Focus On

The Technical Coefficient of Cement in a Long-Term Perspective

March, 26th 2010

1. Introduction

After a long phase of extensive growth, the picture for the construction sector has radically changed due to the worsening of the world economic recession.

As a matter of fact, while construction investment grew steadily with no substantial differences in almost all industrialized and emerging countries since the early '00s, now much more diversified situations are arising. In addition, prospects of a substantial and long lasting decoupling between mature and developing economies have become more and more evident.

In this perspective, a review of past experience may be more useful than any attempt to forecast future scenarios, especially at a time of strong cyclical changes coupled with a by far above usual degree of uncertainty.

The specific purpose of this note is hence to look at the evolution of the technical coefficient of cement between 1995 and 2008 in twenty-three countries, in the belief that past dynamics are useful to identify fundamental trends and problems that are likely to persist even once the current crisis is over.

2. Methodology

This *Focus On* investigates the evolution - over time and among countries - of the technical coefficient of cement (TC). TC is defined here as a measure of cement consumption for a given amount of construction investment and has been calculated for twenty-three countries[1] and for three selected base-years (1995[2], 2000 and 2008) as an accounting identity as follows:

$$\frac{C}{CI} \equiv \frac{C}{P} \div \left(\frac{GDP}{P} \times \frac{CI}{GDP} \right) \equiv \frac{C}{P} \times \frac{P}{GDP} \times \frac{GDP}{CI}$$

[1] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Poland, Czech Republic, Spain, Sweden, Switzerland, United Kingdom (UK), United States of America (US), Thailand and Turkey. This set represents 16% of world cement consumption, nearly 40% excluding China and India, and over 90% of all industrialised countries. It is worth noting that the choice of the panel has been mandated by the lack of data on construction investment for a broader set of countries.

[2] For Greece, the Czech Republic and Turkey data start from 2000, 1996 and 1998 respectively.

where:

- $\frac{C}{CI}$ stands for cement intensity, or technical coefficient (see also box 1);
- $\frac{C}{P}$ indicates cement consumption per capita;
- $\frac{GDP}{P}$ is gross domestic product per capita;
- $\frac{CI}{GDP}$ is the construction investment to GDP ratio.

A prerequisite of this type of analysis is the possibility to compare data both over time and across countries. However, as countries with different currency units are included in our panel, it is impossible to carry out these comparisons without some kind of standardization of national accounts data[3] concerning GDP and construction investment. In this regard, the use of market exchange rates is not satisfactory as results may be distorted by both structural and occasional factors (i.e. changes in terms of trade, economic policy actions, sudden large capital inflows/outflows, etc.). Even the use of the so-called purchasing-power-parity (PPPs[4]) is not the best choice because, while it helps fix the issue of the cross-country comparability, it limits the feasibility of comparisons over time[5].

As a consequence, the analysis has been conducted in two different dimensions. Firstly, we have considered the evolution of the TC over time within each country by using GDP and construction investment data expressed in local currency at constant prices. Secondly, PPPs have been used to make comparisons among countries in three base-years conventionally chosen (1995, 2000 and 2008).

Coming back to the above identity:

- $\frac{C}{CI}$ is measured in the first case (comparisons over time within each country) as Kg of cement consumption per 1000 unit of construction investment expressed in local currency at constant prices, while in the second case (cross-country comparisons in the three selected base-years) as Kg per 1000 unit of US$ at PPPs;
- $\frac{C}{P}$ means Kg of cement per capita;
- $\frac{GDP}{P}$ where GDP is expressed both in terms of thousands local currencies at constant prices, and thousands US$ at PPPs;
- $\frac{CI}{GDP}$ is, as said, the ratio between consumption investment and GDP.

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[3] Cement consumption and population are instead measured through the same unit in all countries.

[4] Purchasing Power Parities are currency conversion rates that eliminate the effects of the differences in price levels between countries. In other words, they show how many units of currency A need to be spent in country A to obtain the same volume of a product or an aggregate of products that X units of currency B purchase in country B.

[5] As a matter of fact, the value of the basket of goods and services - which provides equivalent satisfaction or utility in each country - is expressed in current (not constant) prices.

In order to ease the reading of results, for every country two summary tables (see the statistical appendix) report values of all components of the accounting identity in each of the three base-years (1995, 2000 and 2008), and their changes over time. For cross-country comparisons we used a correlation analysis (in graphs 1-6 data are represented through scatter plots).

