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Estimating heterogeneous agents behavior with different investment horizons in stock markets

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FINMAP –

FINANCIAL DISTORTIONS AND MACROECONOMIC PERFORMANCE: EXPECTATIONS, CONSTRAINTS AND INTERACTION OF AGENTS

DATE: 06/23/2014

TITLE

Estimating heterogeneous agents behavior with different investment horizons in stock markets

by: Zhenxi Chen

ABSTRACT

In addition to the traditional agent types of fundamentalists and chartists, a new dimension of investment horizon is included in evaluating historical performance of strategies. Based on the three stock markets of Japan, Hong Kong and Germany, it is found that investors with different investment horizons exist in al the markets. Regressions based on all the investment horizons produce better fitted results. Different markets can be characterized by different agents and different investment horizons. Ignorance of the heterogeneity of investment horizon may generate biased results due to the concern of omitting variables.

JEL-Classification: G12, C22
Keywords: Investment horizon, Heterogeneous agents, Evolutionary selection, Behavioral finance

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In addition to the traditional agent types of fundamentalists and chartists, a new dimension of investment horizon is included in evaluating historical performance of strategies. Based on the three stock markets of Japan, Hong Kong and Germany, it is found that investors with different investment horizons exist in all the markets. Regressions based on all the investment horizons produce better fitted results. Different markets can be charerized by different agents and different investment horizons. Ignorance of the heterogeneity of investment horizon may generate biased result due to the concern of omitting variables.

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1. INTRODUCTION

Financial markets exhibit many behaviors unexpected by "efficient market hypothesis", such as larger fluctuation and transaction activities. Irrational behaviors such as herding can also be observed in financial markets. This might be due to the fact that investors cannot be represented by a single rational representative of "efficient market hypothesis". Instead, investors are heterogeneous in various aspects. For example, not all investors have fully and equally access to market data due to various constraints, including by not limited to information cost and the lack of analytical skills. Based on the level of information and knowledge as well as trading reference, investors can be categorized into typical agents as fundamentalists and chartists. Fundamentalists have access to information relevant to asset's fundamental value and use that information for trading reference. Chartists do not rely on information of fundamental value for trading decision. Instead, they apply various techniques such as chartist analysis.

Taking account of the heterogeneity among the traders, heterogeneous agents models (HAM) relax the strong assumption of a single rational representative. It has been proven that heterogeneous agents models manage to explain financial markets theoretically (e.g.,

Day and Huang (1990), Brock and Hommes (1998), Lux (1998), Chiarella et al. (2003), Hommes et al. (2005), He and Westerhoff (2005), Dieci and Westerhoff (2010), Huang and Chen (2014)). The development of theoretical models inspires the empirical investigation using HAM. Westerhoff and Reitz (2005) show behavioral heterogeneity in US corn market. Frijns et al. (2010) verify that traders with different beliefs about volatility are active in option market. Manzan and Westerhoff (2007) and De Jong et al. (2010) find the existence of heterogeneous traders in foreign exchange markets. Boswijk et al. (2007) and Chiarella et al. (2012) estimate behavioral heterogeneity in S&P 500 using techniques of nonlinear least square and Markov regime switching respectively.

All of the above literatures have the same presumption that different investors, typically fundamentalists and chartists, have the same investment horizon. In evaluating the fitness of the strategy for the evolutionary composition of investor, only the latest one period is taken into account. However, in real world, investors can be categorized based on investment horizon into short, median and long terms investors. A long-term investor will evaluate the strategy fitness in longer time frame, instead of the latest one period as a short-term investor. There is a research gap in including investment horizon into the HAM models. Lux (2012) constitutes an exception. He estimates an agent based model with optimistic and pessimistic opinions and finds strong and moderate social interaction in short-term and medium-run sentiment formations.

The innovation of this paper is the introduction of heterogeneity in terms of investment horizon in addition to the traditional heterogeneity of agent types such as fundamentalists and chartists. In evaluating the strategy fitness, investors compare the historical performance of strategies with respect to different horizons. Based on monthly data of three stock markets of Japan, Hong Kong and Germany, it is found that investors with different investment horizons exist in all the three markets. Estimations based on different investment horizons achieve better explanatory fitting overall. It is noted that different markets are characterized with different investment horizons.

