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The Impact of Oil Price Shocks on the U.S. Stock Market: A Note on the Roles of U.S. and non-U.S. Oil Production[Δ]

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Abstract

Kilian and Park (IER 50 (2009), 1267–1287) find shocks to oil supply are relatively unimportant to understanding changes in U.S. stock returns. We examine the impact of both U.S. and non-U.S. oil supply shocks on U.S. stock returns in light of the unprecedented expansion in U.S. oil production since 2009. Our results underscore the importance of the disaggregation of world oil supply and of the recent extraordinary surge in the U.S. oil production for analysing impact on U.S. stock prices. A positive U.S. oil supply shock has a positive impact on U.S. real stock returns. Oil demand and supply shocks are of comparable importance in explaining U.S. real stock returns when supply shocks from U.S. and non-U.S. oil production are identified.

JEL classification: E44, G12, Q43

Key words and phrases: Oil prices, Stock returns, U.S. oil production

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1. Introduction

Kilian and Park (2009) present a novel method for examining the relationship between U.S. stock market behaviour and oil price shocks. Building on the seminal contribution in Kilian (2009), which demonstrates that demand and supply shocks in the market for oil have different effects on the United States (U.S.) economy and the real oil price, they show that the reaction of U.S. real stock returns to an oil price shock depends on the source of the underlying cause of the oil price change. One of the major conclusions in Kilian and Park (2009) is that global oil supply shocks are much less important than global aggregate and oil-specific demand shocks in understanding aggregate U.S. stock market behaviour. Our study is concerned with the question: Do U.S. oil supply shocks affect U.S. real stock market returns?

After several decades of steady decline in the U.S. oil production, innovations and new technologies in the extraction of crude oil have resulted in an unprecedented expansion in U.S. oil production in recent years. This development is significant because an increase in U.S. crude oil production directly boosts U.S. domestic income compared with an increase in non-U.S. crude oil production. In addition, enhanced U.S. oil production has consequences for political and economic security and hence U.S. asset markets that are likely to be different from increases in non-U.S. oil production. The recovery of U.S. oil production in recent years is illustrated in Figure 1. We investigate the effect of disaggregating the world oil production variable in Kilian and Park's (2009) Vector Autoregressive Model (VAR) into U.S. oil production and non-U.S. oil production. Hendry and Hubrich (2011) argue that including disaggregated information improves forecast accuracy in VAR models.

In this study we revisit Kilian and Park's (2009) analysis to examine the effect of world oil supply shocks on the U.S. real stock market returns. We find that both the disaggregation of world oil supply and the unprecedented surge in the U.S. oil production since 2009 are important factors in determining U.S. real stock returns. A positive U.S. oil supply shock has a positive impact on U.S. real stock returns that is statistically significant in the fourteenth month and later. This result is sensitive to the inclusion of recent data that captures shale oil production. In a sample ending before the start of shale oil production, a positive U.S. oil supply shock has a positive statistically significant impact on U.S. real stock returns only in the twenty-first and twenty-second months.

Variance decomposition analysis shows that by disaggregating world oil production into U.S. and non-U.S. oil production supply shocks are comparable to demand shocks (in contrast to the Kilian and Park (2009) result) in explaining U.S. real stock returns.

2. Data and methodology

We utilize monthly stock and oil market data and examine the two periods: January 1973 to December 2006, and January 1973 to December 2014. The first period is examined in Kilian and Park (2009) and the second is an update that incorporates the oil production expansion in the U.S. in more recent years. The aggregate U.S. real stock market return (ret_t) is obtained by subtracting the CPI inflation rate from the log returns on the value-weighted market portfolio obtained from the Centre for Research in Security Price (CRSP). The oil supply proxy variables are given by the per cent changes in non-U.S. oil production ($\Delta prod_t^{nonUS}$) and in U.S. oil production ($\Delta prod_t^{US}$) from the U.S. Department of Energy. The global real economic activity proxy is the index of real economic activity (rea_t) constructed by Kilian (2009). The real price of oil (rpo_t) is U.S. refiner acquisition cost of imported crude oil, from the U.S. Department of Energy since 1974:01 deflated by the U.S. CPI, with the series extended back to 1973:01 following Barsky and Kilian (2002).

