Akihiro Omura^{*}, Neda Todorova, Bin Li, Richard Chung

Griffith Business School, Griffith University, Nathan, Queensland 4111, Australia

“Steel Scrap and Equity Market in Japan”

Abstract

Steel scrap is an important raw material in the steel making industry. As steel is a vital metal in modern life, the price of steel scrap is viewed as an important indicator of the macroeconomic activity. Steel scrap is consumed mainly in the electric arc furnace steel making, which represents approximately 30 per cent of the world annual steel production. Unlike other minerals including iron ore, both the supply and consumption amounts of steel scrap can be relatively easily adjusted based on the contemporary industrial activity level. For this reason, the steel scrap price reflects the condition of the macro economy and thereby it can be used as an indicator of future stock market performance in the country by market participants. Nevertheless, there is not much research on the market of steel scrap. This study aims to close this gap by testing the lead-lag relationship between the changes of steel scrap price and the aggregate Japanese stock market movement. Our empirical analyses suggest that the steel scrap price changes are informative in explaining the future stock market performance in Japan.

Keywords: Equity Markets, Commodity Markets, Metal Markets, Steel Scrap, Forecasting, Japan

JEL classification: G12, G14, D51, E2, Q21

^{*} Corresponding author: Department of Accounting, Finance and Economics, Griffith Business School, Griffith University, Queensland 4111, Australia. Phone number: +61-7-3735-7219 E-mail: akihiro.omura@griffithuni.edu.au.

1. Introduction

Predicting equity market returns has been of great interest to academics and speculators. To increase the accuracy of prediction, past studies have incorporated various internal and external factors into economic models. Those factors can be related to the macro economy (e.g., interest rate and industrial production), the micro economy (e.g., earnings of and dividend paid by companies), information regarding stock markets in other regions, information regarding other asset categories (e.g., commodity markets), and the past information of its own stock market (e.g., 12 months moving average market performance). However, in some instances, there are gaps between the perception of academic researchers and financial market participants (such as traders) on what drives the market. To close these gaps, our paper examines the effect of local steel scrap market condition on the equity market return in Japan. The behaviour of this recycled metal market is considered as a leading indicator of the equity market by a number of market participants including Dr Alan Greenspan, a former chairman of the Federal Reserve of the U.S.

The steel scrap price is a “favourite” economic indicator by Dr Greenspan (Desai 2013). The price of this metal might be a good indicator because (1) steel scrap is one of the main raw materials for steel making and steel is an essential material for modern industrial activities, (2) both the supply and demand of steel scrap adjust relatively quickly to macroeconomic conditions, and (3) there is no exchange in which steel scrap is actively traded. In relation to the first two points, steel scrap is mainly remelted in electric arc furnaces (EAF) and the production pace of this type of furnace can be easily adjusted. This is not the case for blast furnaces, which represents a larger portion of the world’s steel production and mainly consumes iron ore. For this reason,

the demand of steel scrap should reflect the contemporary consumption level of steel products and thereby macroeconomic conditions.

Furthermore, the demand of steel scrap is assumed to be minimally affected by speculation activities (Desai 2013). Since an increase in the economic activity gives rise to the growth in the demand of steel products, the consumption level of steel scrap is likely to be a positive function of the macroeconomic condition. If the above rationales are valid, there may exist a positive lead-lag relationship between steel scrap price and equity market, as the condition of macroeconomic activities and the stock market in a country tend to move together. In particular, the result of Kaneko and Lee (1995) indicates that the lagged industrial production index in Japan contains valuable information in determining the current equity market return in the country. Nevertheless, to the best of our knowledge, there is no previous scholarly paper focusing on the influence of steel scrap price on equity market. Our study aims to close this gap and adds a new dimension to equity market related studies.

There are a number of other locally traded commodities such as cement, papers and glass whose supply/demand environment can be also affected by internal factors of a country. However, given many reasons, they are believed not to be suitable proxies for the contemporary macroeconomic condition of the country. For instance, the production of flat glass, an important material directly used in industries such as the construction industry, cannot be easily altered as the furnace used in the production process cannot be stopped on a regular basis (Caner Taşkın & Tamer Ünal 2009). By contrast, this is not the case for the steel scrap market.

In this paper, we focus on Japan to test the presence of the relationship between

steel scrap price¹ and equity market returns. This is because (1) the country is believed to have a sufficient amount of steel scrap reserves in the economy, (2) there is a well-established off-exchange steel scrap market in the country, and (3) the impact of external factors such as an influence of supply/demand in other regions or countries is considered to be small. As steel stock accumulates in the economy (stored as durable final products like buildings) over the years of industrial activities, it requires some time before steel scraps are recycled. An empirical study that examines the notion elaborated above has to be done in the case of a well industrialised country such as Japan. For instance, the life cycle of automotive is usually more than 10 years; e.g., the average age of cars in the U.S. is over 11 years (IHS 2014). The life cycle of steel products used in buildings can be even longer.

It is estimated that there is over 1.3 billion metric tons (MT) of steel accumulated in Japan, equivalent to more than 10 years of domestic steel production (World Steel Association 2014a; HANWA 2015). Supported by this plentifully recyclable metal in the economy, there is a well-developed supply chain of steel scrap and there are over 30 companies identified in the country which produce steel using an EAF, a steel making process which mainly consumes steel scrap as a raw material. In comparison, there are only 19 member companies in the American Iron and Steel Institute (2015) in the U.S. and this includes basic oxygen steelmaking (BOS) companies which use blast furnaces and mainly consume iron ore as a raw material. In addition, the market of steel scrap in Japan is expected to be driven mostly by the domestic supply/demand condition. This is evident from the fact that as much as over 80 per cent of the steel scrap collected is consumed domestically and, at the same time,

¹ We do not incorporate steel scrap trading volumes as such data are not available.

the country imports only a fraction (< 1 per cent) of the overall consumption (Ministry of Economy Trade and Industry 2013; World Steel Association 2014a).

