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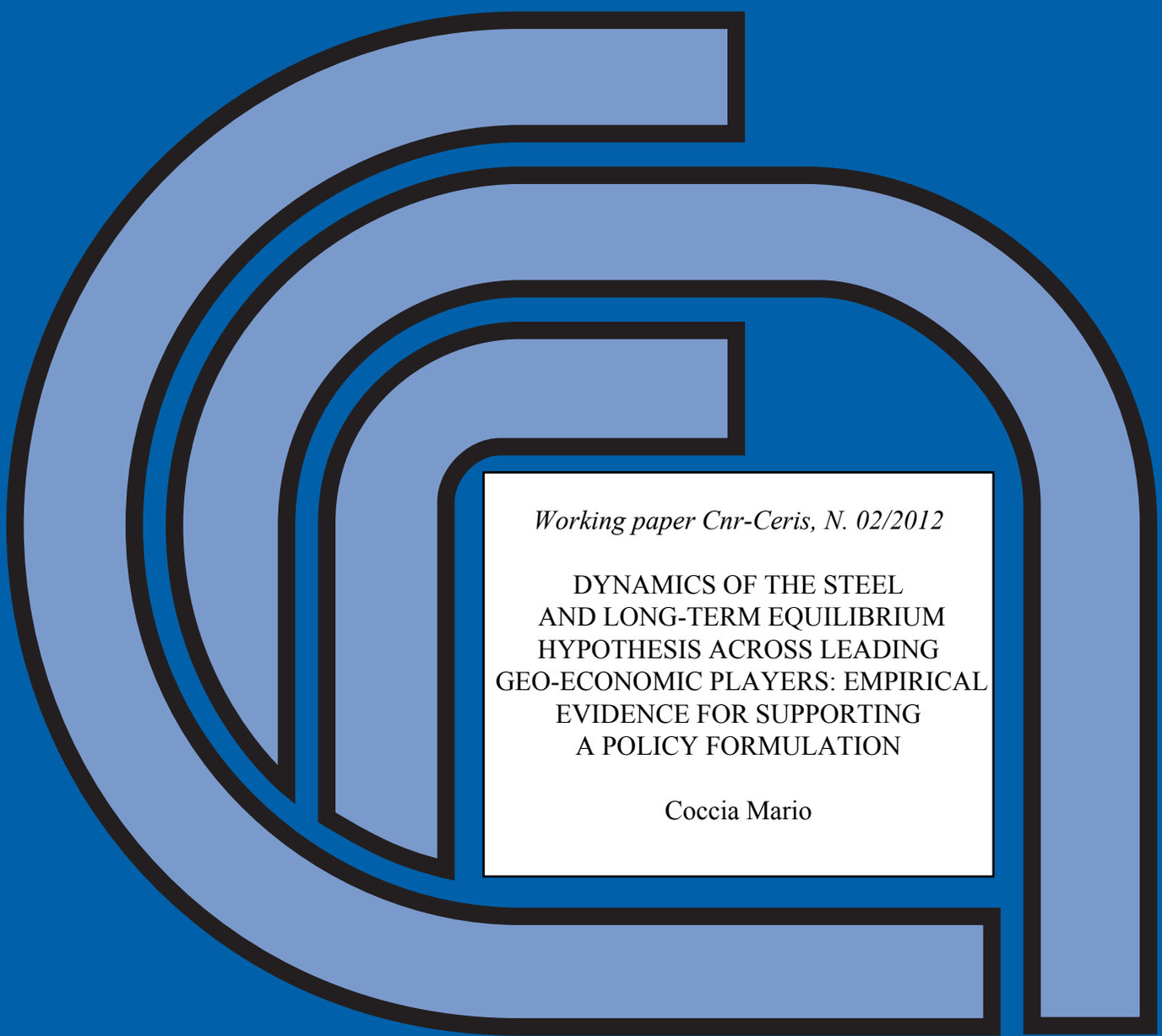

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DYNAMICS OF THE STEEL AND LONG-TERM EQUILIBRIUM HYPOTHESIS ACROSS LEADING GEO-ECONOMIC PLAYERS: EMPIRICAL EVIDENCE FOR SUPPORTING A POLICY FORMULATION

Coccia Mario

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Dynamics of the steel and long-term equilibrium hypothesis across leading geo-economic players: empirical evidence for supporting a policy formulation

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ABSTRACT: The aim of this study is twofold – on the one hand, to report a flow analysis based on historical trends of steel, from 1997 to 2008, across some leading geo-economic players; on the other, the analysis of long-term relationship between steel consumption and economic growth by the sensitivity of the demand for steel consumption to a change in the national income. Results show that steel production and consumption have different economic behaviour across some countries: China and Italy have higher average annual growth of production of crude (CHN 9.75%; ITA 0.83%), steel crude use equivalent (CHN 8.37%; ITA 1.95%) and steel use finished products (CHN 9.38%; ITA 1.65%), whereas the US have higher average annual growth of imports (13.23%) and China of exports of semi-finished/finished steel products (20.38%). In addition, the estimated average elasticity of consumption of steel on national income statistical per countries, based on unidirectional causality that runs from national income to steel consumption, shows *de facto* positive values, except in UK economies. The analysis here provides main information on the industrial structure of countries and for designing industrial policies aimed to support patterns of economic growth in current turbulent and fast-changing markets.

Keywords: Steel consumption; Steel production; Competitive Performance; Economic growth, Industrial Dynamics; Comparative analysis, Time series.

JEL Codes: C22, L61, O13, O57.

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SUMMARY

INTRODUCTION

Steel is a main component for the production of economic systems and is a main material that plays a main role for the competitive advantage of economies (Yellishetty *et al.,* 2010). Steel production and consumption represent the backbone of industries in manufacturing economies, such as Italy, Germany, France, etc. In fact, although several transformations of the industrial structure of countries, the engine of the economic growth is mainly driven by manufacturing sector coupled with steel industry. Steel consumption is also a critical factor that supports industrialization of countries as well as their economic growth pathways (*cf.* Huh, 2011). Evolutionary trends of steel consumption and production, imports and exports of semi-finished and finished products can provide vital signals concerning the upturn and downturn of business cycles and as consequence the recovery or decline of industrial and manufacturing activity across economic systems[1]. Huh (2011) claims that the consumption of steel is an indicator of industrial dynamism since reveals as countries pass to higher stage of development (p. 107). Fruitful effects of the steel industry to the output of national economies are confirmed by higher inducement coefficients than other sectors: *e.g.* Korea has 3.4 for steel industry *and* 2.9 for manufacturing, Japan (3.1 *and* 2.8), etc. (OECD, 2011). These coefficients show the impact of changes in the final demand for products of one industry on the production of all industries of the economic system (*cf.* Huh, 2011, pp.7-8). Globalization and current turbulence have generated market change in the world demand and supply for most major metals, such as the steel. Economists and other analysts have devoted many efforts for investigating this market change in order to support the current behaviour of modern economies for copying with future uncertainty of world scenarios (Roberts, 1988, 1990, McSweeney and Hirosako, 1991). The study here analyses, across leading countries, the production and use of crude steel, steel use of finished products, imports and exports of semi-finished and finished steel products in order to explore the dynamics of steel trends. In particular, as time series of metal market provide premonitory signals concerning the industrial and manufacturing activity of economies, the purpose of this paper is twofold:

- on the one hand, to show the behaviour of some leading geo-economic countries (considering also the competitive role of Italy in a worldwide setting) by a flow analysis based on historical trends of steel;
- on the other, the analysis, within long-term equilibrium hypothesis between steel consumption and economic growth, of the estimated average elasticity of consumption of steel on national income per countries.

