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Panel cointegration analysis of the Fisher effect: Evidence from the US, the UK, and Japan

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Abstract

This paper analyzes the Fisher effect using a panel of monthly data from January 1990 to December 2010 for three major countries: the United States, the United Kingdom, and Japan. Our empirical results contribute to the existing empirical literature in two ways. First, the study conducts panel cointegration tests and estimation. Second, it examines the validity of the Fisher hypothesis using short-term and long-term nominal interest rates. The empirical results show that the full Fisher effect holds from January 1990 to December 2010.

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1. Introduction

Fisher (1930) has greatly contributed to the development of economic theory. The Fisher hypothesis, an important contribution, states that a change in expected inflation implies a proportional change in nominal interest rates and that the real interest rates are constant in the long term. As the behavior of the real interest rates affects the dynamics of asset prices, savings, and investments, it is important for macroeconomists to understand the relationship between nominal and real interest rates.

There is no general consensus among researchers on the Fisher hypothesis, even though many studies have explored this topic. Therefore, it is worthwhile to determine whether or not the Fisher hypothesis holds. Many empirical studies tested the Fisher hypothesis using the cointegration approach; and some of them are listed in Table 1.[1] This table shows that almost all the studies use time series data and that only two papers, to the best of our knowledge, use panel data.[2] There is no consensus among researchers as to whether the Fisher hypothesis holds true, and thus, it is still meaningful to analyze the validity of the Fisher effect empirically.

Table 1. Studies on the Fisher hypothesis that use the cointegration approach

Sources	Country	Sample period	Analysis	Fisher effect
Badillo *et al.* (2011)	EU-15 countries	1983Q1-2009Q1	panel	partial Fisher effect
Bassil (2010)	the US	1978M1:2008M12	time series	full Fisher effect
Ito (2009)	Japan	1987M10-2006M6	time series	short-run full Fisher effect
Westerlund (2008)	20 OECD countries	1980Q1-2004Q4	panel	full Fisher effect
Gul and Acikalin (2008)	Turkey	1990M1-2003M12	time series	partial Fisher effect
Hatemi-J and Irandoust (2008)	Australia, Japan, Malaysia, and Singapore	1973M3-1998M4	time series	partial Fisher effect
Atkins and Chan (2004)	Canada and the US	1950Q1-2000Q2	time series	partial Fisher effect
Granville and Mallick (2004)	the UK	1900-2000	time series	partial Fisher effect
Carneiro *et al.* (2002)	Argentina, Brazil, and Mexico	1980M1-1997M12	time series	full Fisher effect: Argentina and Brazil
Lee *et al.* (1998)	the US	1953M1-1990M12	time series	short-run full Fisher effect
Payne and Ewing (1997)	9 less developed countries	1979Q2-1995Q3	time series	full Fisher effect: Malaysia, Pakistan, and Sri Lanka partial Fisher effect: Singapore
Evans and Lewis (1995)	the US	1947M1-1987M2	time series	full Fisher effect
Inder and Silvapulle (1993)	Australia	1964Q1-1990Q4	time series	rejected

Badillo *et al.* (2011) analyzed the Fisher hypothesis for a panel of 15 European Union (EU) countries using the panel cointegration approach. The empirical results show that the estimators of the slope parameter on inflation are significantly lower than unity, which implies the existence of a *partial* Fisher effect.

Westerlund (2008) proposed two new panel cointegration tests that were applied to a panel of quarterly data converging 20 OECD (Organisation for Economic Co-operation and Development) countries between 1980 and 2004. The empirical results show that the Fisher effect cannot be rejected once the panel evidence on cointegration has been taken into account.

[1] As for details on the cointegration tests, see Engle and Granger (1987), Johansen (1988), and Johansen and Juselius (1990) as well.
[2] As for the studies on time series data, some examples are Ito (2009), Bassil (2010), Gul and Acikalin (2008), Hatemi-J and Irandoust (2008), Atkins and Chan (2004), Granville and Mallick (2004), Cameiro *et al.* (2002), Lee *et al.* (1998), Payne and Ewing (1997), Evans and Lewis (1995), and Inder and Silvapulle (1993).