In addition, by focusing on Japan in this study, we examine whether the price of an important resource for a mineral-poor nation appropriately reflects the economic condition of that country (assuming, as indicated in past studies including Kaneko and Lee (1995) and Jones and Kaul (1996), that the equity market reflects the condition of macro economy). Prices of major natural resources such as crude oil, coal and metallic minerals are determined by various factors including the financial market conditions, the global economic activities, monetary/fiscal policy decisions of major developed nations and political decisions of major mineral exporters. For this reason, mineral poor nations in most cases are price takers of internationally traded commodities and their economies are, therefore, expected to be vulnerable to those external forces. For instance, a rapid drop in the crude oil price in 2015 was assumed to have a 7 trillion yen (approximately 60 billion USD as of April 2015) positive impact on the Japanese economy (The Mainichi Newspapers 2015).

Our study examines the lead-lag relationship between the prices of steel scrap and the equity market in Japan for the period from January 2003 to March 2015. We conduct bi- and multi-variate VAR and associated Granger-causality tests to study this relationship. In the multivariate settings, we consider various control variables. Our work contributes to the literature in the following ways. First, the secondary metals (recycled metals) including steel scrap are important resources for industrialised yet mineral poor nations and our study helps understand whether the prices of those crucial natural resources appropriately reflect the economic activities in those countries. Second, it introduces a new country-specific indicator for the equity market. Unlike

other macroeconomic variables such as unemployment rate, industrial production and GDP, there is no considerable announcement time lag for steel scrap prices. This is a strong advantage of such a variable being used as an indicator for the stock market behaviour. Third, our work adds further evidence to existing inconclusive discussions of which internal and external factors contribute to the understanding of the dynamic nature of the Japanese stock market. In summary, our results generally support our hypothesis. In particular, we find that the monthly change in the steel scrap price in Japan contains valuable information in explaining the variation of the future stock market returns.

The remainder of the paper is structured as follows. Section 2 provides a review of related past studies and the motivation of our study. Section 3 introduces our hypotheses in the study. Section 4 presents the methodology and the data. Section 5 reports our results, while Section 6 concludes.

2. Background

2.1. Steel scrap as an indicator

In the past, Dr Greenspan made various comments and statements about the steel scrap market:

“The aggregate scrappage rate has a pronounced cyclical pattern, falling sharply during recessions and rebounding during recoveries” (McKee & Cohn 1996).

“Scrappage [of motor vehicles] varies with the business cycle” (Greenspan & Cohen 1999).

“It is shown that scrappage [of motor vehicles] varies in a procyclical manner”

(Greenspan & Cohen 1999).

“Every day, I still look for the price of No.1 heavy melt steel scrap [one of the most major categories of steel scrap]” (Boselovic 1997).

“[Scrap price is] a not insignificant indicator [of the economy]” (Boselovic 1997).

As steel is an affordable crucial material for various industries such as construction, automotive and electronics industries, its demand is assumed to be closely related to the overall state of the macro economy. For this reason and as this is one of the important raw materials for steel making, steel scrap is directly fed into consumer and capital spending (Lahart 2003). Therefore, the industrial activities are presumably driving the consumption of steel scrap. To help understand the markets of essential raw materials for iron and steel making, namely, iron ore and steel scrap, we next elaborate how the two materials are consumed and how the supply/demand of steel scrap is determined.

Steel is 100 per cent amenable to recycling by means of a remelting process (World Coal Association 2014), and recycled steel scraps are a vital raw material for the EAF steel making (Fenton 1998). EAFs use an electric charge to remelt the recycled metal. In today’s world, approximately 30 per cent of the global steel is produced from this type of furnace (World Steel Association 2014a), while the figure differs across countries. For example, the proportion of the steel made by the EAFs is slightly above 20 per cent in Japan, but it is as large as 60 per cent in the U.S. In contrast, a BOS mainly consumes iron produced in blast furnaces (BF), by reducing iron ores using coking coal (World Coal Association 2014; American Iron and Steel Institute 2014a,

2014b). In addition to iron ore, steel scraps are also used as a raw material in the BOS steel making process. The proportion of scraps in the BOS varies by country. For instance, the ratio is 25 to 35 per cent in the U.S. but it is less than 15 per cent in Japan in recent years (Ministry of Economy Trade and Industry 2013; American Iron and Steel Institute 2014a).

A significant difference between the two types of steel making furnaces, apart from the feeding material and the quality of steel produced, is how easily the production can be ceased and resumed. While it takes weeks and months for operation of once stopped (either for a short-term or long-term) BF to resume and reach normal production level, EAFs can be easily stopped and restarted on a regular basis (SteelGuru 2011; World Steel Association 2013). Hence, the production of EAFs can be altered more flexibly than that of BFs, and thereby EAFs can react in accordance with the current supply/demand environment.

When it comes to the supply side, unlike mined minerals, recycled raw materials are supplied by collecting and recovering already distributed durable products. The main sources of steel scraps are old buildings, industrial machineries, consumer durables, disposed motor vehicles and manufacturing operations (Fenton 1998). Hence, an accumulated quantity (somewhat equivalent to the amount of reserves for natural resources) is mainly distributed in mature industrialised economies such as the U.S. and Japan. As Dr Greenspan states, aggregate scrappage is closely related to the economic activity in the country. Moreover, ultimately, the supply of steel scrap can be altered by the distributors through adjusting the collection activities, especially during “quiet” periods. This is usually not the case in the mining industry. For these reasons, better macroeconomic conditions in a country favour local steel scrap demand.

In addition to the local supply/demand conditions, externalities such as the state of the financial market often play an important role in the commodity market. However, there is no active exchange that trades steel scraps. For instance, steel scrap futures is listed on the New York Mercantile Exchange (NYMEX), a part of the Chicago Mercantile Exchange & Chicago Board of Trade (CME group); however, the trading volume is far smaller than those of more frequently traded metal futures. For instance, it is less than 0.1 per cent of copper futures listed on the Commodity Exchange (COMEX) (CME Group 2015). Thus the steel scrap market is mainly driven by the physical supply/demand condition. As a result, the steel scrap price may be a good indicator for the industrial activities and thereby the equity market.