The rest of the paper is organized as follows. In Section 2, an empirical model is developed with the inclusion of investment horizon into the typical HAM model. Section 3 presents the data and the regression results. Lastly, Section 4 concludes the paper.

2. THE EMPIRICAL MODEL

An empirical agent based model is developed in this section. In market i, there are two groups of traders in each market: fundamentalists and chartists. Fundamentalists trade based on the market fundamental value while chartists based on the short-term price movement pattern. The compositions of the traders evolve based on fitness measures with different investment horizons. Instead of just considering the historical performance of the strategy in the latest transaction period, this paper considers one more dimension by taking into account the investment horizon. That is, even within investors with the same agent type, investors are heterogenous in terms of investment horizon. By summing up the excess demands of all traders, master equation of changes of price is derived.

2.1. Fundamentalists

At time t, fundamentalists (f) are assumed to know the information of fundamental value, u_{t-1}. Based on the log difference between the fundamental value and price, $\ln u_{t-1} - \ln p_{t-1}$, excess demand of fundamentalists with investment horizon k is defined as:

$$D_{f,t}^{k} = b_{f}^{k} \left(\ln u_{t-1} - \ln p_{t-1} \right), \tag{1}$$

where b_f^k is the demand coefficient of fundamentalists. $b_f^k > 0$ means fundamentalists believe that price will converge to fundamental value. Fundamentalists will buy (sell) the asset if price is lower (higher) than the fundamental value. On the other hand, $b_f^k < 0$ means fundamentalists believe that price will move further away from the fundamental value and hence investors will sell (buy) the asset if price is lower (higher) than the fundamental value.

Following Chiarella et al. (2012), fundamental value u_{t-1} is derived based on static Gordon growth model of Gordon and Shapiro (1956) as well as Fama and French (2002),

$$u_{t-1} = d_{t-1} \frac{1+g}{y}, \tag{2}$$

where d_{t-1} is dividend flow, g is the average growth rate of dividend, and y is the average dividend yield. In addition, the discount rate r is equal to the sum of average dividend yield y and average rate of capital gain that is equal to the growth rate of dividend g in the static Gordon growth model, that is

$$r = y + g.$$

2.2. Chartists

Instead of using the fundamental value, chartists (c) with investment horizon k trade based on the short-term price movement. Their demand can be simply formulated as

$$D_{c,t}^{k} = b_{c}^{k} \left(\ln p_{t-1} - \ln p_{t-2} \right), \tag{3}$$

where b_c^k is the demand coefficient of chartists. $b_c^k > 0$ means chartists believe the trend of price movement will continue and behave as momentum traders. On the other hand, $b_c^k < 0$ means chartists believe the trend of price movement will reverse and behave as contrarians.

2.3. Market setup

Excess demands of fundamentalists and chartists contribute to the price change in the aggregate level. A positive excess demand will drive price up while a negative one will push price down. The price change in time t can be expressed as

$$\begin{aligned} \ln p_t - \ln p_{t-1} &= \delta \left(\sum_k \omega_{f,t}^k D_{f,t}^k + \sum_k \omega_{c,t}^k D_{c,t}^k + e_t \right) \\ &= \delta \left[\sum_k \omega_{f,t}^k b_f^k \left(\ln u_{t-1} - \ln p_{t-1} \right) + \sum_k \omega_{c,t}^k b_c^k \left(\ln p_{t-1} - \ln p_{t-2} \right) + e_t \right] \\ &= \sum_k \omega_{f,t}^k \alpha_f^k \left(\ln u_{t-1} - \ln p_{t-1} \right) + \sum_k \omega_{c,t}^k \alpha_c^k \left(\ln p_{t-1} - \ln p_{t-2} \right) + \varepsilon_t \end{aligned} \tag{4}$$

where δ is coefficient of price updating, $\alpha_f^k = \delta b_f^k$, $\alpha_c^k = \delta b_c^k$, and $\varepsilon_t = \delta e_t = N\left(0, \sigma^2\right)$ denoting price change due to noise traders. $\omega_{f,t}^k$ and $\omega_{c,t}^k$ are the compositions of fundamentalists and chartists with investment horizon k. The corresponding composition is determined evolutionarily by the historical performance of the strategy following Brock and Hommes (1998),

