DO MONEY AND PRICE MOVE TOGETHER? A TEST OF COINTEGRATION.

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I. Introduction

Inflation in the Indian economy has been one of the most controversial issues till today. It primarily revolves around the debate between monetarist and non monetarist explanation of inflation.

Pure monetarists argue that inflation should be explained in terms of the increase in money stock (M) relative to real income (Y) when velocity of money (V) is constant. Needless to say this argument originates from the identity MV ≡ PY, where P is the price level.

Following this a series of studies were carried out in India during sixties and seventies (e.g., Ramana (1968) Colaco (1969), Rao (1974), Brahmananda (1977), Gupta (1974, 1979)). All these studies argue that increase in money supply is the main factor causing inflation in India.

However, Saini (1984), Bhattacharya (1987), and Bala krishnan (1991, 1992) reject this view. They argue pure monetarist approach fails to explain Indian inflation. Balakrishnan's argument (1991) is based on an `encompassing test' which has been used to select from the rival models.

Recently Brahmananda et.al. (1992) have reiterated their position by arguing that currency or M_1 or M_2 is a crucially important variable affecting wholesale price index even in the short period[1].

In our view, this controversy arises mainly due to the fact that certain assumptions of pure monetarist approach like exogeneity money neutrality and constant velocity' are untenable. Furthermore, in a credit based economy like India output can not be neutral with respect to money supply. Both public and private investments in India depend significantly on money supply through bank credit.

Nevertheless, we shall make an attempt in this paper to re-examine money-price relationship using a new technique known as "cointegration". Two variables are said to be cointegrated if they do not diverge from each other substantially, at least in the long-run. They may drift apart in the short-run but in the long-run market mechanism will begin to bring them together (see also Granger 1991). However, certain statistical properties need to be satisfied before one can say whether the two series are cointegrated or not. We shall discuss these properties in the next section.

II. Statistical Background:

An economic time series is said to be nonstationary if the underlying stochastic process that generated the series is not invariant with respect to time. If the process is nonstationary, then it will often be difficult to represent the time series over past and future intervals of time by a simple algebraic model. Many economic time series are believed to be nonstationary (e.g. GNP, M_1, M_2 etc.)

Nonstationary time series are frequently de-trended before further analysis is done. De-trending can be done by two methods, (1) estimating regression on time, or (2) successive differencing. Let us suppose that the time series Y_t obeys the following relationship.

$$Y_t = \alpha+\beta t+u_t \quad ....(1)$$

Where u_t is a stationary series with zero mean and constant variance. Then we call the model (1) "trend-stationary processes" (TSP). On the other hand, if Y_t is generated by the model,

$$Y_t-Y_{t-1} = \beta+e_t \quad .... . \quad (2)$$

Where e_t is a stationary series with mean zero and variance σ^2_e. Then the model (2) is called a "difference-stationary process" (DSP) or a random walk with drift. Furthermore, we say in this case that Y_t is I(1) [integrated of order one], in other words, first difference produces a stationery series.

Let us consider the model of the following type.

$$Y_t = \mu + \beta t + \alpha_1 Y_{t-1} + \sum_{i=1}^{m} \tau_i \Delta Y_{t-i} + e_t \quad ....(3)$$

Or

$$\Delta Y_t = \mu + \beta t + \alpha_1' Y_{t-1} + \sum_{i=1}^{m} \tau_i \Delta Y_{t-i} + e_t \quad ....(4)$$

Now it can be shown following Dickey and Fuller (1979) that if $\alpha_1=1$ in (3), then the DSP hypothesis is valid[2]. The problem of testing the hypothesis $\alpha_1=1$ in (3) (or $\alpha_1'=o$ in 4) is called "testing for unit root". For this, one needs the t-ratio calculated by Fuller (1976), since the usreal t-ratios have been proved as not having the student t-distribution properties. Alternatively, one can use the "Likelihood Ratio (LR) test" as suggested by Dickey and Fuller (1981) to test the null hypothesis $\alpha_1=1$, $\beta=o$ Critical values for the test are available in Dickey and Fuller (1981). Notice that equation 3 has been augmented by writing it as an AR of order m to whitten the residual. However, selection of **m** is still arbitary in the literature. Campbell and Perron (1991) suggested that one should start with some upper bound on m, m_{max}. If the last included lag is significant, select $m=m_{max}$. If not reduce the number by one until the last included lag is significant. If none is significant, select m=o. However, one practical problem still remains. It might be the case that m^{th} lag is significant but $(m-1)^{th}$ is not.