However, there is an opposing view that the supply/demand of steel scrap does not well represent the overall economic activities. This is because steel scrap is consumed in industrial activities but the service sector represents an increasingly large portion of the economy (McKee & Cohn 1996). In fact, the service sector in a broad sense represents more than 70 per cent of the GDP in Japan (The World Bank 2015). This argument will bias against finding any significant results in our tests. Nevertheless, while it is a well debated topic among speculators, there is no academic research addressing this issue.

For each month, we take the mid-point of the high and low prices from the three major regions in Japan and compute the average mid-points across the three regions as the steel scrap price for that month. Figure 1 displays the relationship between the monthly changes in the steel scrap price and the aggregate Japanese excess (to the short-term Gensaki interest rate) stock market returns which are estimated from the data obtained from the Kenneth R. French's Data Library. While the steel scrap price is more

volatile than the equity market, it appears that the two variables are reasonably correlated. This is consistent with the notion of Dr Greenspan. In the following sections, we identify a gap in the current literature and explore the control variables in our empirical tests.

Figure 1: Monthly change in steel scrap price and Japanese stock market price

Note: The Japanese stock market return is the value-weighted log return in excess to the Gensaki short-term interest rate and it is denominated in Japanese Yen. *Scrap price monthly change* is the monthly change in a log difference form and the price is the average of the prices in the three major regions in Japan.

2.2. Review of related studies

There are a number of studies which attempt to understand the dynamic nature of the Japanese stock market using various macro/micro- economic factors. Examples of those factors are: inflation rate (Hamao 1988; Gorton *et al.* 2005; Hartmann & Pierdzioch 2007; Hsing 2013), industrial production (Hamao 1988; Kaneko & Lee 1995; Jones & Kaul 1996; Hartmann & Pierdzioch 2007; Hsing 2013), unemployment rate (Hartmann & Pierdzioch 2007), short-term interest rate (Campbell & Hamao 1992; Rapach *et al.* 2013), risk premium (Hamao 1988), the investor confidence (Hamao 1988), foreign exchange market (Hamao 1988; He & Ng 1998; Hartmann & Pierdzioch 2007), dividend/price ratio (Campbell & Hamao 1992; Rapach *et al.* 2013), the seasonal

effect such as the January effect (Campbell & Hamao 1992; Hartmann & Pierdzioch 2007), gold price (Baur & McDermott 2010; Thuraisamy *et al.* 2013), crude oil price (Hamao 1988; Kaneko & Lee 1995; Jones & Kaul 1996; Faff & Brailsford 1999; Sadorsky 1999, 2001; Hartmann & Pierdzioch 2007; Park & Ratti 2008; Thuraisamy *et al.* 2013; Souček & Todorova 2013a).

However, inconsistent results (in some cases contradictory results) are often found among those studies. In particular, the significance of the industrial production on the Japanese stock market is supported by studies such as Hsing (2013) and Jones and Kaul (1996), while Hamao (1988) denies such a relationship. As we incorporate the above mentioned factors in our study as the control variables, our work contributes to the existent discussion of the statistical significance of those macro/micro- economic factors in explaining the Japanese stock market behaviour.

In addition, relationships between the stock market in Japan and other major countries have been examined by researchers including Hamao *et al.* (1990), Karolyi and Stulz (1996) and Rapach *et al.* (2013). Comovements between the individual stock markets is suggested to be due to common stock risk premia across countries, rather than fundamental variables (Ammer & Mei 1996).

Further studies focus on predicting a stock price or portfolio returns by utilising factors such as market returns, size of the market capitalisation and book value of companies, past performance of stocks or portfolios, the profitability of company (Sharpe 1964; Lintner 1965; Mossin 1966; Banz 1981; Bondt & Thaler 1985; Fama & French 1993; Lakonishok *et al.* 1994; Carhart 1997; Fama & French 2012, 2014). Those studies are often first conducted on the U.S. market and then applied to markets in other countries. In addition, there are other studies which attempt to explain the behaviour of

equity market in some countries by observing other major equity markets such as the U.S. and Japan (Darrat & Zhong 2002; Darrat *et al.* 2012). In this strand of research, the U.S. market appears to be more informative than Japan in explaining the behaviour of other stock markets (Darrat & Zhong 2002).

Even though the literature on equity markets is very broad, there are no studies focusing on the impact of steel scrap price change on the equity market. Nevertheless, as rationalised above, the supply/demand environment of steel scrap reflects the contemporary condition of the country's macro economy and the price of this recycled metal is well determined by its own supply/demand environment. Behaviour of the steel scrap price is expected to be a good indicator for the equity market of a country where the price is quoted.

3. Research Hypothesis

As the demand of steel scrap in Japan is presumably mainly driven by the industrial activities in the country, its price movements are hypothesised to contain meaningful information about the future stock market returns. To be more specific, since macroeconomic conditions and the demand of steel products in a country are assumed to be positively related, the demand of steel scrap, a crucial raw material for steel making, and anticipated growth in the economic activities are also expected to be positively related. Hence, as the current and past condition of macroeconomic activities are found to be informative in determining the current equity market return in Japan (Kaneko & Lee 1995; Jones & Kaul 1996), we expect to observe a positive lead-lag relationship between the steel scrap price change and the stock market return in a country. This study poses the following hypothesis.

H1. The equity market return is positively related to the lagged steel scrap price change.

The purpose of examining this issue is to close the gap between the perception of academic researchers and market participants regarding the interrelation of the equity and steel-scrap market. Furthermore, studying whether the past information is informative in determining the future stock market returns will contribute to the discussions on the efficiency of the capital market including Fama (1970), Fama (1991) and Jensen (1978).