Results can provide information about the current competitive behaviour of leading world players in order to support their industrial policy to foster economic growth over current turbulent and fast-changing markets.

1. RELATED WORKS AND THEORETICAL FRAMEWORK

The Organization for Economic Cooperation and Development (OECD), World Steel Association, and other international institutions carry out several statistical analyses about steel industry of countries. Economists, scholars and analysts have analyzed, by different approaches, steel market in order to understand the current industrial dynamics over time. For instance, Saraceno (1953, p. 12) describes an interesting comparison of the average rhythm of growth of steel consumption over 1925-1952 among main economies, showing the following average rates of growth: Japan 4.16%, UK 3.15%, USA 3.04%, Italy 2.27%, France 1.98%, and Germany 1.76%. Instead, McSweeney and Hirosako (1991, p. 258) claim that: "crude steel consumption declined by about 2% per annum (pa) from 1973 in absolute terms (and by more than 4% pa when expressed in quantity per dollar of GDP)". Roberts (1988), applying the intensity use technique on OECD countries, showed that 25% of the decline in crude steel consumption can be due to a slowdown in GDP and 65% is attributable to a decline in intensity of use. Roberts (1990) has

[1] *Cf.* Lenti (1972), Cap. XI, pp. 1055-1206; Coccia (2010)

also developed a general model to explain trends in metal consumption over 1963-1983 US data in order to make forecast of metal requirements in the long run: he indicates a slow growth in the use of steel in the USA. Instead, Rebiasz (2006), analyzing Polish steel consumption over 1974-2008, shows a small decrease of the intensity of steel use.

Current analyses focus on the relationship between steel consumption and economic growth based on case-study of countries in order to verify the so-called long-run stationary equilibrium hypothesis: "to determine if steel consumption and economic activity follow a common stochastic trend or whether the two series randomly drift apart over time" (Evans, 2011, p. 97). In general, steel consumption has been associated to higher rate of economic growth because it is linked to the level of steel intensive industrial sectors (Crompton, 2000; Roberts, 1990; Rebiasz, 2006). Studies carried out on these topics show mixed results. Labson and Crompton support the presence of a long-term relationship between steel consumption and economic growth, as in Japanese economy (*cf.* Huh, 2011, p. 108). Other scholars do not found a relationship and Evans (2011, p. 9) argues that the divergence of steel consumption from economic activity is due to short-run disequilibrium in the transition phase of its dynamics.

Ghosh (2006) studies cointegration and Granger causality between steel consumption and economic growth in India where steel industry tracks the overall economic growth of the country (p. 7). He does not find a long-run equilibrium relationship between steel consumption and economic growth in India, but "unidirectional Granger causality running from economic growth to steel consumption" (Ghosh, 2006, p. 7 and p. 10). In other words, income growth pushes steel consumption increases. In addition, the statistical analysis also shows that Indian GDP growth is not susceptible to steel consumption increase (Ghosh, 2006, p. 10). The causality from economic growth to steel consumption increase and the lack of "any feedback effect" means that a growth in income is a determinant for fostering steel consumption. This effect is due to the recovery of economic activity, during the upturn of business cycle, driven by higher demand of consumer goods, construction, transportation and infrastructure that use steel as main input.

Instead Crompton (2000), for the Japanese economy, shows a stable long-run equilibrium hypothesis. The ambiguity of the relationship between economic growth and steel consumption is confirmed by other conflicting results to demonstrate the equilibrium hypothesis. These divergent results can be due to the specificity of industrial structure of countries, their level of economic development, as well as different specification of econometric modelling and time periods. For instance, the divergent results between Japan and India are that Japan has an advanced and competitive manufacturing sector, while in India the manufacturing sector has a low influence on the national economic system (*cf.* also Hah, 2011, p. 108). Recently, Hah (2011) has tested the long-run stability of equilibrium hypothesis between steel consumption and economic growth for Korean economy that has a strong economic growth driven by the manufacturing sector. Results show that in Korea steel consumption and GDP have a long-term equilibrium that runs from GDP to steel consumption: i.e. income growth is a critical determinant of steel consumption. Instead, Evans (2011) analyses a long-run stationary equilibrium hypothesis between economic activity and consumption of crude steel in UK. He finds a long-run equilibrium hypothesis, arguing that economic growth, as all economic phenomena, can change over time. This result is at odds with other studies because some econometric models do not consider structural breaks in the equilibrium hypothesis.

This current economic literature shows as the analysis of the dynamics of steel trends and equilibrium hypothesis have been receiving considerable attention. In addition, the analysis of steel trends is important in industrial organization and resources policy of current economies, since this major material is a main engine of the manufacturing sector of economies and as consequence of their long-run patterns of economic growth. Before describing the results, let me describe the methodology of research in the next section.

TABLE 1: Variables, period and their sources

Variables	Period	Sources
▪ Total production of crude steel ▪ Steel crude use equivalent ▪ Steel use finished products ▪ Imports of semi-finished and finished steel products	1975-2008	World Steel Association (2011)
▪ Exports of semi-finished and finished steel products	1980-2008	
▪ GDP per capita PPP (current International $) ▪ GDP PPP (current Int. $)	1975-2002	World Bank (2008)
▪ Population	1975-2008	
▪ GDP constant 2000 US$	1989-2006	
▪ GDP per person employed constant 2000- PPP $		
▪ Population employed	1989-2006	OECD(2011)

Note: * Purchasing Power Parity (PPP)

2. SOURCES AND STRATEGY OF ANALYSIS

This research focuses on China, France, Germany, Italy, Japan, UK and USA, since these main countries have generated in 2006 the 67% of world GDP -constant 2000 US$ (World Bank, 2008). In addition, over 1999-2008, they have produced the 57.03% of the world crude steel, consumed the 56.61% of crude steel and 58.51% of steel finished products, as well their steel handling of import and export has been roughly 35% of world materials (World Steel Association, 2011). In order to probe the main steel trends of these world geo-economic players, this paper analyzes the period from 1975 to 2009. I do not consider the previous period since is an abnormal one, because of the 1973 oil crisis. In particular, data source of steel are from World Steel Association (2012): "The World Steel Association was founded as the International Iron and Steel Institute on 19 October 1967. . . . is one of the largest and most dynamic industry associations in the world. . . . World steel members produce around 85% of the world's steel" (*Source*: worldsteel.org, accessed January 2012). Steel data per countries are gathered in Steel Statistical Yearbooks by World Steel Association, from 1075 to 2009. These data are integrated by those of Gross Domestic Product and Population of *World Development Indicators* by World Bank (2008), and population employed by OECD (2011). Table 1 shows variables, period and their sources. The global steel mass flows are expressed in kilograms unless otherwise mentioned. Table 1 describes apt variables to explore long-term trends per countries and their competitive behaviour in comparison to other economies, as well as to analyse the relationship between steel consumption and economic activities, within the theoretical framework of long-run equilibrium hypothesis.

