consumption and current price. This demand function, in turn, allows for deriving different kinds of elasticities, depending on whether price variations can be anticipated in previous periods or, by contrast, whether consumers cannot anticipate such changes. Once the theoretical demand function and elasticities have been derived, these expressions are estimated using Spanish time series data of per capita consumption and prices during the period 1964-95.

The second section presents the household theoretical model of rational addiction, deriving the expressions of elasticities; the third section considers the data and empirical results; and the fourth section closes with a summary of the main conclusions.

The Theoretical Model

The rational addiction model for tobacco considers a utility function for consumers which incorporates the addiction that is given by the dependence between the current utility and the past consumption of the addictive good. Moreover, we assume that individuals are rational because their objective is to maximize the utility obtained during their entire lifetime. In this context, at any given moment in time, an individual's utility is assumed to be a function of health, $H(t)$, the relaxation produced by addictive consumption, $R(t)$, and a composite of other consumption goods, $Z(t)$. That is, $U(t) = U[H(t), R(t), Z(t)]$. We assume that this utility function is quasi-concave and twice continuously differentiable, and that each of the three arguments exhibit positive but diminishing marginal utilities.

The first variable, health, is assumed to be a function of some market goods, such as medical care, and the individual's own time spent, for example, on exercise, $M(t)$. These inputs have positive but diminishing effects on health, which is also affected by the cumulative past consumption of the addictive stock, $S(t)$. The stock accumulation process is described by a simple investment function, $\dot{S} = C(t) - \delta S(t)$, where $\dot{S}$ is the rate of change over time in S, C is the consumption of the addictive good, and δ is the constant depreciation rate. Cigarette consumption at time t can be thought of as a gross investment in the addictive stock. Therefore, the health production function can be expressed as $H(t) = H[M(t), S(t)]$, where $H_M > 0$, $H_{MM} < 0$, $H_S < 0$, and $H_{SS} < 0$. Relaxation, that is, the psychological benefits of smoking, is produced by the addictive good, $C(t)$, and the addictive stock, $S(t)$. Therefore, $R(t) = [C(t), S(t)]$, where $R_C > 0$, $R_{CC} < 0$, $R_S < 0$, $R_{SS} < 0$, and $R_{CS} > 0$. Increased consumption has a positive effect on the production of relaxation, whereas higher past consumption has a negative effect. This assumption incorporates the notion of tolerance into the model. To capture reinforcement effects in consumption, the marginal productivity of cigarette consumption in the production of relaxation is assumed to increase with the level of the addictive stock. Finally, the composite good is produced using inputs, $X(t)$, that include market goods and the individual's own time, with each of these assumed to have positive but diminishing marginal productivity, that is, $Z(t) = Z[X(t)]$, where $Z_X > 0$ and $Z_{XX} < 0$. In summary, we derive an instantaneous utility function, $U(t) = U[C(t), S(t), Y(t)]$, where $Y(t)$ is a vector that includes inputs into the production of the composite good and health.

Under the assumption of a time-additive utility function, with a length of life equal to T and a constant rate of time preference, σ, $Y(t)$ is treated as a composite which is considered a numeraire, $PC(t)$ is the money price of the addictive good, r is the constant market interest rate, and A_0 is the discounted value of lifetime income and assets. Thus, rational behavior implies the maximization of the lifetime utility function, subject to the lifetime budget constraint and the simple investment function:

$$\begin{aligned} \max\ U &= \int_0^T e^{-\sigma t} U[Y(t), C(t), S(t)]\, dt \\ \text{subject to} \quad & \int_0^T e^{-rt}[Y(t) + P_C(t)\ C(t)]\, dt \le A_0 \qquad (1) \\ \dot{S} &= C(t) - \delta S(t) \quad . \end{aligned}$$

On the basis of (1), a demand function is derived for the addictive good using a quadratic utility function in the difference between present consumption and addiction stock as an indicator of past consumption [Pollak, 1970]. We assume that first derivatives are positive and that the utility function is quasi-concave with negative second derivatives:

$$\begin{aligned} U(t) = {} & \frac{U_{CC}}{2}[C(t) - S(t)]^2 + \frac{U_{YY}}{2}[Y(t)]^2 + U_C[C(t) - S(t)] \\ & + U_Y Y(t) + U_{CY}[C(t) - S(t)]\,[Y(t)] \quad . \end{aligned} \qquad (2)$$

This function clearly shows the effect of consumption on utility. The addicted consumer obtains a disutility if he does not consume a minimum quantity, $S(t)$.