A structural VAR model of order p is utilized to extract the separate supply and demand-side sources underlying oil price changes and their relation to the U.S. stock market return:

$$A_0 y_t = c_0 + \sum_{i=1}^{p} A_i y_{t-i} + \varepsilon_t, \tag{1}$$

where $y_t = (\Delta prod_t^{nonUS}, \Delta prod_t^{US}, rea_t, rpo_t, ret_t)$ is a 5×1 vector of endogenous variables, A_0 denotes the 5×5 contemporaneous coefficient matrix, c_0 represents a 5×1 vector of constant terms, A_i refers to the 5×5 autoregressive coefficient matrices, and ε_t stands for a 5×1 vector of structural disturbances.

The identifying restrictions on A_0^{-1}, as a lower-triangle coefficient matrix in the structual VAR model, follows the setup in Kilian (2009). Kilian (2009) argues that oil production does not respond to contemporaneous changes in oil demand within a given month because of the high adjustment cost of changing oil production. Fluctuation in the real price of oil will not affect global economic activity within a given month due to the sluggishness of aggregate economic reaction. The real stock return ordered after oil shocks is motivated by Lee and Ni (2002) and Kilian and Vega (2011), who argue that oil prices are predetermined with respect to U.S. macroeconomic aggregates within a given month. We assume that non-U.S. oil production does not respond to U.S. oil supply shock within a given month. The U.S. is an oil importing country whose oil production averages 11.5% of the global oil production over January 1973 to December 2014.

3. Empirical results

In Figure 2 we report the cumulative impulse response of U.S. real stock returns to negative one standard deviation structural shocks in non-U.S., U.S., and world oil production over 1973:01-2006:12 and over 1973:01-2014:12. Results for shocks in non-U.S. and U.S. oil production are obtained from estimation of the five variable model in equation (1) and results for shocks in world oil production are obtained from estimating the four variable model in Kilian and Park (2009).

The results in Figure 2a based on data over 1973:01-2006:12 are in line with the Kilian and Park (2009) paper in that non-U.S. and U.S. oil production shocks are mostly not statistically significant in determining U.S. real stock returns. The result for a negative non-U.S. oil production shock on real stock returns is similar to the result for a negative world oil production shock on real stock returns reported by Kilian and Park (2009), and replicated here in the first diagram in Figure 2c.

Figure 2b using data over 1973:01-2014:12 shows a negative U.S. oil supply shock is associated with a negative response in U.S. real stock returns that is statistically significant over most of the horizon. The response of U.S. real stock returns to a negative shock to non-U.S. oil supply is markedly different from that to a negative shock to U.S. oil supply. In Figure 2b a negative innovation in non-U.S. oil supply is associated with a rise in U.S. real stock returns that is statistically significant or close to being statistically significant in the fourth through twelfth months. This result is hard to reconcile with the intuition that non-U.S. oil supply disruptions are associated with a fall in the U.S. stock market.

The result for a negative world oil supply shock on real stock returns in the Kilian and Park (2009) model over 1973:01-2014:12 are reported in the second diagram in Figure 2c. The impulse responses in the fourth through twelfth months range are positive and partially statistically significant, indicating a problematic result for the effect on U.S. real stock returns of both world oil supply and non-U.S. oil supply shocks for the 1973:02-2014:12 sample.

The difference in the results for the original sample in Kilian and Park (2009) and the full sample, suggests that the model for the full sample is influenced by the events of increased U.S. shale oil production (since 2007) and with the global financial crisis (GFC). We will add a dummy variable set to 1 for the key financial crisis months 2008:09 - 2008:11, and otherwise zero, in equation (1).[1] In the monthly data real stock returns in September, October and November are an extraordinary run of -9.89%, -17.60% and -6.69%, respectively.

The cumulative impulse responses of U.S. real stock return to negative one standard deviation structural shocks in non-U.S. and in U.S. oil production over 1973:01-2014:12 with a dummy variable for the GFC in equation (1) appear in Figure 2d. The presence of a dummy variable for the GFC reduces the distinctiveness of the effects of shocks to non-U.S. oil production and U.S. oil production on real stock returns. In particular, the presence of the GFC dummy variable mutes the anomalous result of a positive effect on real stock returns of a negative shock to non-U.S. oil production.