In order to highlight the dynamics of the variables involved, for each country of our panel the statistical appendix also reports the evolution of construction investment, cement consumption and GDP (graphs 7-29).

BOX 1 – The Technical Coefficient of Cement

The concept of technical coefficient necessarily over-simplifies the manifold nature of works within construction investment. Indeed, building works change significantly from year to year depending on the cyclical position of the construction sector. Notably, the mix among public, residential and non residential works varies and - within each segment - also the breakdown of works varies (e.g. between single and multi-family houses, between roads and railways, etc.). This affects cement consumption significantly, being cement usage lower in the case of housing and on average much higher in the case of public works. It follows that if, for example, in two periods *t* and *t+1* the same volume of total construction investment is associated with an increase (decrease) in cement consumption, it is not possible to determine to what extent the change depends on the building mix or on the use of more (less) cement intensive construction techniques.

It is worth also considering that, at the peak of a building cycle the share increases of new realizations over maintenance works, and the opposite occurs during recessions. Since cement consumption is structurally very low for maintenance works, it follows that the cement cycle is amplified compared to that of total construction. In this regard, it is noticeable that – according to Euroconstruct estimates – spending for maintenance currently reaches nearly 50% of the total construction investment, a share lower by almost 10 pp than during the previous boom.

There are also further issues influencing TC, which relate to the long time needed for completion of building works. In this regard, the use of cement is much more intensive in the early stages of construction processes. As a consequence, when there is an acceleration (deceleration) of construction activity (i.e. when, the number of new projects starting in *t* is much higher (lower) than that in t-1) there is a positive (negative) leverage effect on cement consumption which tends to expand cyclical fluctuations.

Finally, the evolution of TC is also affected by specific technical factors, dependent upon the increasing complexity of the building process (for instance, higher value added components at the design and implementation stages are becoming more and more relevant), which lead usually – but not necessarily – to reduce cement consumption per unit of construction investment.

3. The Evolution of Technical Coefficients by Country

It is well known that the higher the degree of a country's development, the higher the shift of economic activity towards services. This process also affects the construction sector, where the increasing complexity of activity implies a growing share of services per unit of construction investment.

Against this backdrop, in a country where the per capita income grows a gradual reduction of cement intensity might be expected.

Despite the limitations related to our panel, data collected in Tables 1 and 2 essentially confirm the above assumption.

As a matter of fact, TC decreased in most of the selected countries. Among the exceptions, in Western Europe, Austria saw an increase in the technical coefficient given the strong performance of its non-residential sector (graph 7). TC improved also in Sweden due to base effects (levels of per capita cement consumption are among the lowest in Europe) and boosted by the acceleration of public investment in the last part of the selected period (graph 18)[6].

Among the non-European mature economies, a substantial stability of TC has been observed in Japan, where cement consumption decreased on average a bit less than construction investment (graph 28)[7], and in New Zealand where the recovery of the technical coefficient, which had previously dropped by more than 30 pp between 1995 and 1998, was very strong also thanks to the healthy performance of the non-residential components (graph 27).

Among the remaining countries, TC has increased significantly in Thailand where construction techniques remain highly cement intensive (graph 29)[8].

4. A Cross-Country Comparison

As already said in section 2, the use of local currencies allows to compare data over time only within each country. With the limitations referred above, the use of PPPs makes it possible to extend the analysis also to cross-country comparisons.

Notably, we aim to investigate the correlation between the technical coefficient and per capita income and between this latter and per capita cement consumption.

The relationships among different couples of variables are represented through scatter plots (graphs 1-6) and, in this regard, three major aspects stand out, namely:

- cement intensity and levels of per capita income are inversely related (graphs 1-3), so that the higher the incomes, the lower cement intensity (the correlation coefficient, R^2, achieves almost 80% in 2008);
- the variability of per capita GDP, measured by the variation coefficient, is lower than that related to cement intensity. This is true even considering only mature countries, which in some cases show - even within narrow income brackets - strong differences in the value of technical coefficients;
- a relation between specific geo-economic areas and TC seems to be confirmed. This is the case of three Mediterranean countries (Spain, Italy and Greece) where, due to local high cement intensive building models, TC results structurally higher than the overall average (charts 1-3). In contrast, all Commonwealth countries in our panel (i.e. New Zealand, Australia, UK and Canada) show very low values of TC. The same is true for the North-European countries (Sweden, Finland, Denmark and Holland), traditionally

[6] A significant increase in cement consumption per capita occurred in all Scandinavian countries.