The aim of the paper is twofold and the research method is:

- a steel flow analysis (SFA) that has the aim to accurate show the flow of steel into and out of a country. SFA displays the main trends of key variables concerning the dynamics of the steel that plays an important role for the "industrial metabolism" (Yellishetty *et al.*, 2010, p. 1084) of countries.

  As data are time series, with annual data, they can be represented as $T_t = f(t) + \varepsilon_t$. Scatter data show that trends in our series are approximately linear, because there is a

steady-state growth over time, such that the apt specification is:

$$T_t = \alpha_i + \beta_i t + \varepsilon_{it} \quad [1]$$

t = time ε = error term

Time series of variables cover different periods. Statistical analysis applies exponential smoothing procedure that produces fit values and residuals for time series, using an algorithm that smoothes out irregular components of time series data. Initial smoothing state represents the parameter α_i of Eq. [1]: arithmetic mean of the steel production or consumption (or other variables of the steel applied in the econometric modelling) over time.

β_i of Eq. [1] is the average absolute annual rate of growth and is estimated by Prais-Winsten estimation method, by the autoregression estimate procedure from time series with first-order autocorrelated errors. Prais-Winsten transforms the regression equation to remove the autocorrelation. Outputs of the Prais-Winsten estimation method are: Durbin-Watson statistic, mean squared error at each iteration, adjusted R^2, standard error of the estimate, analysis-of-variance table, and regression statistics for the ordinary least-square and final Prais-Winsten estimates. The method Prais-Winsten, is equivalent to an ARIMA (1,0,0) model. A synthetic and critical indicator to analyse the dynamics of these variables and to assess its competitive behaviour is the average annual relative rate of growth that is given by:

$$\frac{\beta}{\alpha} \times 100 \quad [2]$$

As far as Chinese case study is considered, scatter of data shows that the apt trend is the exponential function; in this case the apt specification of T_t is represented by an exponential function:

$$T_t = \alpha \beta^{t} \quad [3]$$

Parameters are estimated by Prais-Winsten method applied to natural logarithmic transformation:

$$Ln\ T_t = Ln\ \alpha + t\ Ln\ \beta \quad [4]$$

if $Y_t = \text{Ln}\ T_t$; $a = \text{Ln}\ \alpha$

and $b = \text{Ln}\ \beta$

we have $Y_t = a + b\ t$ [5]

a is the average geometric level of variables, whereas average annual relative rate of growth is given by:

$$(b-1) \times 100 \quad [6]$$

- the long-term relationship between steel consumption and economic growth is analyzed by the sensitivity of the demand for steel consumption to a change in the national income. Considering the theoretical framework (Ghosh, 2006, Huhn, 2011, Evans, 2011), the model setting is based on the following:

Assumption: Steel consumption and GDP have a long-term equilibrium, running from GDP to total steel consumption.

Hypothesis: Average elasticity of steel consumption on national income is positive.

The pioneering research by Tinbergen (1939) is applied to analyse the relationship between consumption of steel and national income. In particular, the specification of the function of steel consumption is:

$$y_t = b \cdot x_t^{\alpha} \quad [7]$$

Where y is the consumption (use) of steel and the explanatory variable x is the Gross Domestic Product. Logarithmic transformation of this exponential function gives the average elasticity of consumption of steel on national income.

In fact:

$Y = ln\ y_t$ $X = ln\ x_t$ $B = ln\ b$

Hence, exponential function is transformed in:

$$Y = B + \alpha X \quad [8]$$

The elasticity is:

$$\varepsilon = \frac{dY}{dX} = \alpha \quad [9]$$

ε shows the sensitivity of the demand for steel consumption to a change in the national income. This simple indicator provides main information on the extent to which changes in economic growth affect the pattern of steel consumption and as consequence the reaction of the industrial structure of the economic system. In addition, the elasticity provides critical information of the long-run stability of equilibrium hypothesis between steel consumption and economic growth patterns.

Statistical analysis are carried out by software statistics SPSS (2011).

3. EMPIRICAL EVIDENCE

The analysis is expected to provide main information to support efficient policy formulation of countries. Main results are twofold.

First. Results of the statistical analysis of historical trends to evaluate the competitive behaviour of countries are synthesized in table 2 by average annual relative rates of growth (%) per countries. These results are based on significant regression coefficients (at the 0.01 level), and the majority of models have high adjusted R^2 (goodness of fit), as well Durbin-Watson statistic indicates low or lack of autocorrelation within time series. For the sake of briefness, the 76 estimated relationships are not reported. In particular, table 2 shows that the highest average annual relative growth of total production of crude steel is in China (9.75%), followed by Italy 0.83% and Germany 0.75%. Negative annual growth of the total production of crude steel is in the UK (–0.98%) and the USA (–0.68%). Conversely, annual growth of steel crude use equivalent is driven by China 8.75%, Italy 1.95% and Germany 0.96%.

Similar considerations for steel use finished products. Imports of semi-finished and finished steel products have the highest percent annual growth in the USA 13.23%, whereas China has 6.28% and Italy 5.05%. Exports of these materials show the highest value in China with an annual relative growth of 20.38%, whereas US have 5.66%, Italy 3.17% and UK 2.68%. Better economic performance about annual growth of GDP and GDP *per capita* is mainly in China, USA, UK and France.

Figures 1-6 show evolutionary trends of GDP and steel indicators across countries to provide main results of their industrial structure and competitive behaviour in a worldwide setting.

TABLE 2: Average annual relative rates of growth (%) per countries

	ITALY*	FRANCE*	GERMANY*	UK*	JAPAN*	USA*	CHINA δ**
Total production of crude steel %1975-2009 (A)	0.83	#	0.75	–0.98	0.54 p	-0.68	9.75
Steel crude use equivalent % 1975-2008 (A)	1.95	0.69 p	0.96	–1.15	0.67	0.70 p	8.37
Steel use finished products % 1975-2008 (A)	1.65	0.70	1.58	#	#	1.40	9.38
Imports of semi-finished and finished steel products % 1975-2008 (A)	5.05	3.1	2.79	2.98	3.15	13.23	6.28
Exports of semi-finished and finished steel products % 1980-2008 (A)	3.17	2.15	1.76	2.68	#	5.66	20.38
GDP *per capita* PPP % (current Int. $) 1975-2002 (B)	3.65	3.69	3.48	4.33	3.32	3.70	9.38

Note: # values not significant; p=1982-2008 period; δ=1980-2006; ◊= ε is calculated by Eq. [3] n.a. = not available data. *Sources*: (A) World Steel Association (2011); (B) World Bank (2008). * Linear models are applied to estimate trends; Average annual relative rates of growth is calculated by Eq. [3]; ** Exponential models are applied to estimate time series; Average annual relative rates of growth is calculated by Eq. [6];