The finding that shocks to U.S. oil production are positively associated with real stock returns is robust to inclusion of the GFC dummy variable. With recognition of the GFC, a negative shock to U.S. oil production has negative effects on U.S. real stock returns, and the effects are statistically significant in the sixth month and in the fourteenth month and later. In a sample over 1973:01-2006:12, a positive U.S. oil supply shock only has a statistically significantly positive impact on U.S. real stock returns in the twenty-first and twenty-second months. These results underscore the importance when examining U.S. real stock returns of the disaggregation of world oil production into U.S. and non-U.S. oil supply components following the "Shale Revolution".

[1] The months 2008:09 - 2008:11 are associated with the GFC for the following reasons. Lehman Brothers filed for bankruptcy protection on September 15, 2008, and the stock market declined sharply. The week of October 6–10 was the worst week for the stock market since 1933 with the S & P's 500 index losing 18.2 percent. The GFC appears to have stabilized by the end of November 2008 with the U.S. Federal Reserve pledging to purchase mortgage bonds guaranteed by Fannie Mae and Freddie Mac.

We compute forecast error variance decomposition to address the important question of how much of the variation in U.S. real stock returns is due to each structural shock in the crude oil market. Table 1 and Table 2 show the average contributions of each structural shock to the total variation in U.S. real stock returns over 1973:01-2006:12 and over 1973:01-2014:12. It shows that by disaggregating world oil supply into U.S. and non-U.S. oil supply shocks, demand and supply shocks are comparable in explaining the variation in U.S. real stock returns. In the period 1973:01-2006:12, supply shocks explain 14.1% of the variation in U.S. real stock returns, while demand shocks explain 16.8% after 60 months. Over 1973:01-2014:12, supply shocks account for 11.9% and demand shocks account for 11.6% of variations of U.S. real stock returns after 60 months. For a model in which oil production is consolidated as world oil production, supply shocks forecast 6.8% of the variation in U.S. real stock returns over 1973:01-2014:12.

4. Effects of oil supply shocks on real stock returns across industries

To shed light on the nature of the information contained in the U.S. oil production we examine whether the effects of the structural oil market shocks on real stock returns differ across industries. If the main channel of the U.S. oil production-stock market index correlation is limited to the oil production related sector, then it seems reasonable treating the recent U.S. oil production increase as a positive supply innovation. We report forecast error variance decomposition results for sector real stock returns for the four industries considered by Kilian and Park (2009) in Table 3.[2] These industries are the petroleum and natural gas industry, because of possible ownership of oil resources; the automotive industry, because it may be sensitive to energy prices; the retail industry, because oil price has an effect on

[2] In generating results, a U.S. sector real return replaces U.S. real stock return in equation (1). The data are at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

discretionary income; and the precious metals sector, where high oil prices might be associated with political uncertainty

In Table 3, at the 60 month forecast horizon, shocks to U.S. oil production account for statistically significant 4.7%, 9.6%, 4.7% and 5.0% of the variation in real returns in the petroleum and natural gas, automobile, retail and precious metals industries, respectively. U.S. oil production does not mainly predict returns of the petroleum and natural gas industry, but contains information for retail spending, for purchases in the automotive sector, and for uncertainty reflected in demand for precious metals. In results not shown, impulse response functions indicate that the magnitude of response in the returns in the automobile (negative effect) and precious metals (positive effect) industries to a negative U.S. oil production shock are particularly large (Results are available upon request).

Identifying world oil production by non-U.S. and U.S. components has a dramatic effect on the ability of oil supply shocks to forecast industry returns. Over the 60 month horizon, oil production shocks (U.S. and non-U.S.) forecast 9.7%, 14.5%, 10.1% and 9.1% of the variation in real stock returns of the petroleum and natural gas, automobile, retail and precious metals industries, respectively, in Table 3. In contrast, in a model in which oil production is consolidated as world oil production, supply shocks forecast only 5.3%, 5.6%, 6.0% and 3.9% of the variation in real stock returns of the petroleum and natural gas, automobile, retail and precious metals industries, respectively, as shown in Table 4. Identifying oil production shocks originating outside and inside the U.S. is particularly important for forecasting returns in the automobile and truck industry.