[7] The high local seismicity has spurred in this country more cement intensive construction techniques.

[8] In this country, cement consumption seems to hold during a recession and increase more swiftly than construction investment during an upturn.

characterized by more heterogeneous building techniques and construction materials. Relevant exceptions to the above geographic grouping are represented by Ireland, which has experienced a phase of intense growth in the construction sector also supported by a huge inflow of European funds, and France which, although being at least in part a Mediterranean country, shows cement consumption levels (both in absolute and per capita terms) closer to other Central and Northern European economies;

- contrarily to what has been observed for the TC, there is no definite relationship between levels of cement consumption and per capita income (graphs 4-6). As a matter of fact, the variability of the former results dramatically higher than that of the latter. Limiting our view to 2008, the large divergences in cement consumption between pairs of comparable countries in terms of population and income (e.g. UK and Spain, Holland and Ireland) are thus to be explained by a number of different factors that the GDP alone is not able to summarise.

5. Concluding Remarks

Despite our panel data constraints, the above analysis on the technical coefficient confirms what was already by and large known about its dynamics. However, it also allows us to add some remark about likely future trends.

Firstly, cement intensity is declining in most of the selected countries (in our panel in about 70% of cases). Among the mature economies, the exceptions are from countries where the past buoyant performance of construction investment is unlikely to be repeated in the same way and intensity. Outcomes for emerging countries are more controvercial, as most of them have been affected in the late '90s by downturns that have heavily impacted on their technical coefficients.

Secondly, gross domestic product has grown more robustly than cement consumption in over 70% of the selected countries. Referring only to developed economies, such percentage drops to 60%. However, it is worth recalling that the countries where cement consumption showed a better performance than GDP have also experienced exceptionally favourable construction cycles (Spain, Finland, Denmark, Australia and, to a lesser extent, Italy). As these cycles have ended, it seems likely that in the medium term their cement consumption patterns will come back in line with the average of the other industrialised countries (graph 30)[9].

Finally, the tests show that there is an inverse relationship between cement intensity and GDP per capita – i.e. at lower income levels we often find higher values of the technical coefficient. On the other hand, the correlation analysis does not identify a clear relationship between cement consumption and GDP per capita.

With respect to the industrialized countries, the above observations sketch out a fairly gloomy scenario on the evolution of the TC and of cement consumption over the medium term.

As a matter of fact, if we combine the underlying trends identified in this brief analysis with macroeconomic aspects that seem common to most mature countries (low income growth prospects, huge overbuilding in the housing sector, massive stock of

[9] See also our "Focus On": *"Cement Consumption in a Long-Term Perspective*", July 2009.

household debt, interest rates trending upwards, infrastructure investment constrained by perspective tighter fiscal policies, and low population growth rates) we end up inferring a negative impact on construction investment and, therefore, on cement consumption in the coming years.

On the other hand, and as far as the emerging countries are concerned, the picture is mixed but in general much more favourable (even though the lack of a wider set of information suggests a cautious approach). As a matter of fact, high GDP growth prospects coupled with the large possibility to boost countercyclical public investment, together with high growth rates of the younger population as well as with growing housing and infrastructure needs, make reasonable to conclude that cement consumption in this area will keep growing robustly for long time ahead even allowing for a perspective decline in technical coefficients.