4. Methodology and Data

We use a well-established method of bivariate and multivariate Vector Autoregressive (VAR) model and the associated Granger-causality tests to examine the relationship between the scrap price and the stock market. A similar method is used by Hameed (1997), Rossi (2012), Malliaris and Malliaris (2013), and Souček and Todorova (2013a, 2013b). General form of the VAR system in the study is

$$\begin{pmatrix} \Delta y_{1,t} \\ \vdots \\ \Delta y_{h,t} \end{pmatrix} = \begin{pmatrix} c_1 \\ \vdots \\ c_h \end{pmatrix} + \begin{pmatrix} \beta_{1,1}^1 & \dots & \beta_{1,h}^1 \\ \vdots & & \vdots \\ \beta_{h,1}^1 & \dots & \beta_{h,h}^1 \end{pmatrix} \begin{pmatrix} \Delta y_{1,t-1} \\ \vdots \\ \Delta y_{h,t-1} \end{pmatrix} + \dots + \begin{pmatrix} \beta_{1,1}^k & \dots & \beta_{1,h}^k \\ \vdots & & \vdots \\ \beta_{h,1}^k & \dots & \beta_{h,h}^k \end{pmatrix} \begin{pmatrix} \Delta y_{1,t-k} \\ \vdots \\ \Delta y_{h,t-k} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1,t} \\ \vdots \\ \varepsilon_{h,t} \end{pmatrix} \quad (1)$$

where Δy_h denotes monthly changes in the variable h such as stock market index, scrap price changes or industrial productions (the data is in change in natural log figures unless stated otherwise), t is time in monthly frequency, k is the number of time lags in

the VAR model. The number of lags is selected based on the criteria including the Akaike information criterion, Bayesian information criterion and Hannan and Quinn information criterion. To be more specific, a two-month lag is chosen if the largest number of criteria support it. Also, β and c are parameters in the model, and ε is an error term. The bivariate Granger-causality test is also employed to select control variables for the multivariate analyses. In particular, our study only incorporates variables which have a significant causal effect on the Japanese equity market return.

To further check the robustness of our results, we also check the response of the Japanese stock market return to shocks observed on the explanatory variables in the multivariate study. In particular, we use the impulse-response function which tests the reaction of a dependent variable to one standard deviation shock in the explanatory variable. We bootstrap residuals to obtain standard errors for estimating the critical intervals.

The data for this study is sourced from DataStream, the Metal Recycling Japan and Kenneth R. French's Data Library. The study is conducted using monthly observations. We take the longest available sample period of January 2003 – March 2015 (end of the data sample for risk premiums, industrial production, inflation rate and unemployment rate are between October 2014 and February 2015). All variables are the monthly changes in natural log figures or the first difference (for variables such as the risk premiums which can be a negative value) form to overcome a unit-root issue.

This study employs the value-weighted Japanese stock market excess returns estimated in Fama and French (2012). The data is obtained from Kenneth R. French's Data Library. As the returns are in excess of the U.S. T-bill and are quoted in the discrete U.S. dollar term, we convert the data into continuous Japanese Yen term and in

excess of the Gensaki interest rate². We obtain steel scrap price for the three major regions in Japan, namely, Kanto (a region includes Tokyo), Chubu (a region includes Aichi, headquarter of Toyota Motor, is located) and Kansai (a region includes Osaka). To examine the impact of the steel products market on the Japanese stock and steel scrap markets, the study obtains prices of major steel products, namely, reinforcement bar, plate, cold rolled coil, angle and H-beam. The prices of steel scrap/products are quoted in Japanese Yen per MT and provided by the Metal Recycling Japan³. In the case that there is a range in the monthly steel scrap/products prices, an average of the high and low during the month is used. To check the robustness of the results, as mentioned above, this study includes various other control variables (obtained from DataStream). They are selected based on the review of the past relevant studies and presented in Table 1.

Table 2 displays the descriptive statistics of the variables considered in this study. They are quoted in month-on-month log difference (in the percentage form) unless otherwise noted. It is observed that the prices of the commodities are more volatile than the equity markets, while there is no considerable difference in the mean figures. This is somewhat consistent with the trend observed in Figure 1, where the monthly change in the steel scrap price appears to fluctuate more than the Japanese stock market return.

² We obtain similar bivariate VAR/Granger-causality result when the raw data from the library is used.

³ The data for the current month steel scrap price is available from the early following month and hence, the synchronicity issue related to the availability timing of the data is considered to be trivial.

Table 1: List of the considered control variables in the study

<u>Commodities</u>		
Variables		Reference/s
WTI Crude Oil Price		Kaneko and Lee 1995; Jones and Kaul 1996; Souček and Todorova 2013
Gold Price		Thuraisamy et al. 2013
<u>Steel products</u>		
Reinforcement Bar Price		-
Plate Price		-
Cold Rolled Coil Price		-
Angle Price		-
H-beam Price		-
<u>Macroeconomic Factors</u>		
Variables		Reference/s
Industrial Production		Chen et al. 1986; Hsing 2013
Unemployment Rate		Hartmann and Pierdzioch 2007
Inflation Rate Based on the CPI		Chen et al. 1986; Hartmann and Pierdzioch 2007
<u>Other Variables</u>		
Variables		Reference/s
International Stock Markets' Returns (the U.K. and the U.S.)		Rapach et al. 2013
Risk Premium (difference between the corporate bond rate and the government bond rate)		Hartmann and Pierdzioch 2007
Relative Short Rate (difference between the U.S. T-bill and the Japanese Gensaki interest rate)		Campbell and Hamao 1992
<i>Note:</i> The stock market returns for the U.K. and the U.S. are calculated based on the DataStream stock market indexes.		

Table 2: Descriptive statistics variables used in the analyses							
	Mean	Median	Standard Deviation	Kurtosis	Skewness	Minimum	Maximum
JP Stock	0.55	0.72	5.44	3.75	-0.31	-16.91	17.15
Scrap	0.32	0.69	16.17	43.52	-4.80	-142.31	33.65
Industrial Production	0.01	-0.31	8.38	2.23	0.05	-20.15	16.47
Inflation	0.01	0.00	0.33	12.17	1.46	-0.88	2.06
Unemployment Rate	4.40	4.30	0.57	2.32	0.23	3.20	5.80
Relative Short Rate	1.20	0.05	1.64	2.62	1.07	-0.44	4.79
Risk Premium	0.29	0.26	0.12	4.82	1.22	0.11	0.81
Oil	0.29	1.81	9.24	5.18	-0.88	-39.48	26.02
Gold	1.00	1.24	18.32	9.95	0.00	-78.89	78.03
Rebar	0.40	0.00	8.21	45.25	-0.74	-64.10	59.40
Plate	0.47	0.00	10.18	31.79	-0.23	-60.20	59.40
CRC	0.29	0.00	2.46	11.44	0.10	-12.40	11.80
Angle	0.49	0.00	3.42	7.21	1.11	-10.50	13.00
H-Beam	0.47	0.00	4.00	8.45	1.40	-11.90	17.30
UK	0.24	0.86	4.02	4.74	-0.79	-15.28	9.99
US	0.51	1.08	4.13	6.21	-1.05	-19.14	10.60