Now suppose Y_t is I(1) another series X_t is I(I). Then it is generally true that aX_t+bY_t is I(1).[3] However, if there is a nonzero β such that $Y_t - \beta X_t$ is I(0), then Y_t and X_t are said to be cointegrated. Notice that $Y_t - \beta X_t$ is the residual (or equilibrium error) in the regression $Y_t = \beta X_t + U_t$. Essentially it means the "equilibrium error" is stationery, therefore, it fluctuates around its mean. In other words, two series Y_t and X_t will not drift apart without bound (because U_t being I(0), has a tendency to frequently return to, and cross, the mean value). If for example, the velocity of money (V) is constant or at least stationary then the quantity theory identity ($MV \equiv PY$) implies log M, log P and log Y should be cointegrated with known unit parameters. Similarly nominal money and nominal GNP (i.e. PY) should be cointegrated (Engle and Granger, 1987).

Several statistics are proposed for testing the hypothesis, that X_t and Y_t are non-cointegrated. We shall discuss briefly two tests, namely Dickey-Fuller and Augmented Dickey-Fuller tests. Which are as follows:-

Dickey-Fuller Regression:

$$\Delta u_t = -\phi \, u_{t-1} + e_t \quad \ldots\ldots\ldots\ldots\ldots (5)$$

Augmented Dickey-Fuller Regression:

$$\Delta u_t = -\phi \, u_{t-1} + \sum_{i=1}^{m} \delta_i \Delta u_{t-i} + e_t \quad \ldots (6)$$

In both cases u_t are the residuals from the cointegrating regression $Y_t = \alpha + \beta X_t + u_t$. Both test can now be implemented by comparing the t-statistic for ϕ (using OLS option) with critical values given in Engle and Granger

(1987) for two variables and in Engle and Yoo (1987) for more than two variables. These standard tests are not invariant with respect to normalization. However, results differ little across such choices (Engle and Yoo, 1987).

We now move to the next section where these concepts and test have been used to test whether log M_1 (or log M_3), log P (wholesale price index, 1970-71=100) and log Y (real GNP at market prices) are cointegrated or not. As discussed above, to test whether two or three series are cointegrated, we must first establish that they are individually integrated.

The exercise has been calculated on a annual data set for the period 1951-52 to 1988-89. Principal data sources for money supply, GNP and price index are Reports on Currency and Finance, Vol. II (Reserve Bank of India), National Accounts Statistics, and Indian Data Base, Volume I (Chandhok, 1990) respectively.

III. TESTS FOR UNIT ROOTS:

Table 1
Test for Unit Roots

Panel A: t-statistic for α_1' in equation 4

	m=1	m=2	m=3	m=4	First & Fourth Lag	Third Lag	First Lag	First Lag
Price	-2.93	-3.93	-2.77	-2.89	-3.18 [F1,27) =0.94]			
M_1	-1.63	-1.39	-1.59	-2.07		-1.809 [F(1,29) = 0.91]		
M_3	-1.22	-1.11	-1.39	-1.88			-1.22 [F(1,31) = 0.008]	
GNP	-3.15	-2.88	-2.74	-2.26				-3.15 [F(1,31) = 0.20]

Critical Values: No of observations = 25;1%=-4.38,5%=-3.60,10%=-3.24

No of observations = 50;1%=-4.15,5%=-3.50,10%=-3.18

Note: F statistics reported in parentheses indicate lagrange multiplier test of first order residual serial correlation.

Panel B: Likelihood Ratio Test
(F values for the hypothesis $\alpha_1'=0$ and $\beta=o$)

	m=1	m=2	m=3	m=4	First & Fourth Lag	Third Lag	First Lag	First Lag
Price	5.25	9.24	4.36	5.92	6.00			
M_1	5.71	3.95	6.43	6.20		4.86		
M_3	5.39	4.08	4.60	2.86			5.39	
GNP	4.97	4.16	3.76	2.56				1.33

Critical Values: No of observations = 25;1%=10.61,5%=7.24,10%=5.91

No of observations = 50;I%= 9.31,5%=6.73,10%=5.61

As can be seen from panels A and B of Table 1 that at the 5 per cent critical value all but the series on wholesale price index with m=2 exhibit presence of unit root (it may be recalled that the null hypothesis is $\alpha_1'=0$ or $\alpha_1'=0$ and $\beta=0$, which implies the series is I(1)). However, when insignificant lags are dropped and only first and fourth lags are retained, the null hypotheses is accepted at the 5 per cent level. Furthermore, the Lagrange Multiplier test confirms that the residual is white noise. Similarly both test have been carried out for other variables retaining only significant lags. Therefore, one can conclude that price, M_1, M_3 and real GNP belong to the DS process. Similar conclusions regarding M_1, M_3 and the consumer price index for industrial workers are reported in Krishnan, et.al. (1991).