Statistical Appendix

Table 1 - **Technical Coefficient**

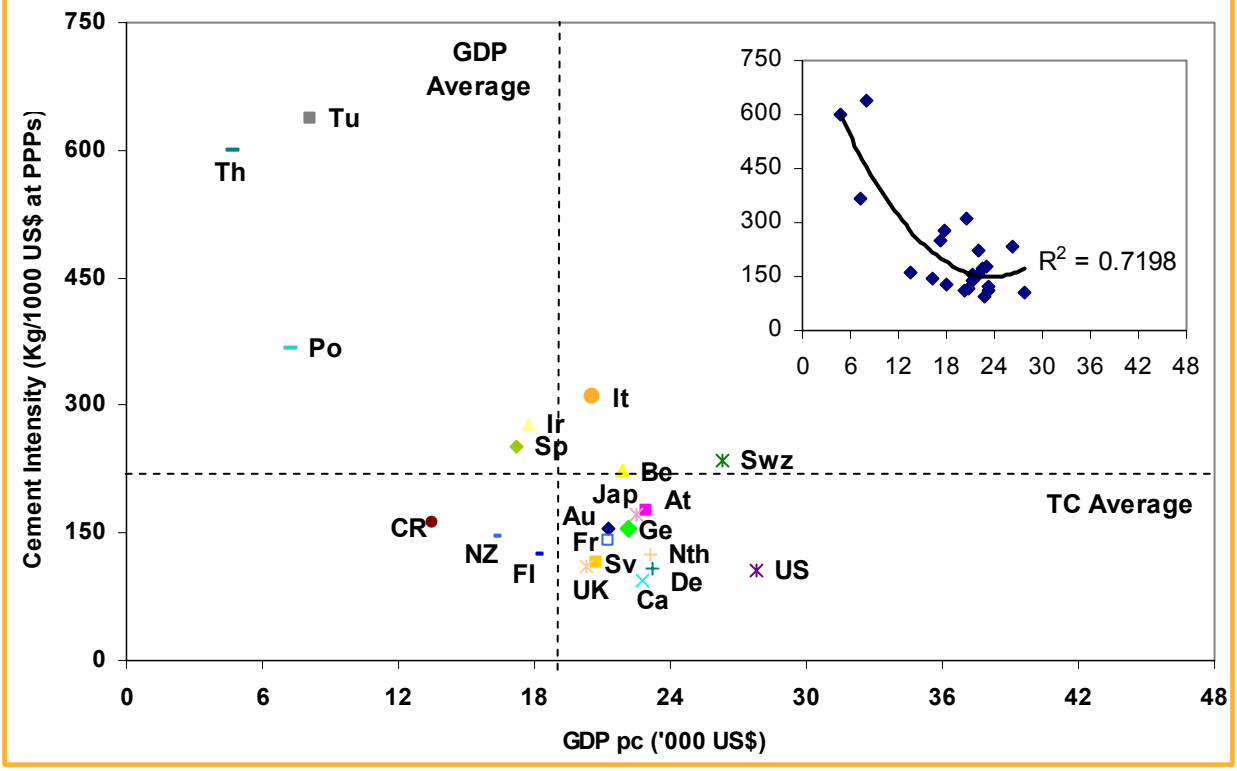
Country	Cement consumption per capita (kg/person)			GDP per-capita ('000 local currency)			Construction investment/GDP (%)			Cement consumption/ construction investment (kg/1000 unit of local currency)		
	1995	2000	2008	1995	2000	2008	1995	2000	2008	1995	2000	2008
Western Europe												
Austria	627	561	717	22.5	25.9	29.6	15.6	13.9	12.2	179	156	198
Belgium	568	597	563	24.6	27.8	30.9	11.7	10.5	10.7	198	205	171
Denmark	227	293	309	216	243	261	9.0	9.9	10.4	11.7	12.1	11.4
Finland	212	329	363	20.5	25.5	31.4	9.3	11.7	11.2	111	110	103
France	343	349	387	21.7	24.4	26.4	11.5	11.0	12.0	138	130	122
Germany	470	435	333	22.9	25.1	27.7	13.7	11.7	9.4	150	148	128
Greece	-	829	895	-	12.5	16.8	-	13.2	9.3	-	506	571
Irland	517	832	924	22.8	34.3	41.6	10.5	12.2	10.1	216	199	220
Italy	609	672	705	19.1	20.9	21.5	9.5	9.4	10.2	335	342	320
Netherlands	344	392	377	22.2	26.2	29.2	12.0	11.9	11.0	129	126	117
Spain	646	955	936	11.4	13.6	15.3	14.9	15.3	16.9	382	458	361
Sweden	170	173	274	216	253	297	7.1	6.0	6.9	11.1	11.4	13.3
Switzerland	614	540	633	54.0	58.7	67.3	9.9	7.8	7.4	114	118	128
UK	220	227	203	16.1	18.8	21.7	9.7	9.2	10.0	140	131	93.9
Eastern Europe												
Czech Rep.	381	353	501	205	214	294	17.3	12.7	11.6	10.8	13.0	14.8
Poland	276	373	448	14.8	19.4	27.0	10.4	13.1	12.4	179	147	134
Turkey	578	502	582	1.2	1.2	1.5	9.8	9.8	9.9	4,942	4,435	4,007
North America												
Canada	238	270	289	30.7	35.9	39.7	11.1	10.8	13.4	69.4	69.4	54.2
US	323	388	326	34.1	39.8	43.7	10.9	11.1	8.9	86.7	87.7	83.8
Oceania												
Australia	364	394	498	38.3	44.3	50.5	11.0	11.2	13.9	86.2	79.2	70.9
New Zeland	258	189	333	25.1	27.5	31.6	10.8	10.6	10.8	94.8	64.6	97.3
Asia												
Japan	635	570	439	3,824	3,967	4,359	16.4	13.4	9.7	1.0	1.1	1.0
Thailand	552	285	409	49.5	48.2	65.8	19.6	7.8	7.0	56.9	75.9	88.4