Note: The table reports the descriptive statistics of the variables in consideration. The data used in the statistics are in the percentage form. All variables are in log difference form except for the inflation rate, the unemployment rate, relative short rate and risk premium (they are in the levelled form). *JP stock* is the value-weighted monthly return of the Japanese stock market in excess to Gensaki interest rate and in Japanese Yen term (originally from the Kenneth R. French's Data Library), *Scrap* is the monthly change in the scrap price in 3 major regions in Japan, *UK* is the monthly U.K. stock market return in excess to the country's short-term risk free rate, *US* is the monthly U.S. stock market return in excess to the U.S. T-bill, *Oil* is the monthly crude oil price change, *Gold* is the monthly gold price change, *Rebar* is the monthly change in the reinforcement bar price, *Plate* is the monthly change in the steel plate price, *CRC* is the monthly change in the cold rolled coil steel price, *angle* is the monthly change in the angle steel price, and *H-Beam* is the monthly change in the H-Beam steel price. Prices of the steel products are for Japanese physical market. Figures are in percentages except for the kurtosis and skewness. The sample period is 2003 January – 2015 March (for industrial production, inflation, unemployment rate and risk premium between 2014 October and 2015 February).

5. Results

First, the Augmented Dickey-Fuller (ADF) test (Dickey & Fuller 1979) is applied to examine the stationarity of the considered variables (the results are available upon request). The test statistics are estimated based on the modified Akaike Information Criterion (AIC) and as mentioned above all the variables become stationary when they are converted into monthly change figures. The variables including the unemployment rate and the risk premium are found non-stationary when levelled data is

used.

5.1. Bivariate VAR results

Table 3 presents the results of the bivariate (the Japan stock return against monthly change in the steel scrap price) VAR and Granger-causality test results. We obtain statistically significant positive one-month and four-month lagged⁴ steel scrap price coefficients, at the 10 per cent level. The positive signs of the significant steel scrap coefficients are consistent with our expectation. The demand of steel products is confirmed to be driven by the increase in the economic activities such as building more houses and manufacturing more automobiles. Hence, anticipation of the macroeconomic growth in a country positively affects the local steel scrap price. For this reason, the equity market return in the country is positively related to its own steel scrap price change⁵.

Furthermore, the results indicate that there is a bi-directional causal relationship between the two variables⁶. To check whether the causal relationship from the scrap price diminishes when the influence from the lagged stock market return is disregarded, we conduct a two-stage regression analysis. In particular, the first stage regression consists of the scrap price at time t as a dependent variable, and one-month and three-month lagged Japanese stock returns as independent variables; and then in the second stage, we re-conduct the VAR and Granger-causality test by replacing the scrap price variable by the residuals from the first-stage regression. The results are presented in Table 4. The unidirectional causal relationship emerging from the steel scrap price

⁴ Obtaining a significant four-month lagged coefficient might be due to the cyclical behaviour of the steel scrap price, which could have been amplified by controlling for the effect of the stock.

⁵ We conduct a similar test on the industry stock market index in Japan (using the TSE 33 sectors index) and the steel scrap is found to significantly cause 15 out of 33 indexes (results are available upon request).

⁶ A similar result is obtained even after disregarding outliers (≤ 1 percentile and ≥ 99 percentile) in the steel scrap price changes.

changes remains significant, while the causal relationship from the stock market return disappears.

Table 3: Bivariate VAR and Granger-causality test results for the causal direction between steel scrap and Japanese stock return

(a)			(b)		
	Coef.	(p-value)		Coef.	(p-value)
constant	0.004	(0.35)	constant	0.003	(0.83)
Scrap			Scrap		
lag 1	0.055*	(0.08)	lag 1	-0.169*	(0.07)
lag 2	-0.027	(0.38)	lag 2	0.149*	(0.09)
lag 3	0.016	(0.61)	lag 3	-0.116	(0.20)
lag 4	0.070**	(0.02)	lag 4	-0.129	(0.14)
JP stock			JP stock		
lag 1	0.072	(0.43)	lag 1	0.526**	(0.05)
lag 2	0.092	(0.30)	lag 2	0.270	(0.30)
lag 3	0.108	(0.22)	lag 3	-0.597**	(0.02)
lag 4	-0.045	(0.62)	lag 4	0.104	(0.69)

Granger-causality test based on the above VAR: (p-value)

scrap price change Granger-causes stock price change: p -value = 0.06

stock price change Granger-causes scrap price change: p -value = 0.03

Note: The table reports the results of the VAR and associated Granger-causality test

$$(a) \Delta JP stock_{(t)} = \alpha + \sum_{k=1}^4 \beta_{k,scrap} [\Delta Scrap_{(t-k)}] + \sum_{k=1}^4 \beta_{k,JP stock} [\Delta JP stock_{(t-k)}] + \varepsilon_t$$

$$(b) \Delta Scrap_{(t)} = \alpha + \sum_{k=1}^4 \beta_{k,scrap} [\Delta Scrap_{(t-k)}] + \sum_{k=1}^4 \beta_{k,JP stock} [\Delta JP stock_{(t-k)}] + \varepsilon_t$$

where $\Delta JP stock$ is the value-weighted excess return on the Japanese stock market in excess of the Gensaki interest rate in Japanese Yen term (originally from Kenneth R. French's Data Library), $\Delta Scrap$ is the monthly change in the scrap price in 3 major regions in Japan. The standard errors in the results are adjusted for the small sample-size and degree-of-freedom in estimating the error variance-covariance matrix. ***, **, * denote the significance level at 1%, 5% and 10%, respectively.