IV Tests for Cointegration:

First we have run the cointegrating regression of price (logP) on money (log M_1 and log M_3) and real GNP (log Y). Regressing the change in the residuals on past levels, the t statistics on the levels are -3.64 and -3.07 for two alternative money supply series M_1 and M_3 respectively which are lower than the critical value for the 5 per cent Dickey-Fuller test (critical value is -4.11 for 50 observations, Engle and Yoo (1987)). Therefore, we do not reject the null of non-cointegration at 5 per cent level.

Next we regress the change in the residuals on past levels and two lagged changes (i.e, first and second lags) and one lagged change (i.e. first lag only) for two alternative sets, namely price, M_1 and GNP and price, M_3 and GNP respectively. The t statistics on the levels are -4.28 and -2.95 which are lower than critical values (-4.45 and -3.75) for the 1 per cent and 5 per cent Augmented Dickey-Fuller test respectively.[4] Whichever way the regression is run, the data accepts the null of non-cointegration between price, money supply and real GNP.

V Cointegration and Error-correction:

Granger (1983) and Engle and Granger (1987) proved that if X_t, Y_t are both I(1) and are cointegrated then there always exist a data generating mechanism of the following types:

$$\Delta X_t = -\delta_1 Z_{t-1} + \text{lagged}(\Delta X_t, \Delta Y_t) + e_{xt}$$
$$\Delta Y_t = -\delta_2 Z_{t-1} + \text{lagged}(\Delta X_t, \Delta Y_t) + e_{yt} \quad \ldots\ldots(7)$$

where $Z_t = Y_t - \beta X_t$

Equation (7) is known as the error correction representation and the theorem popularly known as the `Granger's Representation Theorem'. Since the hypothesis of cointegration implies the existence of the error correction representation (the converse is also true) therefore, a natural testing framework could be to test for the presence of the error correction terms δ_1 and δ_2 in 7. It is worth mentioning that one error correction term is sufficient for cointegration, therefore, one should estimate both δ_1 and δ_2. Notice that every term in 7 is I(0) because X_t, Y_t are both I(1). Equation 7 simply says that the amount and direction of change in X_t and Y_t take into account the size of previous equlibrium error Z_{t-1}.

Engle and Granger (1987) suggest estimating β by OLS and take the residuals, Z, from this estimate and used these in equation 7 to estimate δ_1 and δ_2 along with other parameters. We, therefore, propose to carry out this test. Our previous findings should further be strengthened if both δ_1 and δ_2 are found to be insignificant. However, we carry out this exercise in a bivariate framework to avoid unnecessary complications. In other words, error correction representation between money supply and nominal GNP (i.e. PY) will be examined which essentially shows whether money supply and nominal GNP cointegrated or not. After examining several dynamic specifications, we present some in Table 2.

TABLE 2
Error Correction Representation of Money Supply and Nominal GNP

Model Specification	M_1&PY	M_3 & PY	M_1& PY	M_3& PY
Dep. Variables:	Δ Log M_1	Δ Log M_3	Δ Log PY	Δ Log PY
Δ Log M_{1t-1}	0.51(3.57)		0.46(3.04)	
Δ Log M_{1t-2}	0.43(3.04)			
Δ Log M_{3t-1}		0.73(4.60)		
Δ Log M_{3t-2}		0.26(1.63)		
Δ Log PY_{t-1}			0.27(1.90)	0.51(3.52)
Δ Log PY_{t-2}			0.26(1.88)	0.47(3.20)
Z_{t-1}	-0.35(-2.64)	-0.07(1.67)	-0.22(1.75)	-0.21(2.30)
F	0.39	1.82	0.16	0.58
Degrees of Freedom	(1,31)	(1.31)	(1,30)	(1,30)

Note: 1. F statistics (degrees of freedom given in last row) show Lagrange Multiplier test of residual serial correlation (first order).
2. t-values in parentheses.

It may be noted that under the null Z_t is I(1) (i.e. two series are non-cointegrated), the usual t-test significance levels should not be valid for this error correction coefficient, usually requiring 't' values in excess of three (Hendry, 1986). Therefore, looking at the t-values of the coefficients of Z_{t-1} in different models we can argue that money supply and nominal GNP are not cointegrated.