$$\begin{aligned} \omega_{h,t}^k &= \frac{\exp(\rho_0 \pi_{h,t-1}^k)}{z_{t-1}}, \\ \text{with } z_{t-1} &= \sum_h \sum_k \exp(\rho_0 \pi_{h,t-1}^k),\ h = f, c. \end{aligned}$$

where $\rho_0 = \delta\rho$ and ρ_0 is the intensity of choice in Brock and Hommes (1998). Subsequently, ρ measures the speed of switching among the investment strategies. A large positive ρ indicates that more investors will adopt the strategy with better performance. In contrast, a negative ρ means investors are irrational as a poorer performed strategy gains popularity

among the investors. $\pi^k_{h,t-1}$ is the per period historical profit of strategy h with investment horizon k. It is derived as

$$\pi^k_{h,t-1} = D_{f,t-k}E_{t-k,t-1}/k.$$

where $E_{t-k,t-1}$ is the profit per share within the investment horizon from period from $t-k$ to the latest period $t-1$. $E_{t-k,t-1}$ can be calculated according to

$$E_{t-k,t-1} = p_{t-1} + \sum_{i=1}^{k} d_{t-i} - (1+r)^k p_{t-(k+1)}. \tag{5}$$

3. ESTIMATION RESULTS

3.1. Data

This paper studies three stock markets: Japan (TOPIX 500), Hong Kong (HSI) and Germany (DAX). The monthly data extracted from Bloomberg include Consumer Price Index (CPI), market indexes and dividend. The dividend is the past 12 months value. Sample period is from January 2000 to March 2013. All the indexes and dividend are discounted by CPI to get the real values for evaluation in this paper.

Fundamental values are calculated according to e.q. (2) using the 12 months dividend. In calculating the profit per share $E_{t-k,t-1}$ based on e.q. (5), dividends of each month within the investment horizon are needed. As existing dividend data is the 12 month value, for simplicity, it is divided by 12 to get the monthly dividend of the particular month, d_{t-i}. In addition, the monthly discount rate r is calculated by $r = y/12 + g$ as the average dividend yield y is calculated based on the 12 months dividend.

Real stock price and calculated real fundamental value are compared in column 1 of Fig. 1. Japan and Germany have mismatched prices and fundamental values. They are similar in the way that prices are above and below fundamental values before and after subprime crisis. In contrast, price matches quite well with fundamental value in Hong Kong except the periods of "dot com" bubble and subprime crisis. The differences among the three markets can also be found from Table 1 which summarizes the statistics. Hong Kong has the largest average dividend growth rate and average dividend yield, consequently a largest monthly discount rate. Although Japan has a similar average dividend growth rate with Germany, its dividend yield is smaller than Germany and therefore its monthly discount rate is smaller.