5. Conclusion

In this paper we show the importance of distinguishing between U.S. and non-U.S. oil supply shocks for understanding the impact of structural shocks in the oil market on U.S. real stock returns. Shocks to U.S. oil production are positively associated with U.S. real stock returns and the link is statistically significant in the fourteenth month and later. This is a stronger result than that obtained by estimating the model over a sample period ending before the start of the production of shale oil in 2007. This highlights the importance of separating the influences of U.S. and non-U.S. oil production on real stock returns in recent years. In contrast to the results reported in Kilian and Park (2009), oil demand and supply shocks are of comparable importance in explaining U.S. real stock returns when supply shocks from U.S. and non-U.S. oil production are identified. Distinguishing between U.S. and non-U.S. oil supply shocks is also important to understanding the effects of oil supply shocks on industries' real stock returns, especially for the automobile and truck industry.

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Table 1. Forecast error variance decomposition of U.S. real stock market return: 1973:01-2006:12

Horizon	Non-U.S. oil supply shock		U.S. oil supply shock		Aggregate demand shock		Oil-market specific demand shock		Other shock	
1	0.000	(0.01)	0.001	(0.07)	0.005	(0.36)	0.041	(1.22)	0.954	(25.36)
3	0.003	(0.25)	0.001	(0.06)	0.009	(0.55)	0.061	(1.63)	0.926	(21.73)
12	0.019	(0.99)	0.028	(1.30)	0.029	(1.40)	0.074	(2.09)	0.850	(18.96)
24	0.061	(2.63)	0.056	(2.00)	0.053	(2.42)	0.095	(2.89)	0.735	(16.22)
60	0.067	(2.92)	0.074	(2.26)	0.065	(2.89)	0.103	(3.38)	0.692	(14.92)

Notes: Percent contributions of structural shocks to the variability of real stock market return. The values in parentheses represent the absolute t-statistics when coefficients' standard errors were generated using a recursive-design wild bootstrap.

Table 2. Forecast error variance decomposition of U.S. real stock market return: 1973:01-2014:12

Horizon	Non-U.S. oil supply shock		U.S. oil supply shock		Aggregate demand shock		Oil-market specific demand shock		Other shock	
1	0.001	(0.09)	0.001	(0.09)	0.002	(0.24)	0.006	(0.48)	0.990	(44.90)
3	0.006	(0.48)	0.012	(0.61)	0.005	(0.49)	0.012	(0.74)	0.966	(33.62)
12	0.019	(1.14)	0.031	(1.25)	0.027	(1.56)	0.037	(1.79)	0.885	(23.76)
24	0.056	(2.59)	0.042	(1.69)	0.042	(2.22)	0.063	(2.71)	0.798	(20.71)
60	0.063	(2.86)	0.056	(2.10)	0.049	(2.54)	0.067	(2.95)	0.766	(19.16)

Notes: Percent contributions of structural shocks to the variability of real stock market return. The values in parentheses represent the absolute t-statistics when coefficients' standard errors were generated using a recursive-design wild bootstrap.

Table 3. Forecast error variance decomposition of U.S. real stock market return by industry: 1973:01-2014:12

Horizon	Non-US oil supply shock		US oil supply shock		Aggregate demand shock		Oil-market specific demand shock		Other shock	
Panel 1. Petroleum and Natural Gas										
1	0.002	(0.18)	0.001	(0.05)	0.011	(0.69)	0.026	(1.23)	0.961	(31.47)
12	0.030	(1.64)	0.022	(1.03)	0.044	(2.01)	0.060	(2.42)	0.845	(21.74)
60	0.050	(2.57)	0.047	(1.93)	0.061	(2.77)	0.088	(3.70)	0.754	(18.94)
Panel 2. Automobiles and Trucks										
1	0.000	(0.03)	0.003	(0.28)	0.000	(0.00)	0.031	(1.20)	0.966	(32.08)
12	0.010	(0.73)	0.052	(1.51)	0.054	(2.47)	0.081	(2.76)	0.802	(17.40)
60	0.049	(2.37)	0.096	(2.67)	0.069	(3.19)	0.120	(3.98)	0.666	(15.12)
Panel 3. Retail										
1	0.000	(0.03)	0.001	(0.05)	0.000	(0.01)	0.019	(1.02)	0.980	(40.14)
12	0.023	(1.19)	0.014	(0.81)	0.021	(1.29)	0.045	(1.95)	0.896	(25.08)
60	0.054	(2.35)	0.047	(1.99)	0.032	(1.82)	0.069	(2.93)	0.799	(20.66)
Panel 4. Precious Metals										
1	0.003	(0.30)	0.003	(0.18)	0.002	(0.31)	0.012	(0.80)	0.980	(38.57)
12	0.022	(1.29)	0.036	(1.54)	0.020	(1.25)	0.039	(1.89)	0.883	(25.35)
60	0.041	(2.10)	0.050	(2.11)	0.058	(2.59)	0.048	(2.35)	0.804	(20.25)