VI Conclusion

Two important findings of this paper are (1) money supply (M_1 or M_3), wholesale price index and real gross national product are difference stationary processes, and (2) money supply, price and real GNP or money supply and nominal GNP are not cointegrated. Engle and Granger (1987) also arrived at the same conclusion regarding US money and prices. One important implication of these results is that velocity of money (V) is not stationary (see also the figures).[5]

Figure1:logV1=logPY-logM1

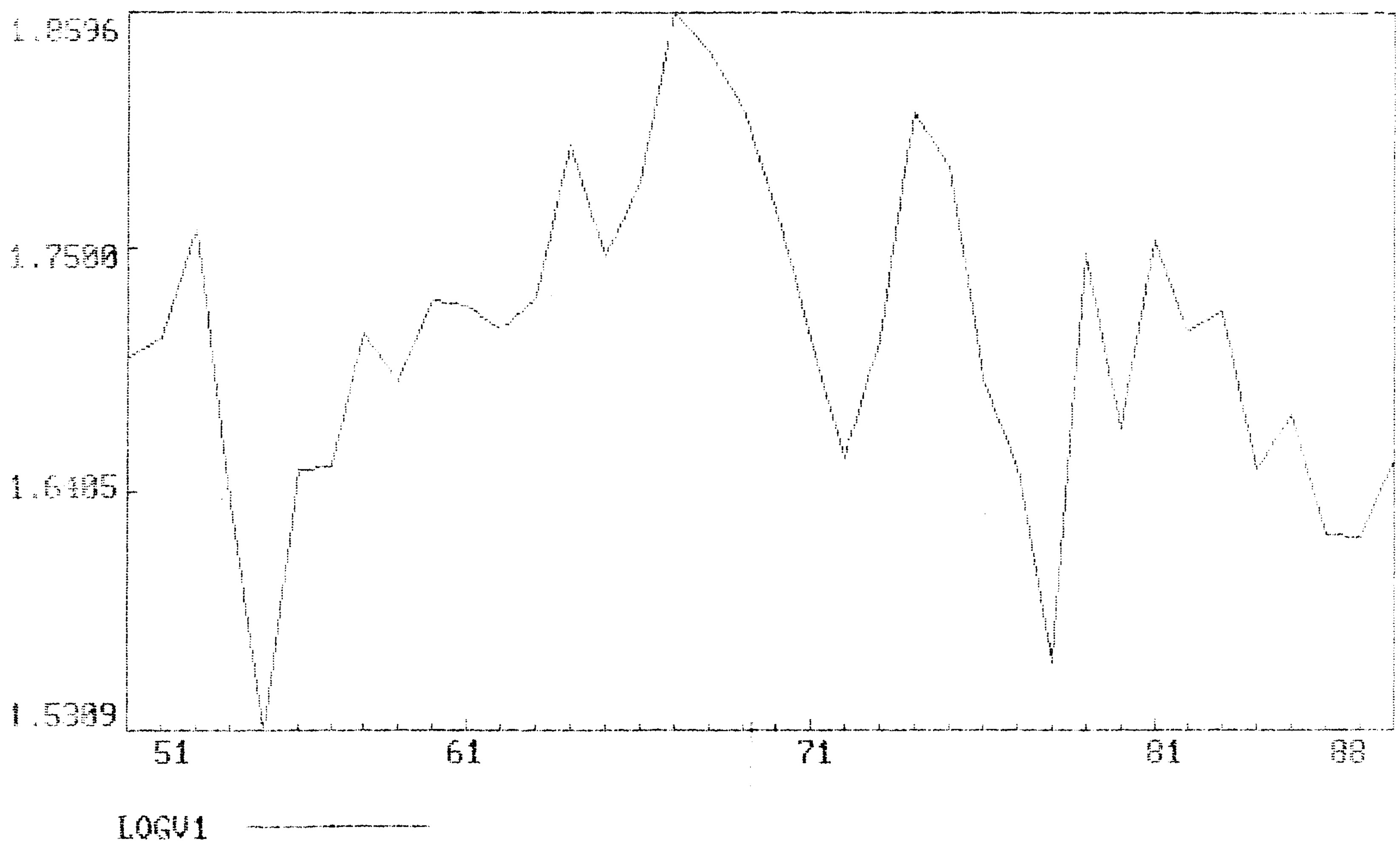
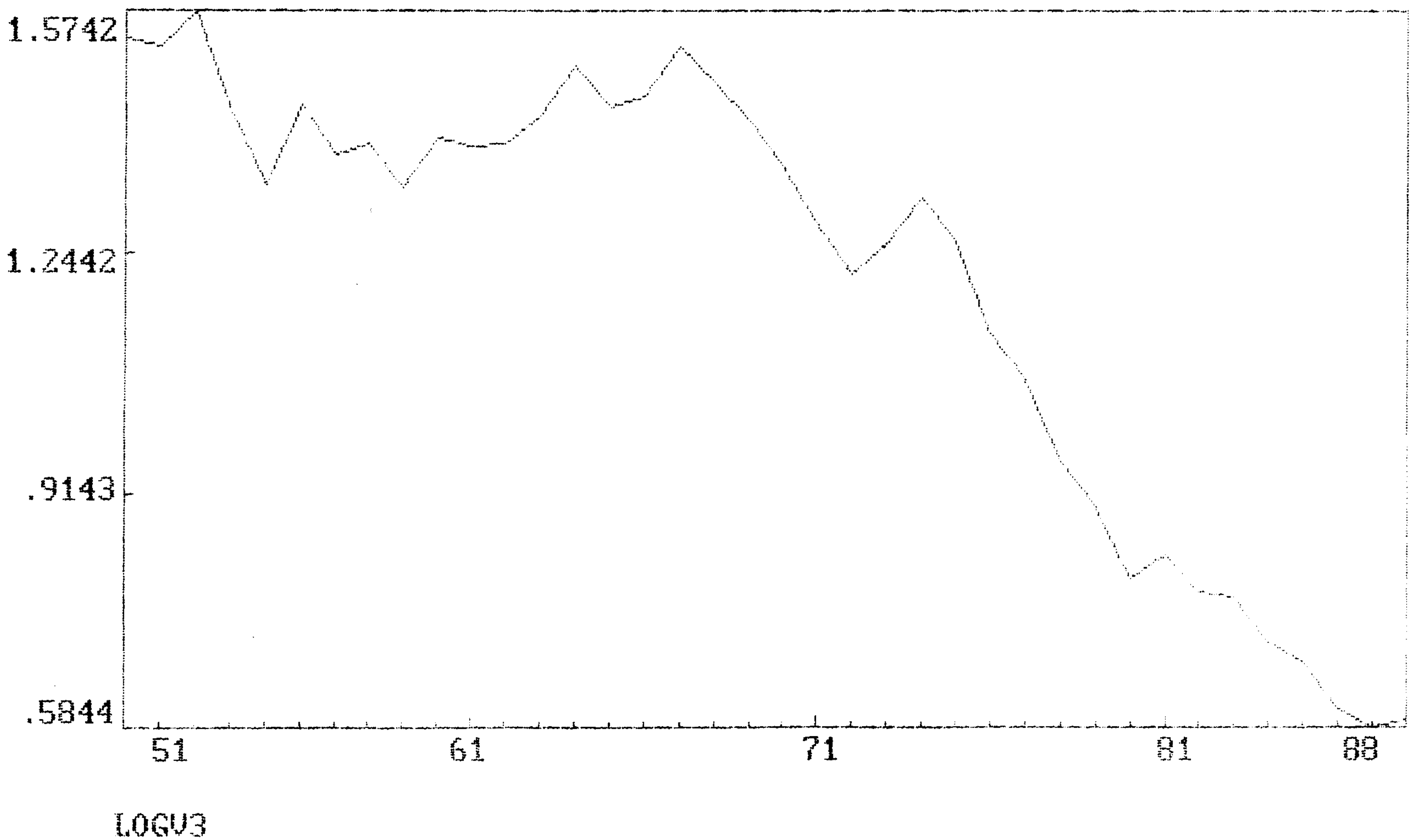


Figure2:logV3=logPY-logM3



NOTES

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1. This study is based on data from January 1990 to May 1992. It is widely believed that inflation and economic crisis during this period was triggered by third oil stock following the invasion of Kuwait. furthermore the study, unlike Brahmananda (1977) is not based on pure monetarist approach.

2. Both hypotheses can be embeded in a single model,

   $$Y_t = \alpha + \beta t + U_t / (1-\phi L)$$

   where L is the back shift operator

   or equivalently, after multiplication by $(1-\phi L)$,

   $$Y_t = \phi Y_{t-1} + [\alpha(1-\phi) + \phi\beta] + \beta(1-\phi)t + U_t$$

   If the DS hypothesis is correct then $\phi = 1$. If the TS hypothesis is correct then $|\phi| < 1$.

3. In other words regression of Y on X or X on Y can not produce a white noise residual which is I(0). This is known as the spurious regression problem in the literature.

4. Higher order lags are not significant.

5. When the Dickey-Fuller test is applied to check this yields t statistics -3.08 and -1.24 for two alternative definitions of V (i.e, PY/M_1 and PY/M_3) respectively, which corroborate our finding.

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