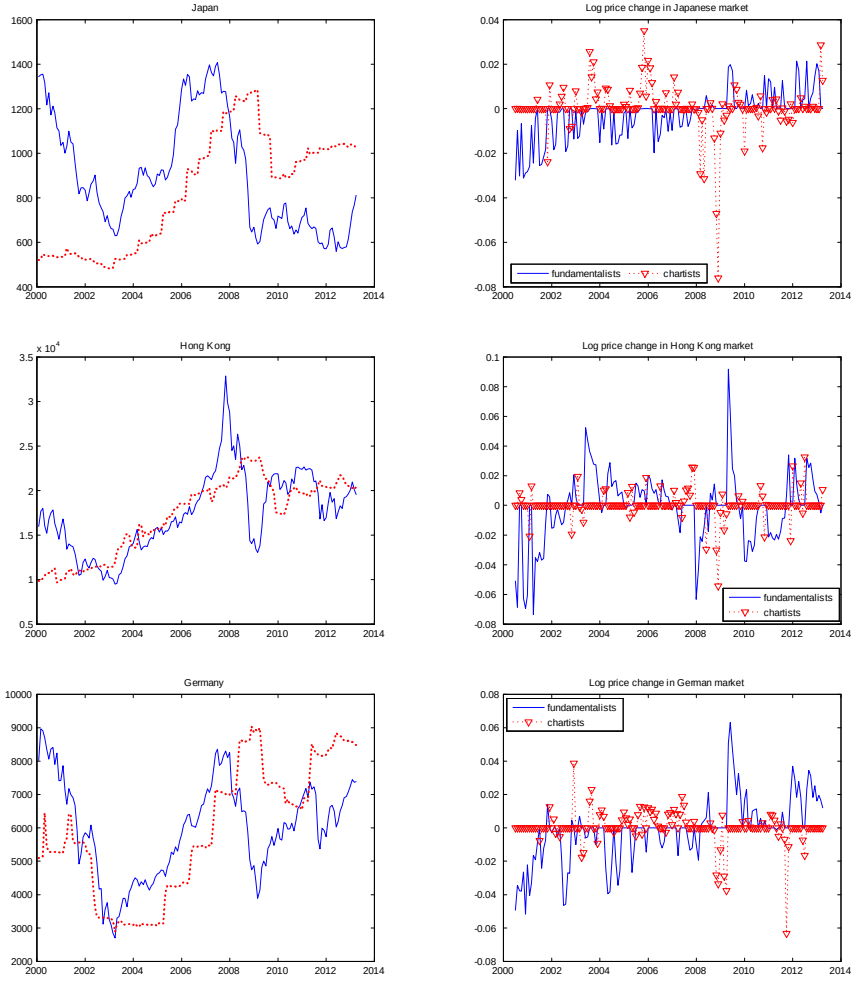

FIG. 1 Real stock price and fundamental value comparison (column 1) as well as price change contributed by traders (column 2) for the three markets: Japan, Hong Kong and Germany.

TABLE 1
Statistics summary, sample period from January 2000 to March 2013.

Variable		p_t	d_t	u_t	g	y	r
Japan	Mean	901.982	11.903	829.116	0.0048	0.0144	0.0061
	Std. dev.	250.431	3.664	255.193			
	Min	559.451	6.934	482.975			
	Max	1407.247	18.474	1286.798			
Hong Kong	Mean	17465.080	526.940	17126.648	0.0051	0.0309	0.0077
	Std. dev.	4509.180	130.854	4253.041			
	Min	9488.407	297.830	9680.094			
	Max	32864.340	732.499	23807.756			
Germany	Mean	5966.460	169.510	5902.947	0.0046	0.0288	0.0070
	Std. dev.	1423.992	56.364	1962.794			
	Min	2701.971	82.985	2889.849			
	Max	8961.211	259.620	9040.899			

3.2. Model estimation for individual investment horizon

To show the existence of different investment horizons, e.q. (4) is estimated for individual k ($k = 1, 2, 3$) separately for each market using technique of maximum likelihood. The detailed regression results are reported in Table 2. Estimated coefficients for fundamentalists (α_f^k) and chartists (α_c^k) are positive for all cases, indicating that fundamentalists believe that price will converge to fundamental value while chartists are momentum traders with belief that price will continue with the trend as in the previous investment horizon. It is found that strategies with different investment horizons exist in all the markets. In Japan, for one-month horizon, both coefficients for fundamentalists and chartists are statistically significant. For two-month horizon, the regression suffers from a singular value and the result may be inaccurate although both coefficients for fundamentalists and chartists are significant. For three-month horizon, only chartists are significant. In the case of Hong Kong, only coefficients for fundamentalists are significant for one-month and two-month horizons. While for three-month horizon, both coefficients for fundamentalists and chartists are significant with the largest fitness R^2 among the three horizons. Germany also exhibits different investment horizons. Both coefficients for fundamentalists and chartists are significant for the one-month horizon while only coefficient for fundamentalists is significant for the two-month horizon. Regression result for three-month horizon also suffers from problem of singular value. Notice that, the speed of switching ρ is insignificant for all the regressions. This should not be worrying due to the non-linear character of the switching as explained

TABLE 2
Estimation result of individual investment horizon for each market, The investment horizons include 1 to 3 months. Sample period from January 2000 to March 2013. *, **, and *** represent significance at10%, 5% and 1% level. P-value is in parenthesis.