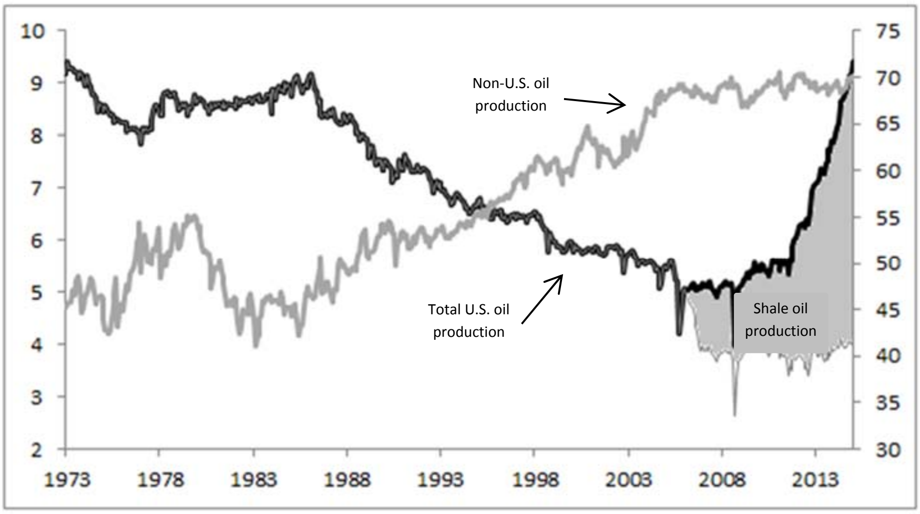
Notes: Percent contributions of structural shocks to the variability of real stock market return across industries. The values in parentheses represent the absolute t-statistics when coefficients' standard errors were generated using a recursive-design wild bootstrap.

Table 4. Forecast error variance decomposition of real U.S. stock market return across industries with consolidated world oil supply shock: 1973:01-2014:12

Horizon	World oil supply shock		Aggregate demand shock		Oil-market specific demand shock		Other shock	
Panel 1. Petroleum and Natural Gas								
1	0.001	(0.08)	0.008	(0.47)	0.040	(1.55)	0.952	(29.02)
12	0.029	(1.56)	0.037	(1.70)	0.071	(2.55)	0.863	(23.02)
60	0.053	(2.51)	0.063	(2.63)	0.099	(3.59)	0.786	(20.24)
Panel 2. Automobiles and Trucks								
1	0.001	(0.07)	0.001	(0.16)	0.011	(0.61)	0.987	(44.56)
12	0.011	(0.78)	0.061	(2.41)	0.070	(2.43)	0.859	(22.89)
60	0.056	(2.44)	0.081	(3.31)	0.110	(3.50)	0.753	(18.74)
Panel 3. Retail								
1	0.002	(0.15)	0.000	(0.00)	0.009	(0.64)	0.989	(47.53)
12	0.024	(1.24)	0.023	(1.31)	0.031	(1.57)	0.922	(29.15)
60	0.060	(2.39)	0.032	(1.69)	0.061	(2.56)	0.847	(23.03)
Panel 4. Precious Metals								
1	0.003	(0.27)	0.002	(0.17)	0.016	(0.92)	0.980	(43.49)
12	0.021	(1.30)	0.020	(1.14)	0.036	(1.72)	0.923	(29.08)
60	0.039	(1.98)	0.060	(2.38)	0.045	(2.08)	0.856	(21.32)

Notes: Percent contributions of structural shocks to the variability of real stock market return across industries. The values in parentheses represent the absolute t-statistics when coefficients' standard errors were generated using a recursive-design wild bootstrap.