One problem that arises in testing the Fisher hypothesis involves the maturities of nominal interest rates that should be used. Ito (2009) examined the validity of the Fisher hypothesis in Japan using the maturities from 2 to 10 years of the nominal interest rates. The empirical results show that the Fisher hypothesis holds from October 1987 to June 1991.

Considering the above studies, this paper analyzes the Fisher hypothesis using a panel of monthly data from January 1990 to December 2010 for three major countries: the United States, the United Kingdom, and Japan. As Westerlund (2008) pointed out, the use of panel data can generate more powerful tests. In addition, the paper examines the validity of the Fisher hypothesis using short-term and long-term nominal interest rates.

The remainder of the paper is organized as follows. Section 2 discusses the model and data. Section 3 presents the empirical results. Finally, Section 4 provides concluding remarks.

2. Model and Data

We test the following Fisher equation, which is commonly used in this field:

$$i_{it} = \alpha_i + \beta_i \pi_{it} + \varepsilon_{it}, \quad (1)$$

where i_{it} is the nominal interest rate at time *t* for country *i*, π_{it} is the actual rate of inflation at time *t* for country *i*, and ε_{it} is the error term.

If i_{it} and π_{it} are both nonstationary and their linear combination is stationary, then they are said to be in a cointegration relationship. Engle and Granger (1987) shows that the cointegrating relation implies the long-run equilibrium, and develops the econometric techniques to test for the relationship.

Our analysis has two steps. The first step is to analyze whether there exists a cointegrating relation between inflation rates and interest rates. The second step is to test for the cointegrating vector. If we can confirm that i_{it} and π_{it} have a cointegrating relation, we check whether or not cointegration vector (1, 1) (i,e., $\beta = 1$) can be rejected in the following equation.

$$i_{it} = \alpha_i + \beta_i \pi_{it} + \sum_{j=-K}^{K} \delta_i \Delta\pi_{it-j} + u_{it}, \quad (2)$$

where u_{it} is the error term. If $\beta = 1$ in equation (2), the nominal interest rate moves one-for-one with the actual rate of inflation in the long run (i.e., *full* Fisher effect). If $\beta < 1$ in equation (2), it is known as the *partial* Fisher effect.

The annualized rate of inflation is calculated using the monthly consumer price index (CPI). Data were sourced from the *CEIC* database. As for nominal interest rates, interest rate swaps of 2, 3, 5, 7, and 10 years (i^2, i^3, i^5, i^7, i^{10}) are used in the same way as that of Ito (2009).[3] These data are obtained from *Barclays Capital Live*.

This paper uses a panel of monthly data from January 1990 to December 2010 for three major countries: the United States, the United Kingdom, and Japan. The reason behind this analysis was that these three countries are the world's major centers for trade in swap markets. For example, at the end of June 2010, the most common currencies used to dominate interest rate swaps were the US dollar (34.4% of the total), Japanese yen (14.7%), and British pound sterling (8.0%).[4]

Table 2. Panel unit root tests

(a) Level

Variable	Levin, Lin, and Chu		Im, Pesaran, and Shin	
	Statistics	P-Value	Statistics	P-Value
π	1.079	0.860	-1.582	0.057
i^2	-1.530	0.063	-0.312	0.378
i^3	-1.433	0.076	-0.514	0.304
i^5	-0.467	0.320	-0.504	0.307
i^7	-0.671	0.251	-0.612	0.270
i^{10}	-0.896	0.185	-0.900	0.184

Notes:

i^m is the nominal interest rate for maturity m.

The auxiliary regression includes both a constant term and time trend.

(b) First difference

Variable	Levin, Lin, and Chu		Im, Pesaran, and Shin	
	Statistics	P-Value	Statistics	P-Value
π	-13.873	0.000	-9.709	0.000
i^2	-10.445	0.000	-8.602	0.000
i^3	-12.022	0.000	-9.750	0.000
i^5	-21.474	0.000	-17.227	0.000
i^7	-21.981	0.000	-17.840	0.000
i^{10}	-22.994	0.000	-18.674	0.000

Notes:

i^m is the nominal interest rate for maturity m.