	k	α_f^1	α_c^1	α_f^2	α_c^2	α_f^3	α_c^3	ρ	R^2	Remark
Japan	1m	0.027**	0.322***					231.902	0.088	
		(0.034)	(0.000)					(0.947)		
	2m			0.040***	0.150**			3.5∗10^8	0.062	Singular
				(0.008)	(0.044)			(1.000)		
	3m					0.030	0.447***	0.867	0.081	
						(0.119)	(0.004)	(0.497)		
Hong Kong	1m	0.136***	0.068					28.177	0.087	
		(0.000)	(0.360)					(0.978)		
	2m			0.143***	0.143			6.163	0.096	
				(0.000)	(0.183)			(0.889)		
	3m					0.144***	0.448***	0.024	0.097	
						(0.000)	(0.001)	(0.328)		
Germany	1m	0.021*	0.256***					27.691	0.033	
		(0.069)	(0.009)					(0.903)		
	2m			0.071**	0.089			5.833	0.033	
				(0.027)	(0.375)			(0.890)		
	3m					0.063**	0.255***	3.7∗10^8	0.058	Singular
						(0.030)	(0.000)	(1.000)		

by Boswijk et al. (2007) and ter Ellen et al. (2013).

3.3. Model estimation with multiple investment horizons

It has been found that different investment horizons exist in all the three markets. With the aim to obtain a better fitted model, e.q. (4) is estimated with all investment horizons k ($k = 1, 2, 3$), followed by backward elimination to simplify the model with a better fitness R^2. Table 3 reports the regression results for Japan. In case 1 where all the investment horizons are included, only coefficients for fundamentalists with one-month horizon, α_f^1 and chartists with two-month horizons, α_c^2 are significant. To simplify the model, chartists with one-month horizon which is the most insignificant variable, is removed. Run regression and case 2 is obtained. Coefficient for fundamentalists with one-month, α_f^1 becomes insignificant. Besides that, the numerical processing is inaccurate due to singular value. It is implied that chartists with one-month horizon cannot be removed. Case 3 evaluates removing fundamentalists with two-month horizon. Coefficient of chartists with two-month horizon, α_c^2 becomes insignificant, suggesting the necessity of keeping fundamentalists with two-month horizon. Similarly, case 4 and case 5 evaluate removing chartists with three-month horizon

TABLE 3
Estimation result for Japan with multiple investment horizons, sample period from January 2000 to March 2013. *, **, and *** represent significance at10%, 5% and 1% level. P-value is in parenthesis.

	α_f^1	α_c^1	α_f^2	α_c^2	α_f^3	α_c^3	ρ	R^2	Remark
case 1	0.039***	−0.045	0.008	0.327***	0.011	0.067	48.970	0.078	Fitted
	(0.009)	(0.865)	(0.849)	(0.000)	(0.566)	(0.709)	(0.784)		
case 2	−0.027		−0.012	0.205	0.041**	0.387***	1725190.7	0.088	Singula
	(0.185)		(0.869)	(0.208)	(0.013)	(0.000)	(1.000)		
case 3	0.039**	0.104		0.218	0.006	0.403***	216.094	0.091	
	(0.024)	(0.607)		(0.304)	(0.762)	(0.000)	(0.968)		
case 4	−0.018	0.147	0.034**	0.315***	0.018		855833.9	0.072	Singula
	(0.519)	(0.732)	(0.028)	(0.000)	(0.629)		(1.000)		
case 5	0.020	0.138	0.041***	0.217		0.403***	287.228	0.100	
	(0.605)	(0.443)	(0.009)	(0.294)		(0.000)	(0.955)		

and fundamentalists with three-month horizon. Coefficient for fundamentalists with one-month horizon, α_f^1 becomes insignificant for both cases. Hence, case 1 should be the most fitted model among all the cases for Japanese market although coefficients of some of the variables are insignificant. One of the possible explanations for the insignificant coefficients is the multicollinearity among the investment horizons for each agent type.

Regression results for Hong Kong are reported in Table 4. When regressing on all the investment horizons in case 1, only coefficients for chartists with one-month horizon, α_c^1 and two-month horizon, α_c^2 are insignificant. Note that fitness R^2 has been improved to 0.151 compared to the case of regressing on single investment horizon in Table 2 with value 0.097. Case 2 removes chartists with two-month horizon. Consequently, coefficient for chartists with three-month horizon, α_c^3 becomes insignificant. Case 2 is inappropriate. Case 3 removes chartists with one-month horizon. As a result, coefficient for chartists with two-month horizon, α_c^2 becomes even more insignificant. Moreover, fitness becomes smaller with R^2 reduced to 0.117. Hence, case 1 with all the investment horizons for both fundamentalists and chartists is the best model in explaining Hong Kong market.