Table 2 - **Technical Coefficient (Index Number)**

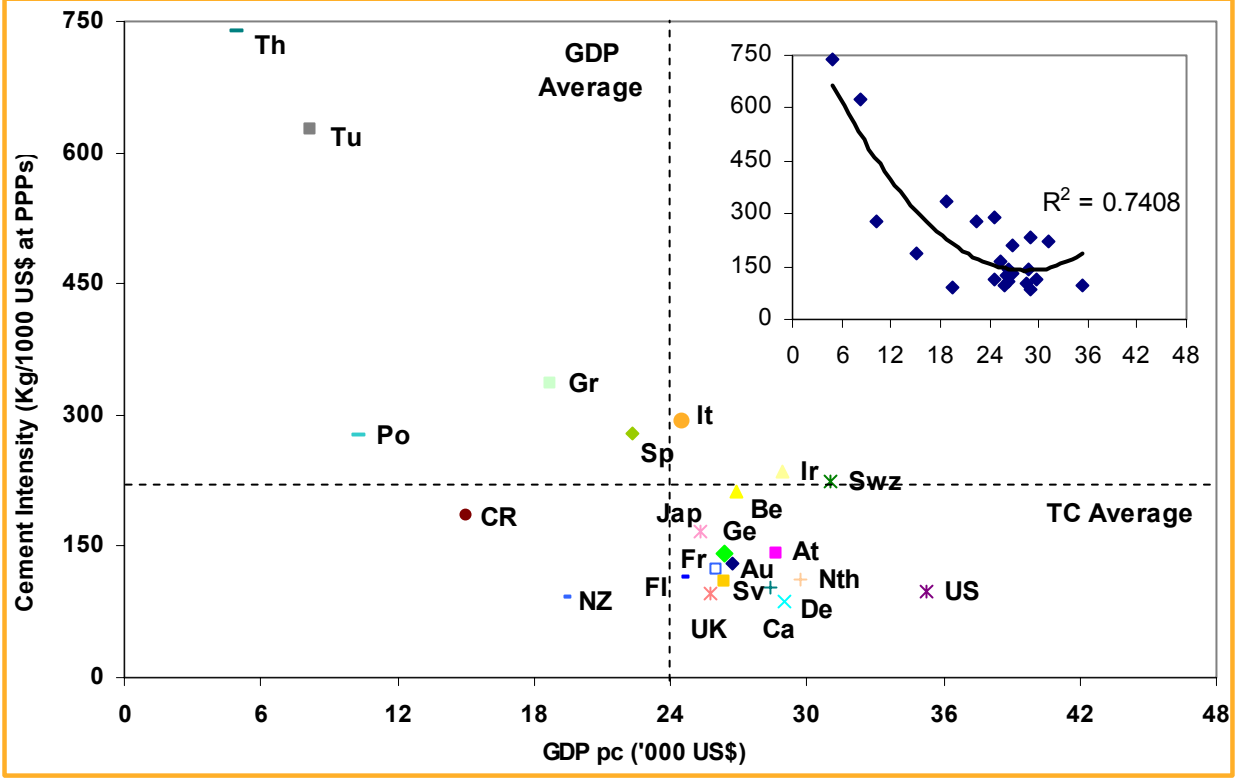
Country	Cement consumption per capita			GDP per-capita			Construction investment/GDP			Cement consumption/ construction investment		
Change*	**00/95**	**08/00**	**08/95**	**00/95**	**08/00**	**08/95**	**00/95**	**08/00**	**08/95**	**00/95**	**08/00**	**08/95**
Western Europe												
Austria	0.89	1.28	1.14	1.15	1.14	1.31	0.89	0.88	0.79	0.87	1.27	1.11
Belgium	1.05	0.94	0.99	1.13	1.11	1.25	0.90	1.02	0.92	1.04	0.83	0.86
Denmark	1.29	1.06	1.36	1.13	1.08	1.21	1.10	1.04	1.15	1.04	0.94	0.98
Finland	1.55	1.10	1.71	1.25	1.23	1.53	1.25	0.96	1.20	0.99	0.93	0.93
France	1.02	1.11	1.13	1.12	1.08	1.21	0.96	1.09	1.04	0.95	0.94	0.89
Germany	0.92	0.77	0.71	1.10	1.10	1.21	0.85	0.80	0.69	0.99	0.86	0.85
Greece	-	1.08	-	-	1.35	-	-	0.71	-	-	1.13	-
Irland	1.61	1.11	1.79	1.50	1.21	1.82	1.16	0.83	0.96	0.92	1.11	1.02
Italy	1.10	1.05	1.16	1.09	1.03	1.13	0.99	1.09	1.07	1.02	0.94	0.96
Netherlands	1.14	0.96	1.10	1.18	1.11	1.31	0.99	0.93	0.92	0.97	0.93	0.91
Spain	1.48	0.98	1.45	1.20	1.13	1.35	1.03	1.10	1.14	1.20	0.79	0.95
Sweden	1.01	1.58	1.61	1.17	1.17	1.37	0.84	1.15	0.97	1.03	1.17	1.20
Switzerland	0.88	1.17	1.03	1.09	1.15	1.25	0.78	0.94	0.74	1.03	1.08	1.12
UK	1.03	0.90	0.93	1.17	1.16	1.35	0.94	1.08	1.02	0.94	0.72	0.67
Eastern Europe												
Czech Rep.	0.93	1.42	1.32	1.04	1.37	1.43	0.73	0.91	0.67	1.21	1.14	1.37
Poland	1.35	1.20	1.62	1.31	1.40	1.82	1.27	0.94	1.19	0.82	0.91	0.75
Turkey	0.87	1.16	1.01	0.97	1.27	1.23	1.00	1.01	1.01	0.90	0.90	0.81
North America												
Canada	1.14	1.07	1.22	1.17	1.11	1.29	0.97	1.24	1.20	1.00	0.78	0.78
US	1.20	0.84	1.01	1.17	1.10	1.28	1.02	0.80	0.82	1.01	0.95	0.97
Oceania												
Australia	1.08	1.27	1.37	1.16	1.14	1.32	1.02	1.24	1.26	0.92	0.89	0.82
New Zeland	0.73	1.76	1.29	1.10	1.15	1.26	0.98	1.02	1.00	0.68	1.51	1.03
Asia												
Japan	0.90	0.77	0.69	1.04	1.10	1.14	0.82	0.72	0.59	1.06	0.97	1.03
Thailand	0.52	1.43	0.74	0.97	1.37	1.33	0.40	0.90	0.36	1.34	1.16	1.55