Moreover, we can observe that the disutility associated with withdrawal increases with the stock of addiction and, further, when an individual finishes his consumption, the addiction stock does not fall instantaneously to zero. Marginal utility increases with the addiction stock, which is a necessary condition for addiction ($U_{CC} < 0$).

Therefore, the discrete maximization of the finite lifetime utility in (2), considering that the individual's rate of time preference is equal to the market rate of interest, implies solving:

$$V^*(A_0, S(0), P_C) = K + \max_{C} \sum_0^T (1+\sigma)^{-t} F[C(t), S(t)]$$
$$\text{subject to} \quad S(t+1) - S(t) = C(t) - \delta S(t) \quad , \tag{3}$$

where:

$$K = \mu A_0 - \frac{(\mu - U_Y)^2}{2\sigma U_{YY}} \left(1 - e^{-\sigma T}\right) \quad , \tag{4}$$

$$F[C(t), S(t)] = \alpha_C C(t) + \alpha_S S(t) + \frac{\alpha_{CC}}{2} [C(t)]^2$$
$$+ \frac{\alpha_{SS}}{2} [S(t)]^2 + \alpha_{CS}[C(t)\, S(t)] - \mu P_C(t)\, C(t) \quad , \tag{5}$$

and μ is the marginal utility of income.

The first-order condition with respect to $C(t)$, and assuming that the addiction stock constitutes the consumption of the past period, allows for deriving the following demand function (see Chaloupka [1991], Labeaga [1993], Becker et al. [1994], Cameron [1997], and Grossman and Chaloupka [1998]):

$$C(t) = c_0 + c_1 C(t-1) + c_2 C(t+1) + c_3 P_C(t) \quad , \tag{6}$$

where:

$$c_0 = \frac{1}{M}\left[\frac{1}{(1+\sigma)}\alpha_S + \alpha_C\right], \quad c_1 = \frac{1}{M}\alpha_{CS}, \quad c_2 = \frac{1}{(1+\sigma)M}\alpha_{CS},$$
$$c_3 = \frac{-\mu}{M}, \quad \text{and} \quad M = \left[-\alpha_{CC} - \frac{1}{(1+\sigma)}\alpha_{SS}\right] .$$

This equation indicates that current price affects current consumption negatively, whereas past consumption and future consumption affect it positively. Moreover, the marginal utility of income, μ, only appears as a multiplying factor in the current price coefficient. That is, an increase in the marginal utility of income will imply a greater increase in the price coefficient. This means that individuals with less marginal utility of income are less sensitive to price changes which, in turn, suggests that rich individuals with a lower μ will be less sensitive to prices changes and individuals with lower income, that is, with a greater μ, will be more sensitive.

On the basis of this function, we can easily test whether consumers' behavior is addictive and, if so, whether it is rational or myopic. Thus, a good will be addictive if its consumption is complementary in several periods, that is, if its consumption in different periods is positive and significantly related. Moreover, the test of rational addiction, as compared to myopic addiction, consists of proving whether consumers take the future into account when currently making their own decisions. Thus, myopic demand is only backward looking, while rational demand is both backward looking and forward looking. Finally, the rational model implies that the past period has more influence over current consumption than the future period.

The demand function in (6) can be used to derive the different anticipated and nonanticipated demand elasticities, which appear in Table 1. These effects can be obtained by solving the second-order difference equation implicit in the demand function. Thus, the solution of the difference equation is:[1]

$$
\begin{aligned}
C(t) = {} & \frac{1}{c_1 \phi_1 (\phi_2 - \phi_1)} \sum_{s=1}^{\infty} \phi_1^s \, g(t+s) + \frac{1}{c_1 \phi_2 (\phi_2 - \phi_1)} \sum_{s=0}^{\infty} \phi_2^{-s} \, g(t-s) \\
& + \frac{1}{\phi_2^t} \left(C^0 - \frac{1}{c_1 \phi_1 (\phi_2 - \phi_1)} \right) \sum_{s=1}^{\infty} \phi_1^s \, g(s) \quad ,
\end{aligned}
\tag{7}
$$

where $g(t) = c_0 + c_3 P_C(t-1)$ and:

$$
\phi_1 = \frac{1 - \sqrt{1 - 4c_1 c_2}}{2c_1} , \; \phi_2 = \frac{1 + \sqrt{1 - 4c_1 c_2}}{2c_1} \quad .
$$

This solution results in an equation in which consumption in period t depends on prices in all periods. This equation determines the sign of the effects of changes in the price of tobacco in period τ on tobacco consumption in period t. Since an increase in past consumption increases current consumption if a good is addictive, anticipated price effects must exceed nonanticipated price effects in absolute terms. The former describes a price change in period t that is anticipated in previous periods, so past consumption is affected, whereas the latter describes a price change in period t that is not anticipated until that period, so past consumption is not affected. Moreover, there are important differences between long- and short-run responses to price changes. Thus, the short-run price effect describes the response to a change in price in period t and all future periods, whereas the long-run price effect pertains to a price change in all periods, thus, the long-run price effect must exceed the short-run price effect.