Table 4: Bivariate Granger-causality test results for the causal direction between steel scrap and Japanese stock return after controlling for the impact of stock returns on the steel scrap variable

(a)			(b)		
	Coef.	(p-value)		Coef.	(p-value)
constant			constant		
	0.004	(0.40)		0.000	(0.98)
Scrap			Scrap		
lag 1	0.060*	(0.06)	lag 1	-0.161*	(0.08)
lag 2	-0.038	(0.24)	lag 2	0.159*	(0.09)
lag 3	0.004	(0.91)	lag 3	-0.145	(0.13)
lag 4	0.079**	(0.01)	lag 4	-0.120	(0.20)
JP stock			JP stock		
lag 1	0.062	(0.49)	lag 1	-0.048	(0.86)
lag 2	0.147	(0.10)	lag 2	0.156	(0.55)
lag 3	0.108	(0.23)	lag 3	0.142	(0.59)
lag 4	-0.081	(0.35)	lag 4	0.159	(0.53)

Granger-causality test based on the above VAR: (p-value)

scrap price change Granger-causes stock price change: p -value = 0.04

stock price change Granger-causes scrap price change: p -value = 0.87

Note: The table reports the results of the VAR and associated Granger-causality test

$$\Delta Scrap_t = \alpha + \beta_1[\Delta JP stock_{(t-1)}] + \beta_2[\Delta JP stock_{(t-3)}] + \varepsilon_{pure_scrap,t}$$

$$(a) \Delta JP stock_t = \alpha + \sum_{k=1}^4 \beta_{k,pure_scrap} \varepsilon_{pure_scrap,t} + \sum_{k=1}^4 \beta_{k,JP stock} [\Delta JP stock_{(t-k)}] + \varepsilon_{stock,t}$$

$$(b) \varepsilon_{pure_scrap,t} = \alpha + \sum_{k=1}^4 \beta_{k,pure_scrap} \varepsilon_{pure_scrap,t} + \sum_{k=1}^4 \beta_{k,JP stock} [\Delta JP stock_{(t-k)}] + \varepsilon_{scrap,t}$$

where $\Delta JP stock$ is the value-weighted excess return on the Japanese stock market in excess of Gensaki interest rate, in Japanese Yen term (originally from the Kenneth R. French's Data Library), $\Delta Scrap$ is the monthly change in the scrap price in 3 major regions in Japan ($Scrap$ in the table is the monthly change in the scrap price changes after controlling for the impact of the Japanese equity market). The standard errors in the results are adjusted for small sample-size and degree-of-freedom in estimating the error variance-covariance matrix. ***, **, * denote the significance level at 1%, 5% and 10%, respectively.

5.2. Multivariate VAR results

Next, we check the robustness of the results by conducting multivariate VAR and Granger-causality tests. To avoid issues associated with over identifying the explanatory variables, we examine the explanatory power of each of the above proposed control variables. In particular, we conduct the bivariate Granger-causality tests against the Japanese stock market return and we eliminate variables which fail to reject a null hypothesis that a variable does not Granger-cause the Japanese stock market return. The results are presented in Table 5. In summary, the gold price, and the stock market returns of the U.K. and the U.S. affect the Japanese stock return, at the 10 per cent level,

while none of the steel product has a significant impact on the country's stock market returns. This may be directly influenced by backlogs that steel producers have in their order book⁷. The multivariate studies in the following section use the steel scrap and those three control variables as explanatory variables.

Table 5: Bivariate Granger-causality tests results (Japan stock return vs. control variables)

Explanatory variable	(p-value)
Scrap	(0.06)
Industrial production	(0.38)
Inflation	(0.20)
Unemployment	(0.86)
Risk premium	(0.60)
Relative short rate	(0.54)
Oil	(0.18)
Gold	(0.01)
Rebar	(0.83)
Plate	(0.67)
CRC	(0.44)
Angle	(0.21)
H-Beam	(0.96)
UK	(0.00)
US	(0.01)

Note: The table reports the results of the Granger-causality tests (the table only displays the results for causal direction from the control variables to the Japan stock return. The comprehensive results are available upon request) based on the results from the VAR

$$\Delta y_{(h,t)} = \alpha + \sum_{i=k=1}^j \beta_{i,y} [\Delta y_{(h,t-k)}] + \sum_{i=k=1}^j \beta_{i,jp_stock} [\Delta JP\ stock_{(t-k)}] + \varepsilon_t$$

$$\Delta JP\ stock_{(t-k)} = \alpha + \sum_{i=k=1}^j \beta_{i,y} [\Delta y_{(h,t-k)}] + \sum_{i=k=1}^j \beta_{i,jp_stock} [\Delta JP\ stock_{(t-k)}] + \varepsilon_t$$

where Δy is the monthly change in the control variables. To be more specific, *Default Risk premium* is the corporate bond rate – the government bond rate in Japan, *Relative short rate* is the first difference of the difference between the U.S. T-bill and the Japanese Gensaki interest rate, *Industrial production* is the monthly change in the industrial production in Japan, *Oil* is the monthly change in the WTI spot crude oil price, *Gold* is the monthly change in the gold price, *Inflation* is the log difference of the inflation rate based on the CPI in Japan, *Unemployment* is the log difference of the unemployment rate in Japan, and *UK* and *US* are the monthly change in the DataStream stock market price index for each country, respectively. Also, $\Delta JP\ stock$ is the overall excess return on the Japanese stock market in Japanese Yen term (originally from the Kenneth R. French's Data Library). j is the number of lags. The standard errors in the results are adjusted for small sample-size and degree-of-freedom in estimating the error variance-covariance matrix.

Furthermore, to investigate the relationship between the equity and the steel scrap market changes during the global financial crisis (GFC) and after the

⁷ In general, steel makers have several months of order backlogs and in some cases, the backlog can be more than 4 months (Japan Metal Bulletin 2007).

“Abenomics” was introduced, we add time dummy variables and interaction terms (with the steel scrap price variable) into our model. In particular, the GFC dummy has a value of one in the financial crisis time, July 2008 – December 2009. We follow Souček and Todorova (2013a) in selecting the GFC period. Also, the Abenomics dummy has a value of one for the period before December 2012.