The auxiliary regression includes both a constant term and time trend.

The first step of our empirical analysis for testing the Fisher effect is to investigate whether inflation and nominal interest rates are nonstationary for the panel

[3] Interest rate swaps are used because the swap curve is more accurate than the government bonds curve. As almost all the government bonds are issued every one month or three months, we need to adjust the government bonds data according to the constant maturity. The reason why we use the swap rate is that the swap curve has a more sophisticated yield curve than the bond curve.

[4] These data are sourced from the BIS Quarterly Review.
(http://www.bis.org/statistics/otcder/dt21a21b.csv)

as a whole. Accordingly, we perform panel unit root tests for each variable. Two types of tests developed by Levin *et al.* (2002) and Im *et al.* (2003) are used. The auxiliary regression of each test includes both a constant term and time trend. The statistics and probabilities for each variable are reported in Table 2. As shown in this table, we find that the null hypothesis of a unit root cannot be rejected for the level of each variable, whereas the null hypothesis of a unit root is rejected for the first difference of each variable at the conventional significance level. Thus, it is obvious that all the variables are integrated with order one, i.e., I(1).

3. Empirical Results

3.1 Panel Cointegration Tests

The second step is to perform panel cointegration tests for the inflation and nominal interest rates. We adopt the Johansen-Fisher tests developed by Maddala and Wu (1999), who proposed two statistics: the Fisher statistic from the trace test and the Fisher statistic from the maximum eigenvalue test. In these tests, we set the lag order from 1 to 3.[5] In the null hypothesis, there is no cointegrating relationship, whereas in the alternative hypothesis, there is one.

Table 3 shows the results of the panel cointegration tests. For case 1, regarding lag 1, under the null hypothesis of no cointegration, the test statistics is 32.280 for the Fisher statistic from the trace test and 24.400 for the Fisher statistic from the maximum eigenvalue test. Regarding lag 2, these values are 29.050 and 18.930 respectively, and for lag 3, these values are 35.490 and 26.120 respectively. The null hypothesis is rejected at the 5% significance level in every test. Similar results are obtained for cases 2 to 5. Therefore, it can be said that the inflation and nominal interest rates have a strong cointegrating relationship in every case.

Table 3. Panel cointegration tests

Case 1: i^2, π

Techniques		Test Statistics	Prob.
Johansen-Fisher tests			
Fisher statistic from the trace test			
	Lag = 1	32.280	0.000
	Lag = 2	29.050	0.000
	Lag = 3	35.490	0.000
Fisher statistic from the maximum eigen-value test			
	Lag = 1	24.400	0.000
	Lag = 2	18.930	0.004
	Lag = 3	26.120	0.000

Notes:
The Pedroni statistics are obtained from Pedroni (1999, Table 1).
As for the lag periods of the Johansen-Fisher tests, we also checked lags from 4 to 10. These results are consistent at a conventional significance level.

[5] As for the lag periods of the Johansen-Fisher tests, we also checked lags from 4 to 10. These results are consistent at a conventional significance level.

Table 3. Panel cointegration tests (continued)

Case 2: i^3, π

Techniques		Test Statistics	Prob.
Johansen-Fisher tests			
Fisher statistic from the trace test			
	Lag = 1	31.270	0.000
	Lag = 2	28.520	0.000
	Lag = 3	35.010	0.000
Fisher statistic from the maximum eigen-value test			
	Lag = 1	24.060	0.001
	Lag = 2	19.620	0.003
	Lag = 3	26.250	0.000

Notes:
The Pedroni statistics are obtained from Pedroni (1999, Table 1).
As for the lag periods of the Johansen-Fisher tests, we also checked lags from 4 to 10. These results are consistent at a conventional significance level.