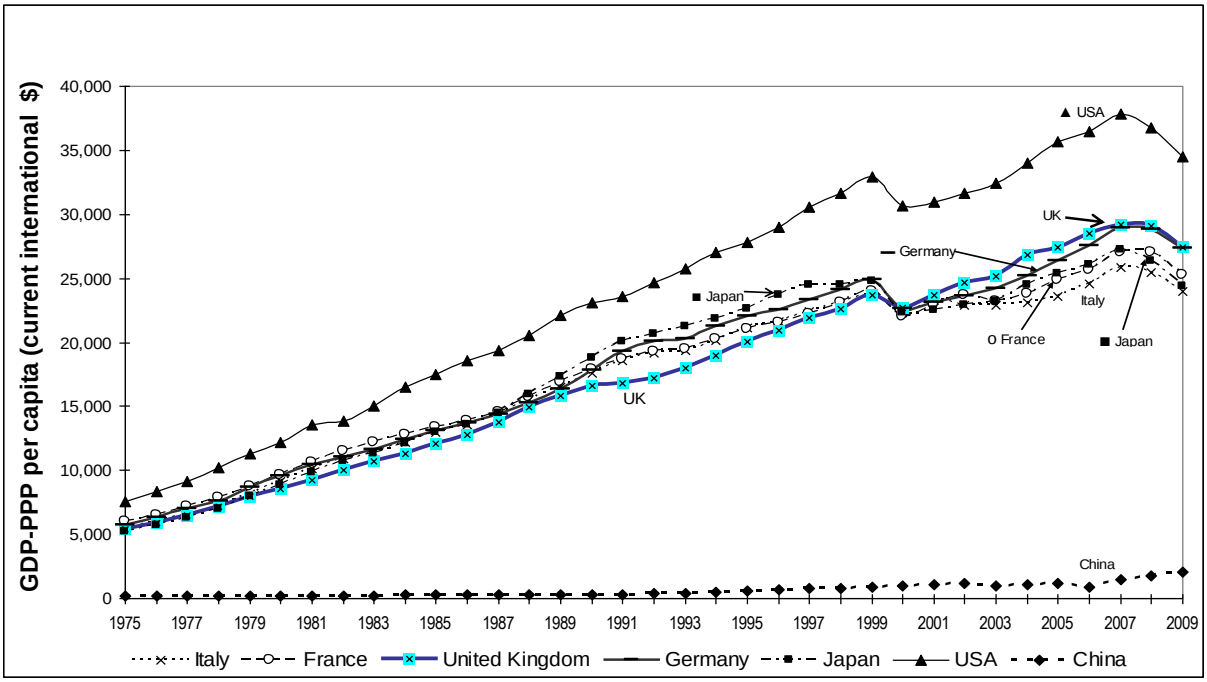

FIGURE 1: GDP per capita ($) across leading countries

In particular, figure 1 shows trends of GDP *per capita* across leading worldwide players: the highest economic performance of this structural indicator (over 1999-2009) is by USA and UK, lower values are in Italy and Japan. China has a lower flat trend because of higher population (more accurate information about their annual rate of growth is table 2).

As far the evolutionary dynamics of steel, figure 2 shows that higher trends of crude steel production *per capita* (kg) are in Japan, Germany and Italy, lower in UK and USA. Figure 2 also shows the negative effects generated by global economic downturn over 2007-2010 with declining values across all main countries.