Table 5 reports the regression results for Germany. In case 1 with all the investment horizons included, coefficients for all horizons are significant except chartists with one-month and two-month horizons. Similar to Hong Kong market, fitness R^2 improves to 0.097 from 0.033 in the case of single horizon. Case 2 removes chartists with one-month horizon.

TABLE 4

Estimation result for Hong Kong with multiple investment horizons, sample period from January 2000 to March 2013. *, **, and *** represent significance at10%, 5% and 1% level. P-value is in parenthesis.

	α_f^1	α_c^1	α_f^2	α_c^2	α_f^3	α_c^3	ρ	R^2	Remark
case 1	0.169***	−0.260	0.147***	0.210	0.155***	0.199**	234.463	0.151	Fitted
	(0.000)	(0.283)	(0.006)	(0.297)	(0.000)	(0.028)	(0.999)		
case 2	0.209***	−0.339	0.131**		0.105**	0.117	592.307	0.160	
	(0.000)	(0.298)	(0.011)		(0.028)	(0.111)	(0.999)		
case 3	0.088***		0.172***	−0.040	0.113***	0.227***	1720.172	0.117	
	(0.000)		(0.000)	(0.755)	(0.001)	(0.001)	(0.990)		

TABLE 5

Estimation result for Germany with multiple investment horizons, sample period from January 2000 to March 2013. *, **, and *** represent significance at10%, 5% and 1% level. P-value is in parenthesis.

	α_f^1	α_c^1	α_f^2	α_c^2	α_f^3	α_c^3	ρ	R^2	Remark
case 1	0.065**	−0.080	0.116***	0.217	0.082*	0.295*	1687.246	0.097	Fitted
	(0.017)	(0.469)	(0.000)	(0.354)	(0.097)	(0.085)	(0.998)		
case 2	0.080**		0.045	0.254*	0.096**	0.293*	4286.538	0.096	Singular
	(0.026)		(0.621)	(0.095)	(0.017)	(0.066)	(0.999)		
case 3	0.044	0.198	0.077**		0.089**	0.285	54.250	0.084	
	(1.000)	(0.413)	(0.029)		(0.015)	(0.112)	(0.947)		

Coefficient for fundamentalists with two-month horizon, α_f^2 becomes insignificant and the regression suffers from singular value. Case 2 is inappropriate. Case 3 removes chartists with two-month horizon. Coefficient for fundamentalists with one-month horizon, α_f^1 becomes insignificant consequently, implying that case 3 is also inappropriate. Overall, the most fitted model for German market is case 1. That is, fundamentalists and chartists with all three investment horizons should be included in the model.

Compared to the separated regressions for individual investment horizon in Table 2, the regressions with multiple investment horizons have better fitting R^2 overall. Moreover, ignorance of the existence of different investment horizons in investment strategies can produce misleading results. For the Japanese market, if heterogeneity in investment horizon is not taken into account and regressions are run based on single investment horizon, it is inconclusive for the existence of investor with two-month horizon. Besides that, fundamentalists with three-month might be considered wrongly as absent from the market.

Based on the regression results of fitted models with multiple investment horizons, fundamentalists in Hong Kong markets have larger demand strengths compared to other markets.

In addition, the ratios of fundamentalists demand strengths to chartists are also larger in Hong Kong. The market of Hong Kong has a larger stabilizing force in moving price towards the fundamental value. This explains the less mismatch between price and fundamental value in Hong Kong as shown in Fig. 1.

3.4. Price movements contributed by traders

Based on the fitted models including multiple investment horizons in the previous subsection, price movements due to fundamentalists and chartists are calculated and plotted in column 2 of Fig. 1. To contrast the contributions of the two agent types, fundamentalists and chartists, all the investment horizons are aggregated for both agents. This can contrast the roles of the two typical agents in markets, especially during the major events such as subprime crisis.