* 00/95= X_{2000}/X_{1995}; 08/00= X_{2008}/X_{2000}; 08/95= X_{2008}/X_{1995}

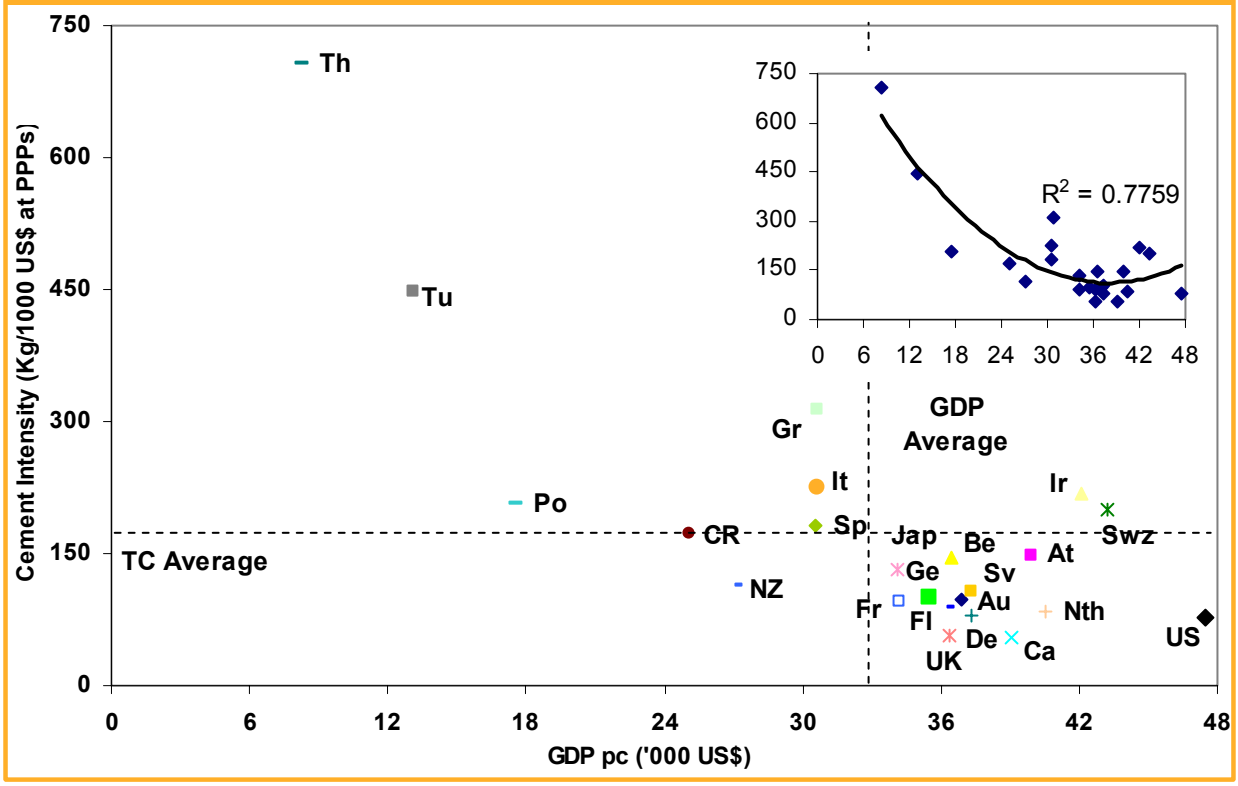