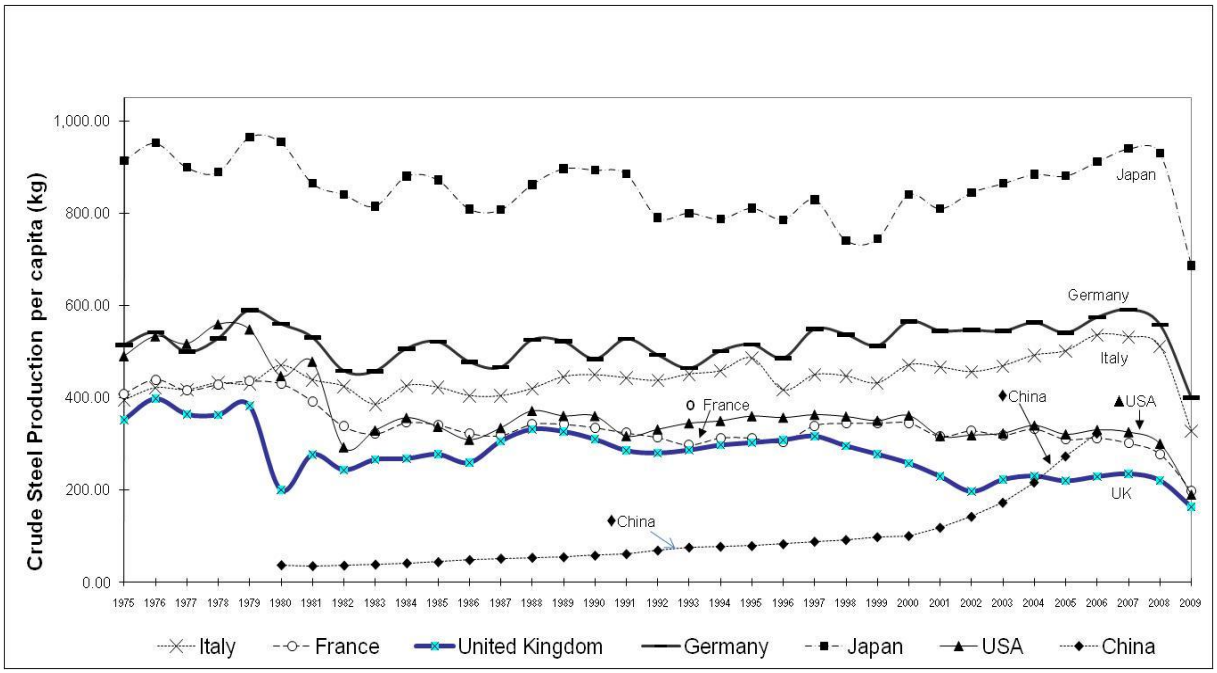

FIGURE 2: Crude steel production per capita (kg) across countries

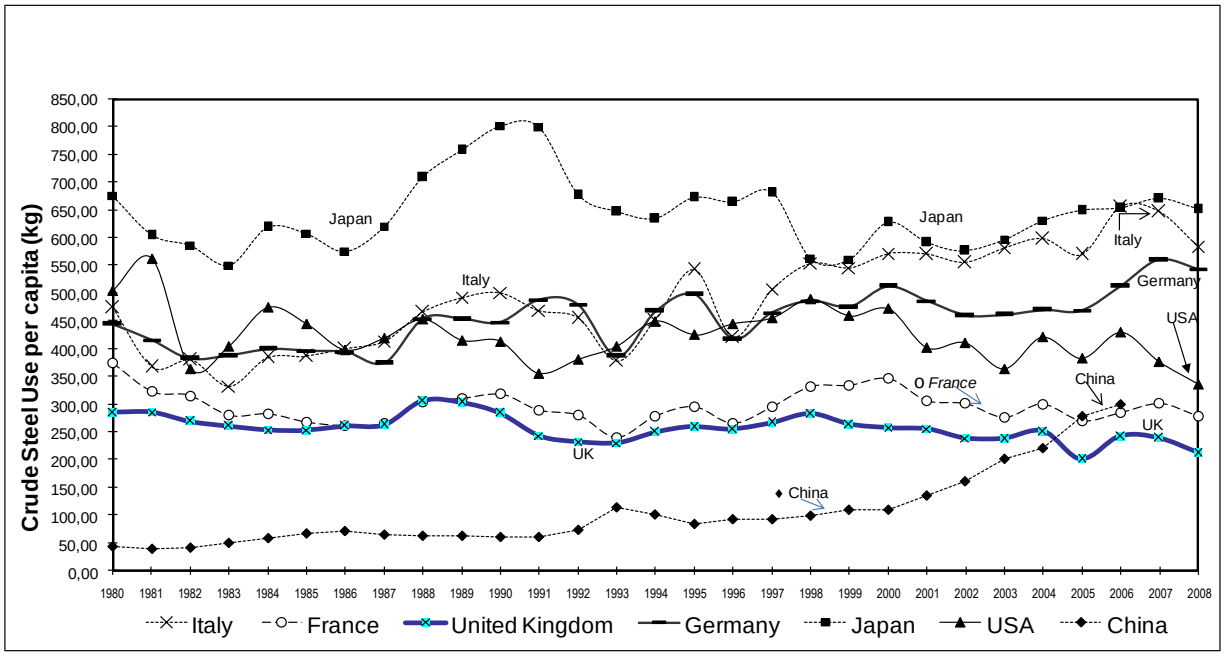

FIGURE 3: Crude steel use per capita (kg) across countries

Figure 3 shows the evolutionary trends of crude steel use *per capita*. Higher performances are given by Japan, Italy and Germany. Crompton (2000, p. 103) claimed that: "crude steel consumption in Japan will fall from 82.1 million tonnes in 1997 to around 73.1 million tonnes in 2005. The cause of this reduction in consumption is cyclically low GDP growth and further permanent reductions in the steel intensity of Japanese production over the forecast period". It is important to note the exponential growth of China that from 2005 has overtaken the consumption of UK and France, and the declining value of US, from 2007, that may be due to strong effects of global economic downturn on this country. In fact, Chinese steel crude use equivalent has an average growth per annum roughly 8.3% (table 2), higher than previous forecasts. Chen *et al.* (1991, p. 196) argued that: "Chinese steel demand wills growth from 60 million tons in the late 1980s to 100 million tons by the year 2000. . . . After a strong recovery in 1992-93, steel demand will then grow at 5% per annum in the second half of the 1990s". Instead, Ma *et al.* (2002), analyze the Chinese growth showing the main role of technical efficiency and productivity change of China's steel industry.

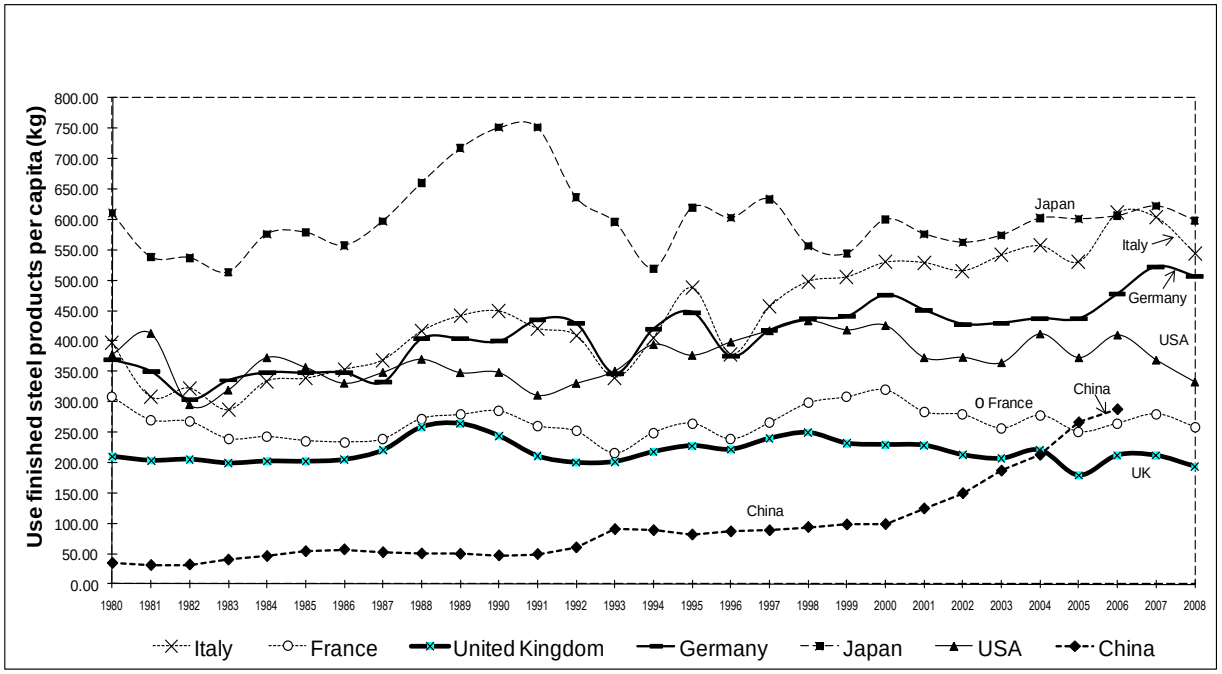

FIGURE 4: Use finished steel products per capita (kg) across countries

Figure 4, use finished steel products *per capita*, shows similar results to previous figure 3 because these two variables of steel consumption have high positive correlation.

Interesting results are in figure 5 on imports of semi-finished and finished steel products *per capita*. The highest trend, from 1997, is by Italy, followed by Germany and France. Lower performances in terms of imports are by the UK and USA. This indicator also shows the effects of global economic downturn since 2007.

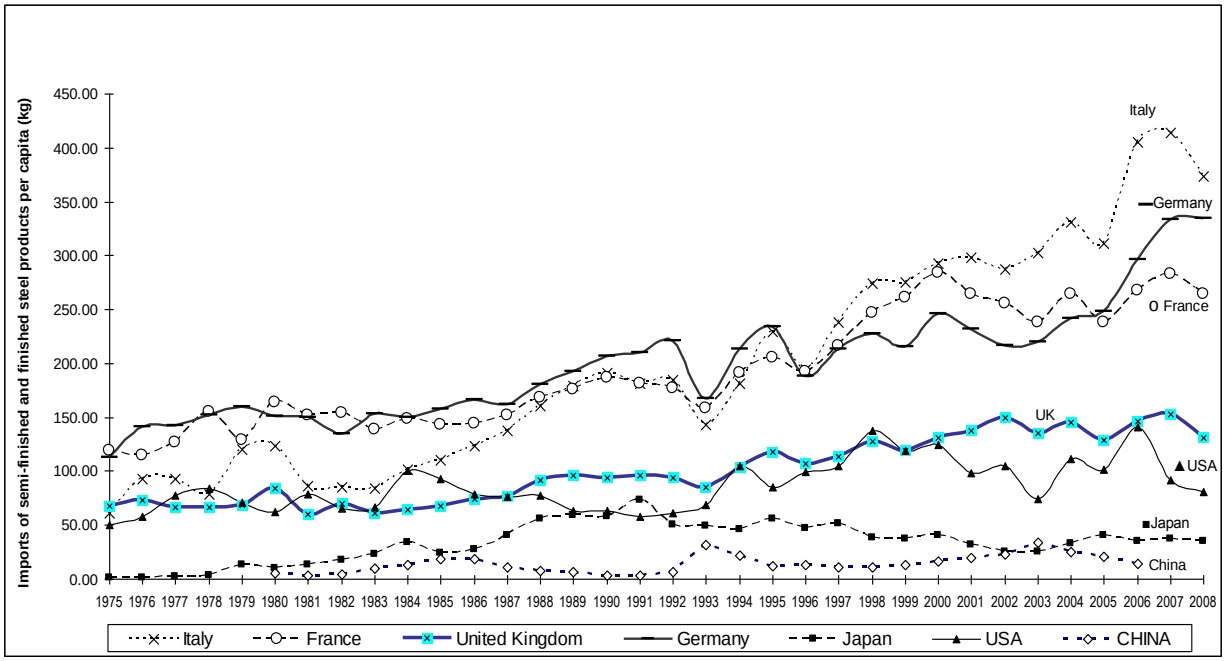

FIGURE 5: Imports of semi-finished and finished steel products per capita (kg)