TABLE 1
Elasticities

	Anticipated	Nonanticipated
Current	$e_{CA} = \frac{P_C(t)}{C(t)} \frac{c_3}{c_1(\phi_2 - \phi_1)}$	$e_{CNA} = \frac{P_C(t)}{C(t)} \frac{c_3}{c_1\phi_2}$
Past	$e_{PA} = \frac{P_C(t-1)}{C(t)} \frac{c_3}{c_1\phi_2(\phi_2 - \phi_1)}$	$e_{PNA} = \frac{P_C(t-1)}{C(t)} \frac{c_3}{c_1\phi_2}$
Future	$e_{FA} = \frac{P_C(t+1)}{C(t)} \frac{c_3\phi_1}{c_1(\phi_2 - \phi_1)}$	$e_{FNA} = \frac{P_C(t+1)}{C(t)} \frac{c_3\phi_1}{c_1\phi_2}$
Short Run	$e_{SRA} = \frac{P_C^*(t)}{C(t)} \frac{c_3}{c_1(\phi_2 - \phi_1)(1 - \phi_1)}$	$e_{SRNA} = \frac{P_C^*(t)}{C(t)} \frac{c_3}{c_1\phi_2(1 - \phi_1)}$
Long Run	$e_{LP} = \frac{P_C}{C_\infty} \frac{c_3}{c_1(\phi_2 - 1_1)(1 - \phi_1)}$	

Data and Empirical Results

The demand function in (6) is estimated using tobacco time series from 1964 to 1995, provided by the Department of Planning and Economic Studies of the Spanish national tobacco company, Tabacalera. The sales of cigarettes in millions of packets are used as the indicator of tobacco consumption, obtaining the per capita variable by dividing consumption between the population that is older than 15 years of age. The price of tobacco will be a price index obtained by dividing the nominal price between the national consumer price index (base year: 1995).

Given the time horizon, it is interesting for the model to take into account the impact of government regulatory changes in tobacco consumption by way of dummy variables. In particular, we include several new variables. The first variable, t_{78} (equals zero until 1977, equals 1 from 1978), is derived from a regulation which limits tobacco advertising. The second variable, t_{79} (equals zero until 1978, equals time trend from 1979), incorporates improvements in the quality and presentation of the good. The third and fourth variables, t_{82} (equals zero until 1981, equals 1 from 1982) and t_{88} (equals zero until 1987, equals 1 from 1988), establish restrictions on the sale and consumption of tobacco. Thus, the resulting stochastic demand function is:

$$\begin{aligned} C(t) &= c_0 + c_1 C(t-1) + c_2 C(t+1) + c_3 P_C(t) \\ &+ t_{78} T78 + t_{79} T79 + t_{82} T82 + t_{88} T88 + u(t) \quad . \end{aligned} \tag{8}$$

Equation (8) implies the endogeneity of past and future consumption which, in turn, suggests the instrumental variables method, using the independent variables as well as four lead and lag prices as instruments [Chaloupka, 1991; Labeaga, 1993; Becker et al., 1994; Waters and Sloan, 1995; Olekalns and Bardsley, 1996; Grossman and Chaloupka, 1998].[2]

Table 2 shows the results of the estimation of the demand equation imposing different values of the time preference rate, namely 5, 10, and 20 percent. These results are presented after accepting the use of this new information by way of the Wald test, given that the three particular values, 0.3647, 0.3965, and 0.4597, are all lower than the corresponding critical value of the χ^2 distribution at the 5 percent level of significance, $\chi^2(1)_{0.05} = 3.84$. With respect to the estimated parameters, we can first show that all the parameters of consumption and prices are individually significant at the 5 percent level. Second, note that consumption in different periods is complementary. Thus, the parameter of past consumption is positive for the three rates of time preference, 0.1543, 0.1577, and 0.1640, respectively, which implies the addictive character of tobacco, whereas the coefficients of future consumption, 0.1469, 0.1434, and 0.1367, are also positive, which reflects the rationality of individual behavior. Moreover, the current prices have the expected negative sign, -0.00076, in all three situations. Further observe that the past consumption parameter is always higher than the future consumption coefficient, as the rational addiction model predicts. Therefore, we can affirm that our three estimations support the addictive rational hypothesis of Spanish tobacco consumption. With respect to the dummy variables, note that the significant parameters have the expected sign, that is, legal restrictions on advertising and sales imply a decline in tobacco consumption, as shown by the negative signs of t_{78} and t_{88}, whereas improvements in the quality and presentation of the good imply a positive sign of the parameter t_{79}.