Since the second Shinzo Abe ministry started in December 2012, the Japanese equity market has advanced significantly. The market favoured the package of his economic policies, known as Abenomics. For instance, the TOPIX has risen from below 800 to over 1,600 points from November 2012 to April 2015. Abenomics is made up of so-called three policy arrows which consist of both quantitative and qualitative easing of money to overcome economic stagnation and deflation issues in the country (Inoguchi 2014; Tudor-Ackroyd 2014). However, although the exporting firms in Japan may benefit from the depreciation in Japanese yen, there are those who question the contribution of Abenomics to a broad economy by claiming that Prime Minister Abe merely achieved “a fleeting feel-good factor” (Hayashi 2014; Park & Kim 2014; Tudor-Ackroyd 2014). If those claims are valid we would observe that the relationship between the steel scrap and the equity market variables is stronger before the second Abe regime.

Tables 6 and 7 report the results of the multivariate VAR and Granger-causality tests, based on the two-stage regression method. To be more specific, the steel scrap price variable is first regressed against the lagged two steel product price variables, namely the cold rolled coil and the H-beam (the number of lags is determined by the same manner as other VAR models), and then the residuals are used as a proxy for the steel scrap price variable in the multivariate VAR. Although the steel products do not

significantly affect the equity market, a bivariate VAR shows that the steel scrap price changes are affected by the lagged cold rolled coil and H-beam price change variables. We use this two-stage analysis to isolate the information of the steel products market inherited in the steel scrap price.

The regression results in Table 6 demonstrate that the one-month lagged steel scrap price change significantly and positively affects the Japanese stock market return, at the 10 per cent significance level. In regard to the magnitude of this impact, the result indicates that a 1 per cent change in the current month's steel scrap price will lead to about a 0.3 per cent increase in the stock market return in the following month. In contrast, we obtain insignificant interaction term coefficients. This implies that the relationship between the equity and scrap markets did not change considerably even during the GFC and after the start of the second Abe ministry. If the above presented views about the contribution of Abenomics is valid, our result indicates that the steel scrap price may contain valuable information that is not contained in the conventional macroeconomic variables. This has to be further examined in a future study in order to make a more comprehensive inference. In addition, our result also shows that the Japanese stock market has been achieving higher returns since the beginning of the second Abe regime. Furthermore, the Granger-causality test results displayed on Table 7 show that there is a unidirectional causal relationship emerging from the steel scrap market to the Japanese equity market.

In comparison with recent studies, our multivariate VAR results are at odds with Rapach *et al.* (2013). In particular, we find that the U.K. and the U.S. stock markets are not significant determinants of the Japanese stock market return. This may be due to the different sample periods used. Also, unlike Baur and McDermott (2010), our study

demonstrates a safe haven role of the gold market from the perspective of Japanese stock market investors. In particular, the lagged gold price variables have a negative impact on the Japanese stock market return. This implies that during the recession time, speculators can diversify the risk by trading gold. In general, the results support our hypothesis.

Table 6: Multivariate VAR results

Explanatory variables	Explained variable				
	JP stock	Scrap	Gold	UK	US
Constant					
Coef.	0.025	-0.013	-0.008	0.001	0.011
(p-value)	(0.02)	(0.64)	(0.80)	(0.88)	(0.18)
JP stock					
Coef. (t-1)	-0.082	-0.035	0.174	0.130	0.070
(p-value)	(0.41)	(0.90)	(0.59)	(0.11)	(0.40)
Scrap					
Coef. (t-1)	0.290	0.176	0.365	0.033	0.070
(p-value)	(0.05)	(0.66)	(0.45)	(0.78)	(0.57)
Scrap*PriorAbe					
Coef. (t-1)	-0.225	-0.091	-0.449	-0.053	-0.051
(p-value)	(0.16)	(0.83)	(0.38)	(0.68)	(0.70)
PriorAbe (dummy)					
Coef. (t-1)	-0.024	0.026	0.033	0.001	-0.007
(p-value)	(0.04)	(0.41)	(0.37)	(0.90)	(0.44)
Scrap*GFC					
Coef. (t-1)	-0.065	-0.615	0.515	0.022	-0.017
(p-value)	(0.31)	(0.00)	(0.02)	(0.67)	(0.75)
GFC (dummy)					
Coef. (t-1)	-0.015	-0.129	0.018	-0.001	-0.011
(p-value)	(0.26)	(0.00)	(0.68)	(0.89)	(0.32)
Gold					
Coef. (t-1)	-0.063	0.014	1.546	-0.025	-0.018
(p-value)	(0.01)	(0.83)	(0.03)	(0.20)	(0.37)
UK					
Coef. (t-1)	0.305	1.609	1.546	-0.137	0.161
(p-value)	(0.17)	(0.01)	(0.03)	(0.44)	(0.38)
US					
Coef. (t-1)	0.127	-0.430	-1.513	0.124	-0.010
(p-value)	(0.57)	(0.48)	(0.04)	(0.49)	(0.96)

Note: The table reports the results from the VAR

$$\begin{pmatrix} \Delta y_{1,t} \\ \vdots \\ \Delta y_{h,t} \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \vdots \\ \alpha_h \end{pmatrix} + \begin{pmatrix} \beta_{1,1}^1 & \dots & \beta_{1,h}^1 \\ \vdots & & \vdots \\ \beta_{h,1}^1 & \dots & \beta_{h,h}^1 \end{pmatrix} \begin{pmatrix} \Delta y_{1,t-1} \\ \vdots \\ \Delta y_{h,t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1,t} \\ \vdots \\ \varepsilon_{h,t} \end{pmatrix}$$

where Δy is the monthly change in the variable h . *Scrap* is the monthly change in the Japanese scrap price after controlling for the impact of the steel products market (cold rolled coil and H-beam), *Gold* is the monthly change in the gold price, and *UK* and *US* are the monthly change in the DataStream stock market price index for each country, respectively, *JP stock* is the value-weighted monthly excess return on the Japanese stock market in Japanese Yen term which is originally from the Kenneth R. French's Data Library, *PriorAbe* is a dummy variable that takes the value of 1 in the before December 2012 (when the second Abe ministry started), *GFC* is a dummy variable that takes the value of 1 during the period of July 2008–December 2009 (during the global financial crisis) and *constant* is an constant term (α in the model). The standard errors in the results are adjusted for the small sample-size and degree-of-freedom in estimating the error variance-covariance matrix. ***, **, * denote the significance level at 1%, 5% and 10%, respectively.