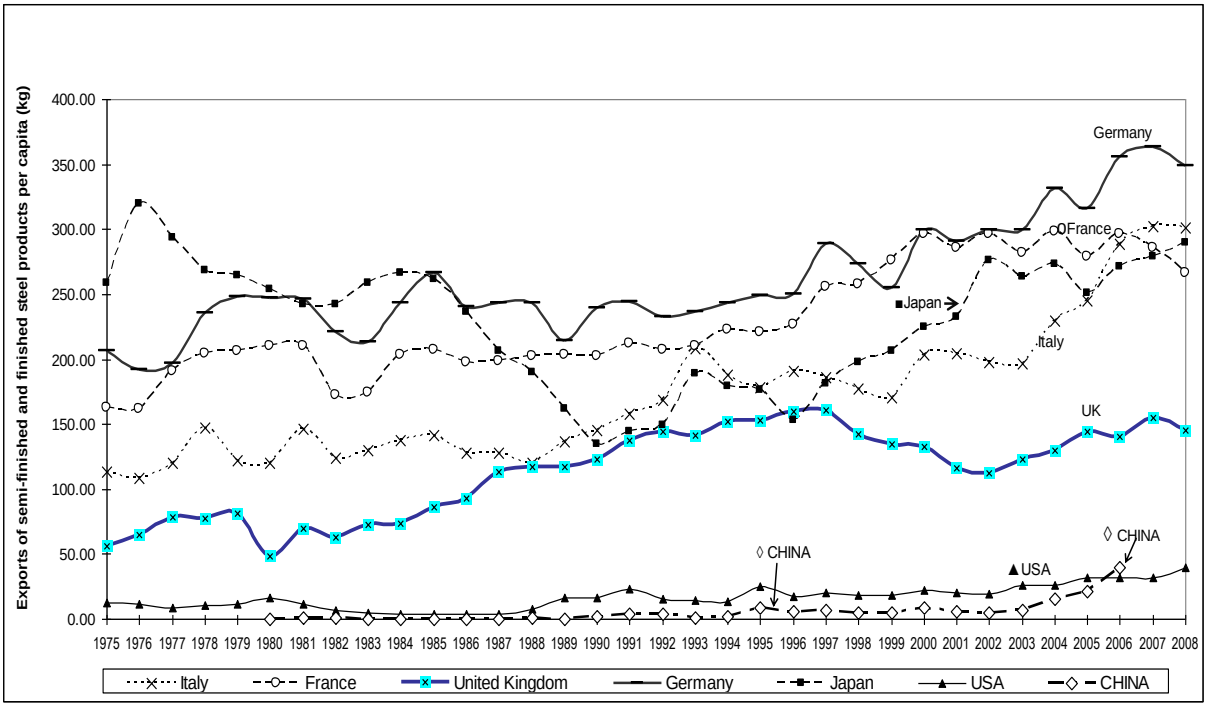

FIGURE 6: Exports of semi-finished and finished steel products per capita (kg)

Figure 6 shows the exports of semi-finished and finished steel products *per capita*. Germany and France have higher trends, although Italy has been having an exponential growth passing Japan and France in 2008.

Second. Results of the analysis of long-term relationship between steel consumption and economic growth are represented in table 3 and 4. First of all, as the relationship between economic growth and steel consumption has provided conflicting views (cf. Huh, 2011, p.107 ff. and Evans, 2011, p. 97ff), table 3 shows the correlation to analyze the main association between these two critical variables of the economic system. In particular, Table 3, shows the high positive correlation between GDP per capita and use crude steel per capita in Italy, Germany and China (significant at the 0.01 level), whereas there is a negative association in the UK, US and France.

In addition, correlation GDP per capita / use finished steel per capita has high positive coefficient in Italy and Germany (significant at the 0.01 level), China and USA (significant at the 0.05 level).

TABLE 3: Pearson Correlation GDP per capita/Consumption of Steel per capita

Correlations			
		USE CRUDE STELL *PER CAPITA*	USE FINISHED STEEL *PER CAPITA*
ITALY	GDP *per capita* PPP current international $	0.85**	0.75**
	Sig. (2-tailed)	0.00	0.00
	N(YEARS)	34	34
FRANCE	GDP *per capita* PPP current international $	–0.50**	0.31
	Sig. (2-tailed)	0.00	0.11
	N(YEARS)	34	29
GERMANY	GDP *per capita* PPP current international $	0.78**	0.87**
	Sig. (2-tailed)	0.00	0.00
	N(YEARS)	29	29
UK	GDP *per capita* PPP current international $	–0.74**	0.03
	Sig. (2-tailed)	0.00	0.89
	N(YEARS)	34	29
JAPAN	GDP *per capita* PPP current international $	0.33	0.11
	Sig. (2-tailed)	0.06	0.57
	N(YEARS)	34	29
USA	GDP *per capita* PPP current international $	–0.64**	0.43*
	Sig. (2-tailed)	0.00	0.02
	N(YEARS)	34	29
CHINA	GDP *per capita* PPP current international $	0.95**	0.97*
	Sig. (2-tailed)	0.00	0.02
	N(YEARS)	27	27

** Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed).

The economic literature has verified that the relationship steel consumption and GDP has a causality running from GDP to total steel consumption. Considering this background, the study considers the following

Hypothesis: Average elasticity of steel consumption on national income is positive.

The purpose here is to see whether statistical evidence supports this hypothesis, in order to analyze the extent to which changes in economic growth affect the pattern of steel consumption and as consequence the reaction of the industrial structure of economic systems.

Results are in table 4 and figure 7. In short, elasticity of crude steel consumption is higher in China 0.72, Italy 0.37 and Germany 0.28, *vice versa* there is a negative elasticity of steel consumption in UK. In addition, last three rows of table 4 show interesting findings:

real GDP growth over 1989-2006 is, almost utterly, due to productivity growth (GDP per person employed) in UK, Germany, and France, since the population employed has a moderate growth in the range 0.30-0.69% over 1989-2006.

TABLE 4: Average annual relative rates of growth (%) per countries

	ITALY*	FRANCE*	GERMANY*	UK*	JAPAN*	USA*	CHINA δ**
ε (Elasticity) 1975-2008 ◊ Ln Crude Steel Use =*f*(Ln GDP) (A)	0.37	0.19 p	0.28	–0.20	0.16	0.18 p	0.72
GDP *per capita* PPP % (current Int. $) 1975-2002 (B)	3.65	3.69	3.48	4.33	3.32	3.70	9.38
GDP PPP (current Int. $) % 1975-2002 (B)	3.85	4.22	3.65	4.55	3.51	4.60	10.63
Population (%) 1975-2008 (B)	0.23	0.59	0.18	0.26	0.38	1.04	1.12
GDP constant 2000 US$ (%) 1989-2006 (B)	1.39	1.93	1.68	2.42	1.29	2.98	n.a.
GDP per person employed (constant 2000, PPP $ -%) 1989-2006 (B)	1.25	1.42	1.30	2.09	1.09	1.90	n.a.
Population employed 1989-2006 (C)	0.66	0.69	0.30	0.52	#	1.16	n.a.