Figure 1. Monthly U.S. and Non-U.S. oil production, 1973:01 – 2014:12

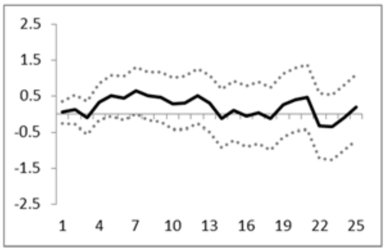


Notes: Data from the U.S. Department of Energy.

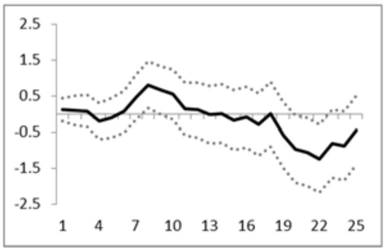
Figure 2. Response of U.S. real stock return to negative oil production shocks

a. Five variable model: 1973:01-2006:12

Non-U.S. oil production

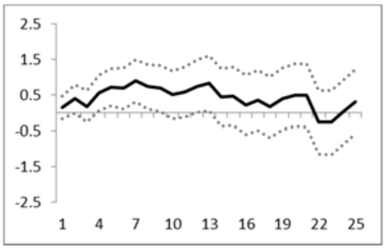


U.S. oil production

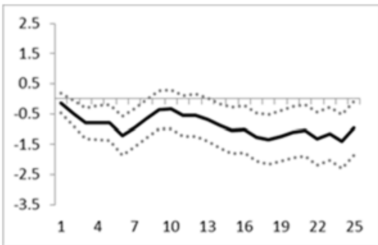


b. Five variable model: 1973:01-2014:12

Non-U.S. oil production

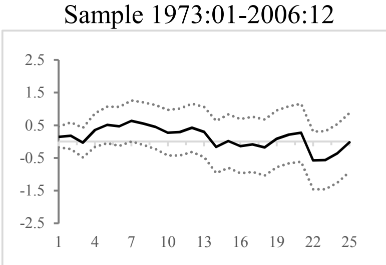


U.S. oil production

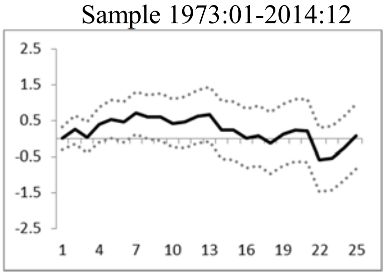


c. Four variable model (Kilian and Park (2009))

World oil production
Sample 1973:01-2006:12

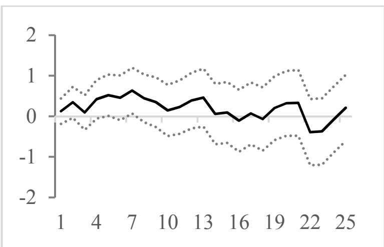


World oil production
Sample 1973:01-2014:12

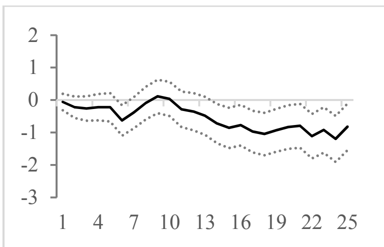


d. Five variable model with GFC dummy variable: 1973:01-2014:12

Non-U.S. oil production



U.S. oil production



Notes: Each diagram shows the cumulative impulse response of U.S. real stock return to negative one standard deviation structural shock in non-U.S., U.S., and world oil production. Results for shocks in non-U.S. and U.S. oil production are obtained from estimation of the five variable model in equation (1) and results for shocks in world oil production are obtained from estimating the four variable model in Kilian and Park (2009). Point estimates are reported with one-standard error bands constructed using a recursive-design wild bootstrap. The exogenous global financial crisis (GFC) dummy variable is set equal to 1 for the months 2008:09, 2008:10 and 2008:11, and 0 otherwise.

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