Table 7: Multivariate Granger-causality test results (p -value)

	Explanatory variable cause Japan stock	Japan stock cause explanatory variable
Scrap	(0.05)	(0.90)
Scrap*PriorAbe	(0.16)	(0.86)
PriorAbe (dummy)	(0.04)	(0.53)
Scrap*GFC	(0.31)	(0.30)
GFC (dummy)	(0.26)	(0.66)
UK	(0.17)	(0.11)
US	(0.57)	(0.40)
Gold	(0.01)	(0.59)

Note: The table reports the results of the Granger-causality tests based on the results from the VAR

$$\begin{pmatrix} \Delta y_{1,t} \\ \vdots \\ \Delta y_{h,t} \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \vdots \\ \alpha_h \end{pmatrix} + \begin{pmatrix} \beta_{1,1}^1 \dots \beta_{1,h}^1 \\ \vdots \\ \beta_{h,1}^1 \dots \beta_{h,h}^1 \end{pmatrix} \begin{pmatrix} \Delta y_{1,t-1} \\ \vdots \\ \Delta y_{h,t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1,t} \\ \vdots \\ \varepsilon_{h,t} \end{pmatrix}$$

where Δy is the monthly change in the variable h . *Scrap* is the monthly change in the Japanese scrap price after controlling for the impact of the steel products market (cold rolled coil and H-beam), *Gold* is the monthly change in the gold price, and *UK* and *US* are the monthly change in the DataStream stock market price index for each country, and *Japan stock* is the value-weighted monthly excess return on the Japanese stock market in Japanese Yen term which is originally from the Kenneth R. French's Data Library, *PriorAbe* is a dummy variable that takes the value of 1 in the before December 2012 (when the second Abe ministry started), *GFC* is a dummy variable that takes the value of 1 during the period of July 2008-December 2009 (during the global financial crisis) and the number of lag is 1, *constant* is a constant term (α in the model). The standard errors in the results are adjusted for the small sample-size and degree-of-freedom in estimating the error variance-covariance matrix. ***, **, * denote the significance level at 1%, 5% and 10%, respectively.

Lastly, based on the multivariate VAR model used above, we examine the response of the Japanese stock market return to shocks observed on the explanatory variables. Figure 2 illustrates the impulse responses resulting from a one standard deviation shocks. We find that the impact of the shock on the steel scrap price variable remains significant for the next one month, with impulse and response being positively related. In addition, consistent with our previous results, the impulse of the gold price is significant.

Figure 2: Impulse response function from explanatory variables to the stock market return

Note: The charts report impulse response functions based on the multivariate VAR.

$$\begin{pmatrix} \Delta y_{1,t} \\ \vdots \\ \Delta y_{h,t} \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \vdots \\ \alpha_h \end{pmatrix} + \begin{pmatrix} \beta_{1,1}^1 & \dots & \beta_{1,h}^1 \\ \vdots & & \vdots \\ \beta_{h,1}^1 & \dots & \beta_{h,h}^1 \end{pmatrix} \begin{pmatrix} \Delta y_{1,t-1} \\ \vdots \\ \Delta y_{h,t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1,t} \\ \vdots \\ \varepsilon_{h,t} \end{pmatrix}$$

where Δy is the monthly change in the variable h . *Scrap* is the monthly change in the Japanese scrap price after controlling for the impact of the steel products market (cold rolled coil and H-beam), *Gold* is the monthly change in the gold price, and *UK* and *US* is the monthly change in the DataStream stock market price index for each country, *JP stock* is the value-weighted monthly excess return on the Japanese stock market in Japanese Yen term which is originally from the Kenneth R. French's Data Library, *PriorAbe* is a dummy variable that takes the value of 1 in the before December 2012 (when the second Abe ministry started), *GFC* is a dummy variable that takes the value of 1 during the period of July 2008-December 2009 (during the global financial crisis) and *constant* is a constant term (α in the model).

The figure reports the response of Japanese stock market returns to the shock on the explained variables and interaction terms in the model (Other results are available upon request). The red dot lines represent the bootstrap 90 per cent critical intervals.

Our study on the aggregate stock market returns, in general, demonstrates a lead-lag relationship using steel scrap price changes. In short, in relation to the Japanese stock market, one could conclude that these results broadly support our hypothesis. That is, the steel scrap market is a promising indicator useful for explaining future stock market returns.

6. Concluding remarks

We examine whether the steel scrap price can be used to explain the variation of future stock market returns. Steel is a vital metal for industrial activities and steel scrap is an important raw material for steel making. Since the collection and consumption activities of steel scrap easily adjust to change in the macroeconomic activities, the local market is expected to reflect the contemporary supply/demand condition of the steel products, which is driven by the industrial activities in the country.

Our study focuses on the market in Japan. This is because it is a well industrialised country with a sufficient amount of steel scrap reserve in the economy; it has a well-established off-exchange steel scrap market; and the impact of external factors such as the influence of other commodity markets is not significantly large. Testing on the aggregate Japanese stock market returns, we find that the steel scrap price behaviour is informative for the country's future equity market returns.

Our findings have practical implications to various stakeholders. For instance, financial market participants may use our finding in their equity market investment decisions. By understanding the linkage between the steel scrap price change and stock market returns, investors may improve the preciseness of their equity investment strategies. Also, our study demonstrates that the steel scrap price in Japan well reflects

industrial activities in the county and thereby the price is relatively better foreseeable than other internationally traded commodities such as iron ore and crude oil. A future study direction could be to generalise the findings in this study and apply similar tests to other regions such as the U.S. and the E.U.

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