Note: p=1982-2008 period; δ=1980-2006; ◊= ε is calculated by Eq. [3] n.a. = not available data. *Sources*: (A) World Steel Association (2011); (B) World Bank (2008); (C) OECD (2011). * Linear models are applied to estimate trends; Average annual relative rates of growth is calculated by Eq. [3]; ** Exponential models are applied to estimate time series; Average annual relative rates of growth is calculated by Eq. [6];

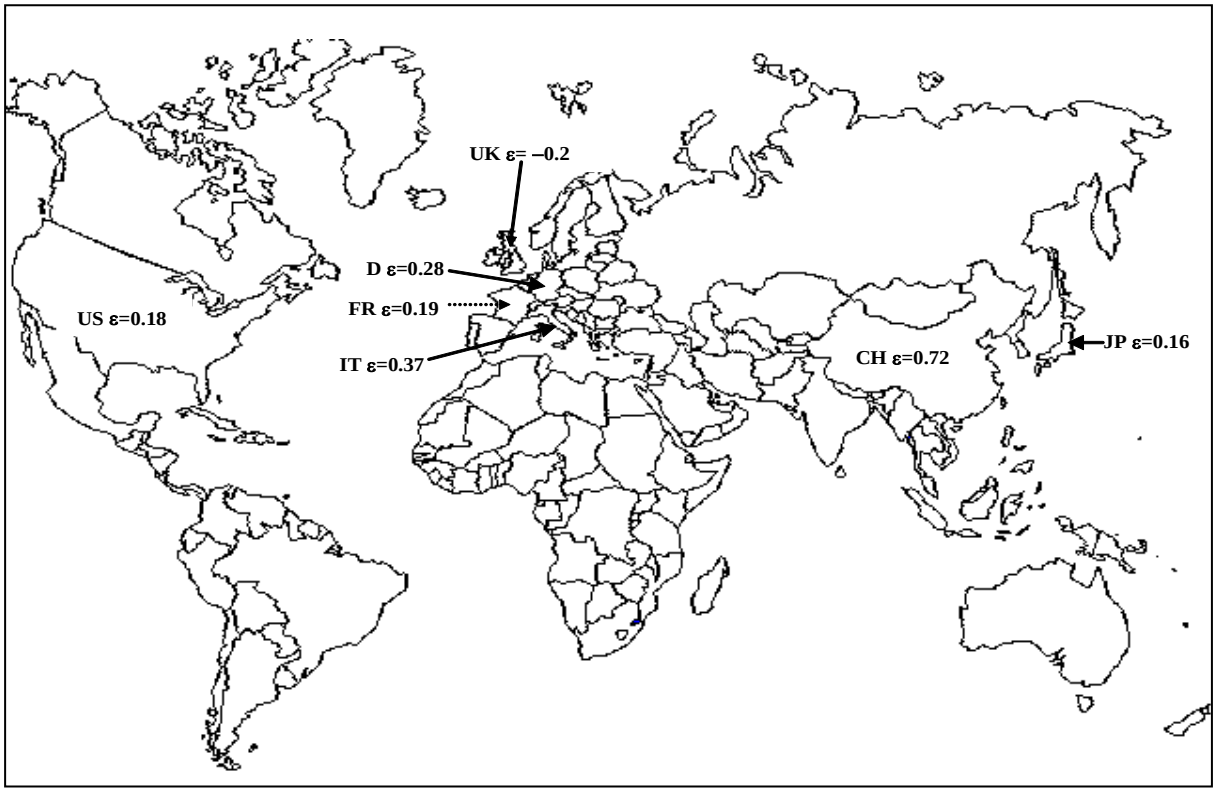

FIGURE 7: Average elasticity of steel consumption on national income across leading countries.

4. DISCUSSION AND CONCLUDING REMARKS

The analysis of steel trends since 1900s has played a main role to assess the industrialization of economies that leads to higher economic development. Steel industry represents the foundation of the industrial structure of several countries and supports the manufacturing sector of several economies. The study here, analyzing the steel trends of some leading countries from different perspective, provides interesting results on their main industrial structure and reaction of steel consumption to shock of national income. Empirical evidence shows the growing role of China in the production and consumption of crude steel as well as in steel use finished products and exports of semi-finished and finished products; whereas US have the highest annual relative growth of imports of semi-finished and finished steel products. In this worldwide scenario, the analysis shows the competitive position of Italy where the manufacturing sector (including steel industry), driven by small and medium enterprises, is the 'engine' of economic growth. In particular, Italy has higher annual relative growth in the production and consumption of crude steel, steel use finished products, imports and exports of semi-finished and finished steel product in comparison with other European countries and Japan. Figure 8 and 9 show the interesting geometrical inner dynamics of Italian case study. In particular, since the second half of 1990s, Italy has a growing consumption per capita of crude steel that in 2007, before the economic downturn, is circa 648kg per capita (France ~301kg, Germany ~560kg, UK circa 239kg, Japan ~670kg, China ~222kg, USA ~377kg). Similar trend for the import of semi-finished and finished steel products that has passed in 1994 the trend of export (in 2007 the import per capita in Italy was circa 414kg). This geometrical analysis, confirmed by the statistical one, shows that Italy is one of the largest consumers of crude steel driven by the high intensity of manufacturing sectors that is the 'engine' of the Italian economic growth, in comparison to other countries, such as UK, that has a rather developed service sector. In addition, it is important to note that the reduction of steel consumption in some countries is attributable to structural change of the economic system. Italy has a strong manufacturing sector that represent the backbone of the economic system and economic growth, but this sector is also vulnerable to downturn of business cycles and in period of turbulence does not support economic growth of GDP. In fact, average annual relative rate of growth of GDP per capita in Italy is 3.65%, whereas in UK is 4.33%.