In Japan, chartists have a larger market power than fundamentalists overall. During the burst of "dot com" bubble before 2003, stock price is mainly driven down by fundamentalists. After that, traders enjoy as being chartists. More investors adopt the chartists strategy and there are two periods in which investors see dramatic rise in price. The two periods correspond to the latter part of 2003 and 2006. The price increments are mainly driven by chartists. At the end of 2007, chartists gain popularity again. This time, chartists are no more bullish, instead, they are bearish. The selling of chartists causes the price to drop dramatically by the end of 2007. But this is not the end, chartists even gain more market power in 2008. An even more severe price drop is caused by the panic sale of chartists. After 2008, market power of chartists is evenly counteracted by fundamentalists and the price is stagnant. After 2012, in viewing the increasing of fundamental value, more and more traders switch to fundamentalist strategy and price increases quickly. The continual increase of price makes chartist strategy profitable and chartists gains major market power again at the beginning of 2013.

In contrasting with Japan, fundamentalists have a larger market power than chartists in Hong Kong. Before 2002, sales of fundamentalists dominate Hong Kong market, causing the dropping down of price. After that, fundamentalists become the main driving force for the booming period till 2007 when chartists take over fundamentalists in pushing price up. At the end of 2007, accompanying the burst of subprime crisis is the large selling of

fundamentalists. Facing the sudden drop in price, more investors adopt the chartist strategy and over react, causing the panic sale of the market such that price is much lower than the fundamental value. Arising from the under-valued price, investment opportunity makes fundamentalist strategy more profitable. Fundamentalists dominate the market with large purchase in 2009, causing a quick rebound of price such that price is at the level comparable to the fundamental value.

Market power of fundamentalists in Germany is in between Japan and Hong Kong. Before 2003, fundamentalists are main sellers in pushing price down. During the booming period from 2003 to 2007, chartists are the main force of purchasing, counteracting the intermittent selling of fundamentalists. In the end of 2007, the drop in price by a small sale of fundamentalists remarks the outbreak of crisis in Germany. Observing the drop of price, investors believe the trend will continue and adopt the chartist strategy, causing the intensive decrease of price in 2008. From then on, the under-valued price makes fundamentalists popular. Price increases continually except the mild drop in November 2011 due to the selling of chartists.

There are some behavioral commonality among the three markets. Before 2002, the drops of price in the three markets are caused by fundamentalists. Another commonality is the 2008 crisis. The selling of chartists in the midst of the crisis exacerbates the crisis in all the markets. On the other hand, there are also differences among the markets. The main difference is the initiation of crisis. It is chartists who starts the crisis in Japan while it is fundamentalists who trigger the crisis in both Hong Kong and Germany. In addition, fundamentalists in Hong Kong and Germany manage to recover the prices closer to the fundamental values.

There is more difference among the three markets if we further decompose the excess demand of traders by investment horizons. Fig. 2 plots the price change due to fundamentalists and chartists with different investment horizons as well as the corresponding investor compositions. Legend is labelled in the way that f and c stand for fundamentalists and chartists while 1, 2, and 3 stand for investment horizons 1 to 3 months. For Japan, fundamentalists with one-month horizon and chartists with two-month horizons often have compositions up to 1, indicating the major roles of the two strategies in the corresponding agent types. As shown in the plot of price change, fundamentalists with one-month horizon

and chartists with two-month horizon exhibit ruling force in different periods of the market.

For Hong Kong, due to the large switching speed, investment strategy with best performance attracts almost all the investors. Consequently, in the price change plot, as long as an investment strategy has major market power, it means the particular strategy will dominate the investor composition. All investment strategies are active in different periods, especially fundamentalists with one-month horizon. For Germany, the investor compositions are similar to Hong Kong in the way that strategy with best performance gets popularity due to the large switching speed. In the price change plot, fundamentalists with two-month horizon and chartists with three-month horizon are major forces in the market. The depressed episode of November 2011 is due to the selling of chartists with three-month horizon.

4. CONCLUSION

Due to various constraints such as information access and behavioral preference, investors are heterogeneous with their trading strategies, instead of homogeneous with fundamental investment strategy presumed by "efficient market hypothesis". Typical example of non-fundamentalist strategies is technical analysis/chartist strategy. Empirical studies based on HAM models have shown the existence of heterogeneity in agent types exemplified as fundamentalists and chartists. This paper further finds out the existence of another dimension of heterogeneity among the investors: investment horizon.