Case 3: i^5, π

Techniques		Test Statistics	Prob.
Johansen-Fisher tests			
Fisher statistic from the trace test			
	Lag = 1	30.600	0.000
	Lag = 2	27.400	0.000
	Lag = 3	34.510	0.000
Fisher statistic from the maximum eigen-value test			
	Lag = 1	23.620	0.001
	Lag = 2	19.730	0.003
	Lag = 3	26.360	0.000

Notes:
The Pedroni statistics are obtained from Pedroni (1999, Table 1).
As for the lag periods of the Johansen-Fisher tests, we also checked lags from 4 to 10. These results are consistent at a conventional significance level.

Case 4: i^7, π

Techniques		Test Statistics	Prob.
Johansen-Fisher tests			
Fisher statistic from the trace test			
	Lag = 1	29.350	0.000
	Lag = 2	27.480	0.000
	Lag = 3	34.850	0.000
Fisher statistic from the maximum eigen-value test			
	Lag = 1	23.000	0.001
	Lag = 2	20.260	0.003
	Lag = 3	26.620	0.000

Notes:
The Pedroni statistics are obtained from Pedroni (1999, Table 1).
As for the lag periods of the Johansen-Fisher tests, we also checked lags from 4 to 10. These results are consistent at a conventional significance level.

Table 3. Panel cointegration tests (continued)

Case 5: i^{10}, π

Techniques		Test Statistics	Prob.
Johansen-Fisher tests			
Fisher statistic from the trace test			
	Lag = 1	29.770	0.000
	Lag = 2	28.480	0.000
	Lag = 3	36.770	0.000
Fisher statistic from the maximum eigen-value test			
	Lag = 1	23.390	0.001
	Lag = 2	21.250	0.002
	Lag = 3	28.070	0.000

Notes:
The Pedroni statistics are obtained from Pedroni (1999, Table 1).
As for the lag periods of the Johansen-Fisher tests, we also checked lags from 4 to 10. These results are consistent at a conventional significance level.

3.2 Panel Cointegration Estimation

The final step is to estimate the Fisher equation using group-mean dynamic ordinary least squares (DOLS) and fully modified ordinary least squares (FMOLS). The former method is developed by Stock and Watson (1993), and the latter, by Pedroni (2001). Table 4 shows the estimation results. As for the 2-year nominal interest rate (i^2), the estimation coefficient is 1.130 for group-mean DOLS, and 1.081 for group-mean FMOLS. As the null hypothesis ($H_0 : \beta = 1$) cannot be rejected at the 5% significance level, it is found that the *full* Fisher effect exists. Similar results are found for the other maturities. Thus, we find that the *full* Fisher effect exists in every case.

Table 4. Estimation of the *β* parameter in panel cointegration equation (1) and hypothesis testing on its value

	DOLS			FMOLS		
	β	t-Statistic (H_0: β =0)	t-Statistic (H_0: β =1)	β	t-Statistic (H_0: β =0)	t-Statistic (H_0: β =1)
i^2, π	1.130	14.708	1.652	1.081	13.089	1.062
i^3, π	1.086	14.223	1.072	1.038	12.859	0.541
i^5, π	1.019	13.523	0.143	0.972	12.436	-0.328
i^7, π	0.967	12.956	-0.530	0.921	12.092	-1.009
i^{10}, π	0.916	12.528	-1.137	0.873	11.876	-1.632

Notes:
The length of lead and lag is set to 3 when estimating the DOLS.

4. Conclusions

As mentioned earlier, there is no general consensus among researchers on the Fisher hypothesis, even though many studies have explored this topic. In addition, almost all the studies use time series data, and only two papers, to the best of our knowledge, use panel data.

This paper analyzes the Fisher effect using a panel of monthly data from January 1990 to December 2010 for the United States, the United Kingdom, and Japan. Our empirical results contribute to the existing empirical literature in two ways. First, the paper conducts panel cointegration tests and estimation. As Westerlund (2008) pointed out, the use of panel data can generate more powerful tests. Second, the paper examines the validity of the Fisher hypothesis using short-term and long-term nominal interest rates. Apart from Ito (2009) and Bassil (2010), no other empirical study has focused on the use of short-term and long-term interest rates. Our empirical results show that the *full* Fisher effect holds from January 1990 to December 2010 for the given data.

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