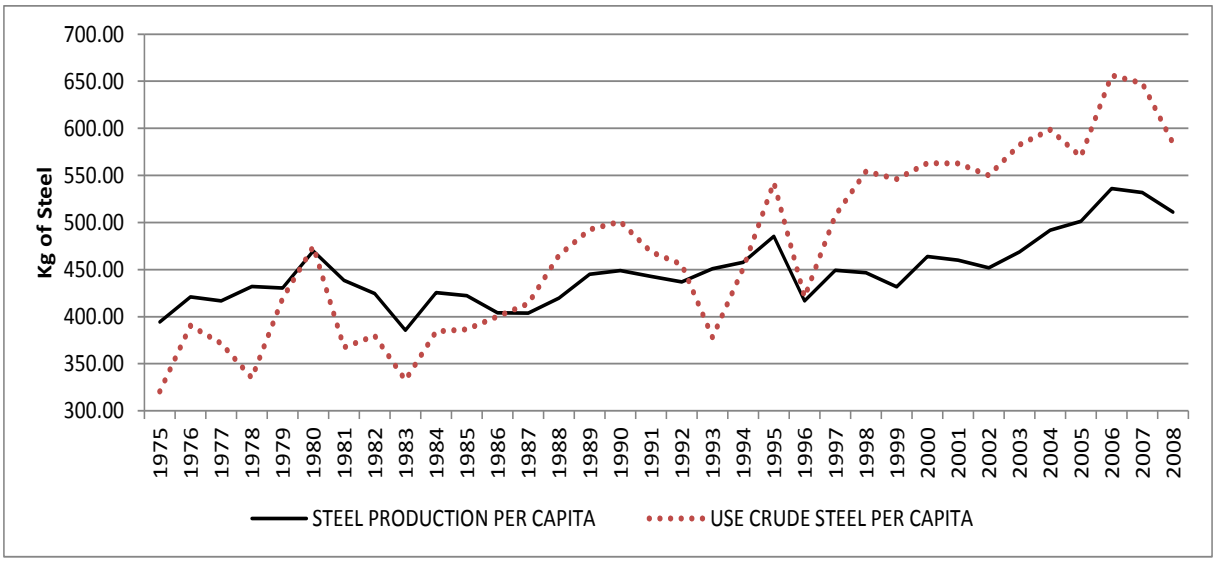

FIGURE 8: Production and use crude steel per capita in Italy

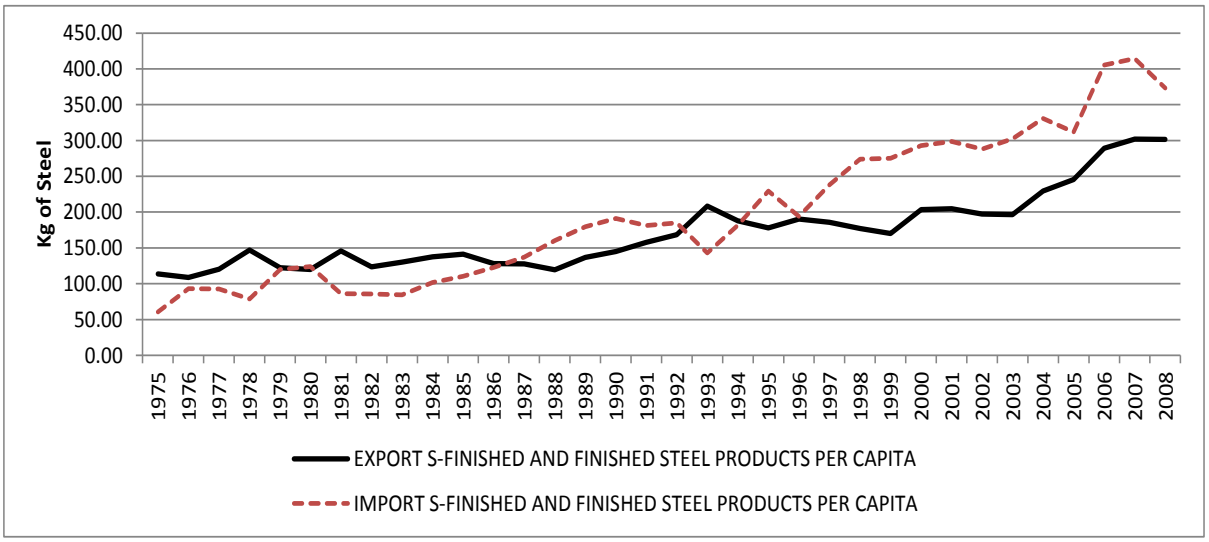

FIGURE 9: Export-Import of semi-finished and finished steel products in Italy

In addition, current economic literature has assigned a considerable attention to the analysis of relationship between economic growth and steel consumption. As the equilibrium hypothesis of these two variables is subject to a hot scientific debate, with ambiguous results, the present study, within this theoretical framework, provides interesting results based on correlation analysis and average elasticity of steel consumption on national income. Correlation analyses show a strong positive coefficient in Italy, Germany and China, whereas there is a negative association for GDP per capita/steel consumption mainly in UK, US and France. The positive result can be due to leading role of the manufacturing sector for some countries that represents the foundation of the industrial structure and support patterns of economic growth. If this analysis is associated to the sensitivity of the demand for steel consumption to a change in the national income (ε), results show that change in GDP has a higher impact in Chinese and Italian steel consumption, lower in Germany, France, US and Japan. For these countries, steel consumption is, in microeconomic terms, a normal good for the economic system.

As far as UK is concerned, the analysis shows a negative correlation coefficient for GDP per capita/steel consumption; in addition, UK is the only country with negative national income elasticity of steel consumption: i.e. steel consumption is similar to an inferior good for this economic system. UK economy has also a negative annual growth about the total production and consumption of crude steel, though GDP *per capita* has higher rate of annual growth. UK case study can provide main information to understand the determinants of steel consumption and of the intensity of use. The decline of steel trends for UK, as well as the negative association between GDP per capita and steel consumption, corroborated by negative elasticity, is due to the change of industrial structure of UK economy. This result may be occurred because of growing share of service sector within UK economic system, diffusion of ICTs and new electronic products (that do not use steel), substitution of steel with new materials (such as plastic) as well as the technological innovation pathways that support the production of same goods with lesser resources (*cf.* Evans, 2011, p. 99ff). UK case study, associate to other results, confirms that the relationship between steel consumption and national income has complex interaction and long-run equilibrium hypothesis can change over time and across geo-economic space. In addition, evolutionary trends of steel, as seen, are also affected by turbulence of markets generated in business cycle downturn. A comprehensive analysis should consider other variables and the continuous technological progress.

Although technological innovation has a main role in reducing steel consumption by saving input resources, the current ratio between consumption of steel and national income seems to be relatively high because of persistence of high unemployment generated by macro-economic instability driven by huge national

debts within European area and US economy (see Goldstein and Hillard, 2009, pp. 263-267) [2]. In fact, economic downturn 2007-2010 has generated serious shocks on labour markets such that government policies have increased public spending by public investments in infrastructure that use resources of modest economic value. The patterns of economic growth, in several countries with turmoil, may be supported by the production of various durables and improving infrastructure (road, ports, rail transport) that have the steel as input (associated, of course, to incentives for total consumption in the economic system). This industrial policy could reinforce the relationship of income growth as determinant for fostering steel consumption, though it may be difficult to prosecute because several countries to cope with economic turmoil and instability have reducing public deficit by balanced-budget rules that constraints public spending (Stockman, 2001). However, global demand of steel should continue to growth by 5% circa, driven by strong demand of emerging economies such as India, Latin America and others (Ghosh, 2006, p. 10).

As a matter of fact, current dynamics of business cycle (Coccia, 2010) across main economies reinforces the hypothesis of growth rates of steel consumption in the next decade similar to average relative growth described in table 2, considering a stable growth of world population. The ratio between increase of steel consumption and increase of real income may be lower in the long run, if and only if, the development of world economy will be supported by economic stability in the Euro Zone that should allow a rational use of labour force and the diffusion of technological innovations[3] for steady-state patters of economic growth.

[2] See Goldstein and Hillard (2009) for an heterodox approach to macroeconomics to analyze these issues.

[3] *Cf.* also Coccia (2010a) for a foresight of technological determinants and primary energy resources of future economic long waves.

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