Using data of the three stock markets of Japan, Hong Kong and Germany, the paper studies three investment horizons: one, two and three months. It is found that fundamentalists and chartists are active in each investment horizons. In the disaggregation level with all the investment horizons in the regressions, it is further shown that agents with different investment horizons exist concurrently. In addition, regressions in the disaggregation level have better explanatory fitting with R^2 improved up to two folds. The regression results reveal the differences among the three markets. For Japan, fundamentalists with one-month horizon and chartists with two-month horizons are major players. For Hong Kong, fundamentalists with one-month horizon have major market power while other investors are also active in different periods. For Germany, fundamentalists with two-month horizon and chartists with three-month horizon are major forces in the market. Overall, investors in Japan and Hong Kong are relatively short-term oriented while investors in Germany are

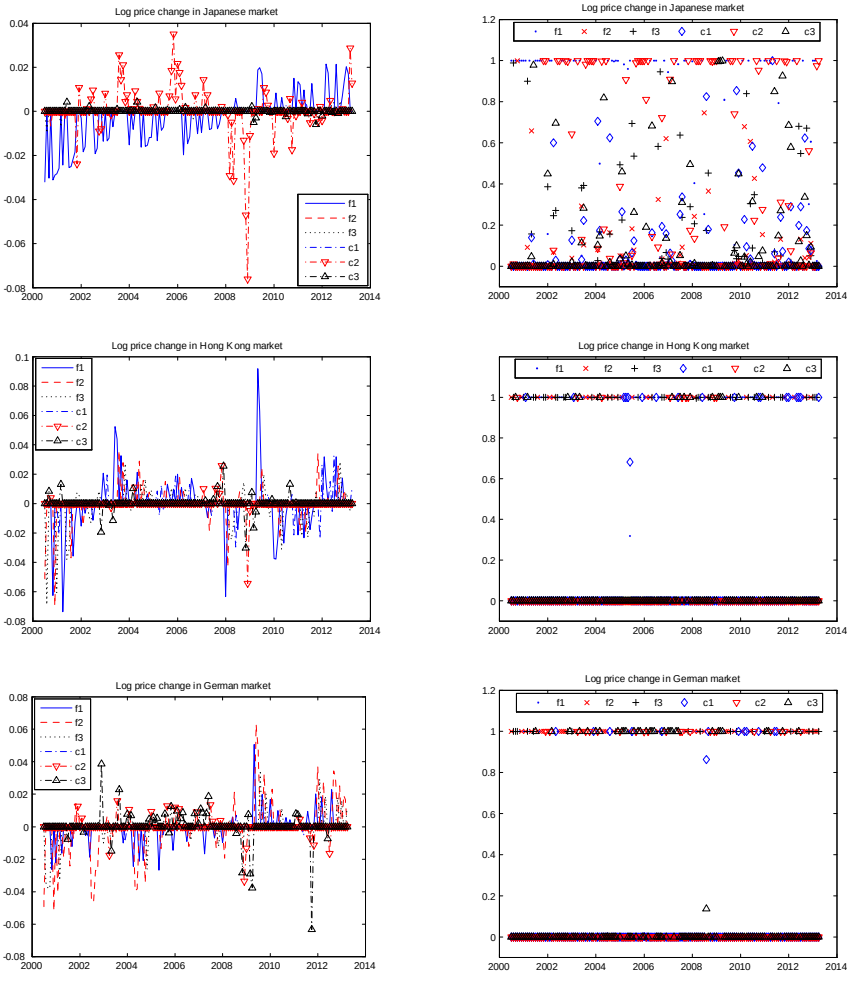

FIG. 2 Plots differentiated by investment horizons for the three markets. price change (column 1) and investor compositions (column 2).

relatively long-term oriented. The larger market power of fundamentalists with different investment horizons in Hong Kong explains the less mismatch between the market price and fundamental value.

Although including one more dimension of heterogeneity in terms of investment horizons makes the empirical model more complicated, ignoring the aspect of investment horizon may render the regression biased result due to the concern of omitting variables. This problem should become more severe for high frequency data. The combination of heterogeneous agents and investment horizon can be applied to investigate the behaviors of investors, such as short-term and long-term (at least one year) traders. This will take place in the future research.

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