After presenting the estimated parameters, the degree of fit and some specification tests are shown. With respect to the former, the excellent fit is observed as confirmed by the high R^2 values, 0.94 in all three cases. Regarding the specification tests, the validity of the instruments was first tested using the Sargan statistic. The particular values for the three cases, 0.0021, 0.0021, and 0.0022, respectively, are lower than the critical value of the distribution, $\chi^2(7)_{0.05} = 14.1$, therefore, we can accept their validity. Second, the existence of first-order autocorrelation was tested and rejected using the Breusch-Godfrey test, given that all three values, -0.3729, -0.3713, and -0.3675, are lower than the asymptotic critical value, $t_{0.05} = 1.96$.

TABLE 2
Estimations of the Demand Equation

	5 percent		10 percent		20 percent	
c_0	0.1675*	(6.221)	0.1675*	(6.191)	0.1675*	(6.139)
c_1	0.1543*	(2.134)	0.1577*	(2.123)	0.1640*	(2.100)
c_2	0.1469*	(2.134)	0.1434*	(2.123)	0.1367*	(2.100)
c_3	-0.00076*	(-6.571)	-0.00076*	(-6.545)	0.00076*	(-6.497)
t_{78}	-0.0106*	(-3.612)	-0.0106*	(-3.606)	-0.0106*	(-3.594)
t_{79}	0.0044*	(5.344)	0.0044*	(5.296)	0.0044*	(5.207)
t_{82}	0.0038	(0.991)	0.0038	(1.009)	0.0040	(1.044)
t_{88}	-0.0101*	(-2.637)	-0.0100*	(-2.619)	-0.0100*	(-2.586)
R^2	0.9430		0.9428		0.9425	
Wald	0.3647		0.3965		0.4597	
Sargan	0.0021		0.0021		0.0022	
Breusch-Godfrey	-0.3729		-0.3713		-0.3675	

Notes: * denotes significance at the 5 percent level. t-rates are in parentheses.

Table 3 shows the estimated elasticities using the average values of prices and consumption. The different effects of prices on current consumption are derived. Shown first, all price effects are individually significant at the 5 percent level and all values have the expected negative sign according to normal demands. That is, it is usual for the effects of different prices to be negative, given that the increases in each price will reduce the quantity consumed in the current period.

Given that the rational consumer anticipates the future in his current decisions, the effects of price over consumption are higher when price changes are anticipated. This is so because if the price increases in a particular period without the consumer anticipating such a change, then he will not react until that period. By contrast, if the consumer knows beforehand that the price will increase in a given period, then he knows that the good will be more expensive in the future and thus will reduce his consumption. Therefore, he is reacting in anticipation, reducing his own consumption. However, given that the consumption of the addictive good is time complementary, a reduction in the consumption of previous periods will reduce consumption in the period in which the price increases, reinforcing the change in consumption. On the other hand, if the variation refers to a future period, then the change in the quantity demanded in that period will also modify the current quantity demanded, given that the rational consumer will consider the future price in his current decisions. Moreover, note that the price and consumption parameters of the past period are higher than the coefficients corresponding to the past period, indicating that the effect of current consumption is higher in the past than in the future. Thus, the elasticity of the past period will be higher than that of the future price.

TABLE 3
Estimated Elasticities

	5 percent		10 percent		20 percent	
e_{CA}	-0.6166*	(-7.702)	-0.6163*	(-7.677)	-0.6158*	(-7.627)
e_{CNA}	-0.6020*	(-7.154)	-0.6017*	(-7.128)	-0.6013*	(-7.077)
e_{PA}	-0.0974*	(-2.156)	-0.0995*	(-2.147)	-0.1034*	(-2.130)
e_{PNA}	-0.0951*	(-2.269)	-0.0971*	(-2.259)	-0.1009*	(-2.240)
e_{FA}	-0.0927*	(-2.156)	-0.0905*	(-2.147)	-0.0861*	(-2.1301)
e_{FNA}	-0.0905*	(-2.269)	-0.0883*	(-2.259)	-0.0841*	(-2.240)
e_{SRA}	-0.7259*	(-7.723)	-0.7224*	(-7.758)	-0.7160*	(-7.821)
e_{SRNA}	-0.7086*	(-8.090)	-0.7053*	(-8.098)	-0.6991*	(-8.105)
e_{LR}	-0.8416*	(-6.053)	-0.8412*	(-6.038)	-0.8402*	(-6.014)

Notes: * denotes significance at the 5 percent level. t-rates are in parentheses.