Graph 1 - **GDP pc at PPPs vs Cement Intensity - 1995**



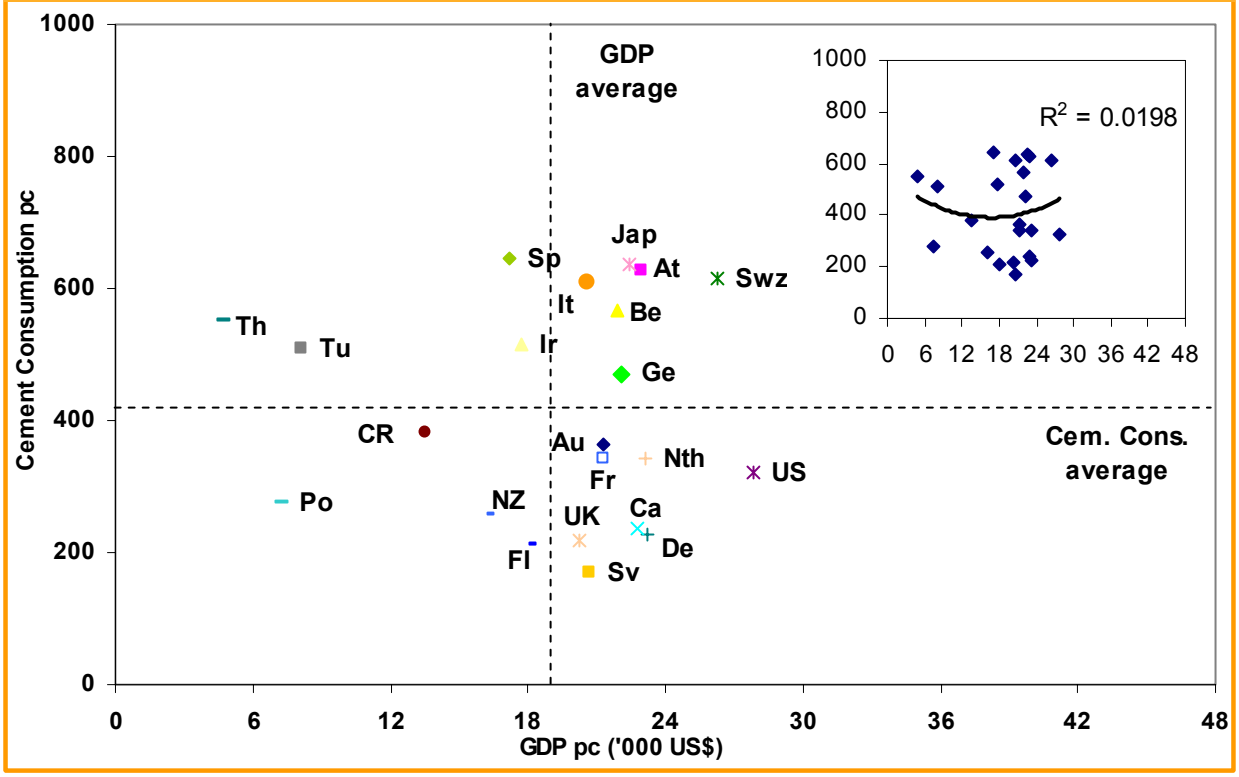
Graph 2 - **GDP pc at PPPs vs Cement Intensity - 2000**