In particular, the range of variation of the anticipated current price is between -0.6158 and -0.6166. Thus, an increase of 10 percent in the current price, if this is anticipated, will reduce current consumption by around 6.16 percent. By contrast, if such a variation is not anticipated, then current consumption will vary by between 6.01 and 6.02 percent. On the other hand, a change of 10 percent in the past price will reduce current consumption by between 0.97 and 1.03 percent if the change is anticipated and by between 0.95 percent and 1 percent if it is not. Finally, if the variation corresponds to the future price, then current consumption is reduced by between 0.86 and 0.92 percent if such a variation is fully anticipated and by between 0.84 and 0.90 percent if not.

The short-run elasticities give higher values than the current elasticities. Thus, a permanent increase of 10 percent reduces consumption by between 7.16 and 7.25 percent if such a variation is anticipated and by between 6.99 and 7.08 percent if not. As expected, the long-run values are higher than those of the short-run and indicate that an increase of 10 percent reduces consumption by around 8.41 percent.

Finally, consider how the values of our estimated elasticities compare with those of other studies. First, our estimations fall within the range of values obtained in other works dedicated to analyzing the demand for tobacco. Thus, our current elasticity, -0.61, lies between the two limits cited by Lewit and Coate [1982], -0.4 and -1.3, which result from their comparative analysis of a number of Western countries. In this same line, our values of -0.7 for the short-run elasticity and -0.84 for the long-run are similar to, albeit sightly higher than, those presented by Becker et al. [1994], using data corresponding to the U.S., with their values being -0.4 and -0.75, respectively. Finally, our estimations of the current elasticity, -0.61, is almost identical to that obtained by Valdés [1993], also for the Spanish economy, but in that case, applying a partial adjustment model.

Summary and Conclusions

In this paper, we have calculated different anticipated and nonanticipated demand elasticities for tobacco in Spain, using an intertemporal model of rational addiction, which has been estimated using time series data of per capita consumption and prices during the period 1964-95. To that end, we have started from a nonseparable intertemporal utility function which includes the notions of tolerance, reinforcement, and withdrawal. The restricted maximization of this utility function has allowed for deriving a demand function which expresses current consumption in terms of past and future consumption as well as the current price. From this demand function, the expressions of different elasticities are derived, depending on whether or not the price changes can be anticipated.

The first results are in accord with the model of rational addiction, in the sense that the estimation of the demand function reveals the addictive character of tobacco consumption, confirming the positive effect that past consumption has on current consumption. Moreover, we find that addiction is not a result of myopic consumer behavior but rather of the maximization of total utility, implying that consumers consider the future effects of their current decisions.

With respect to demand elasticities, a number of conclusions can be drawn. First, it was shown that all the values have the expected negative sign according to normal demands. Second, given that the rational consumer anticipates the future in his current decisions, the effects of price over consumption are higher when price changes are anticipated. Third, the elasticity of the past period will be higher than that of the future price. Fourth, as expected, the long-run values are higher than those of the short-run.

Finally, we include some suggestions for further research with respect to possible policy implications. First, our empirical results could be key factors in the decision-making process when drafting policies at the national level aimed at reducing tobacco consumption. In this line, our results demonstrate that the different measures adopted in Spain, which have limited tobacco advertising or placed restrictions on the sales and consumption of tobacco, have proved capable of meeting the final objective of reducing such consumption among the Spanish population. As the values of the price elasticities show, this same objective could also be achieved though a series of fiscal-type measures that could levy a special tax on the consumption of tobacco, thereby increasing the final sale price of that good. Furthermore, the estimations could be used by those drafting fiscal policies with the aim of analyzing the effects of the different tax rates on the tax collection derived from the consumption of tobacco, bearing in mind that the addictive character of this good clearly shows that the possible increases in this collection would be higher in the short-run than in the long run. Additionally, these results could be used to analyze the viability of different tax policies on the consumption of tobacco. The collection from these taxes could be specifically assigned to financing the different information campaigns that national governments launch to educate the population of the dangers posed by tobacco consumption, thus reducing that consumption.

Footnotes

1. For details, see Becker and Murphy [1988], Chalopukpa [1991], Becker et al. [1994], and Waters and Sloan [1995].
2. Very similar results are obtained using two, three, or five lead and lag prices.

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