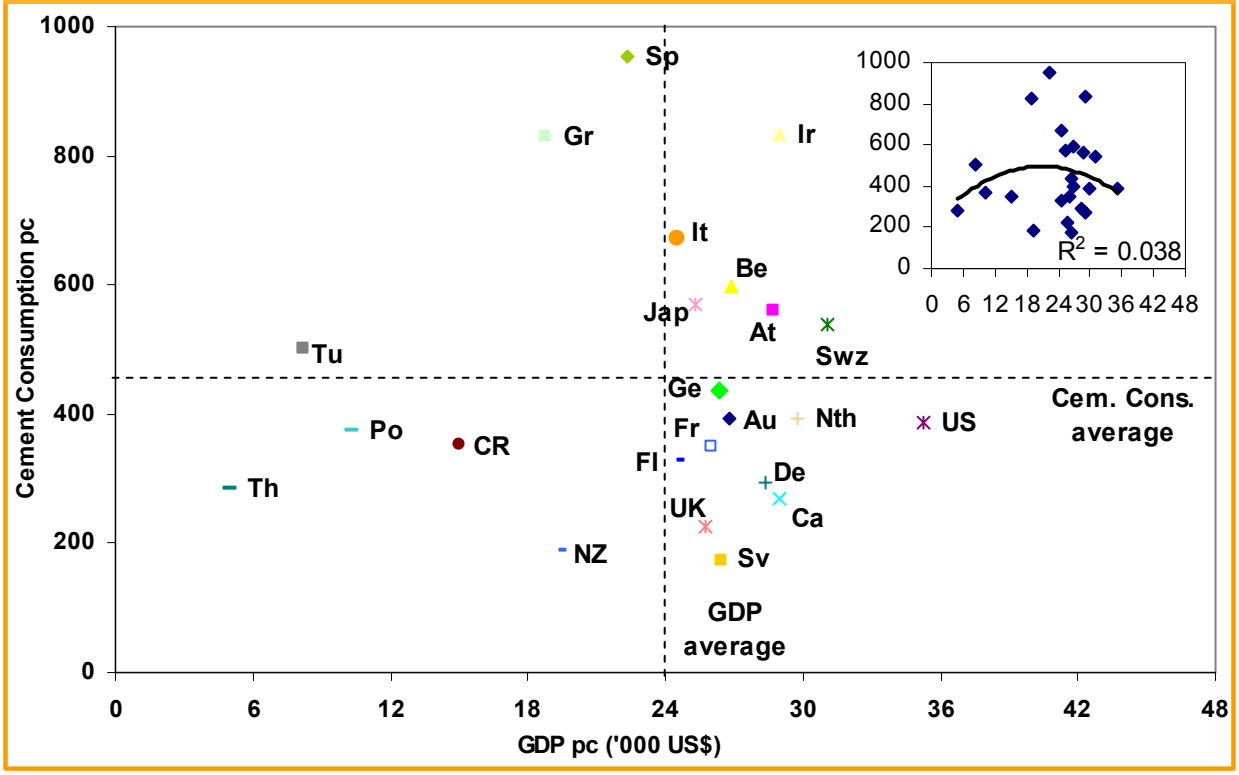
Graph 3 - **GDP pc at PPPs vs Cement Intensity - 2008**



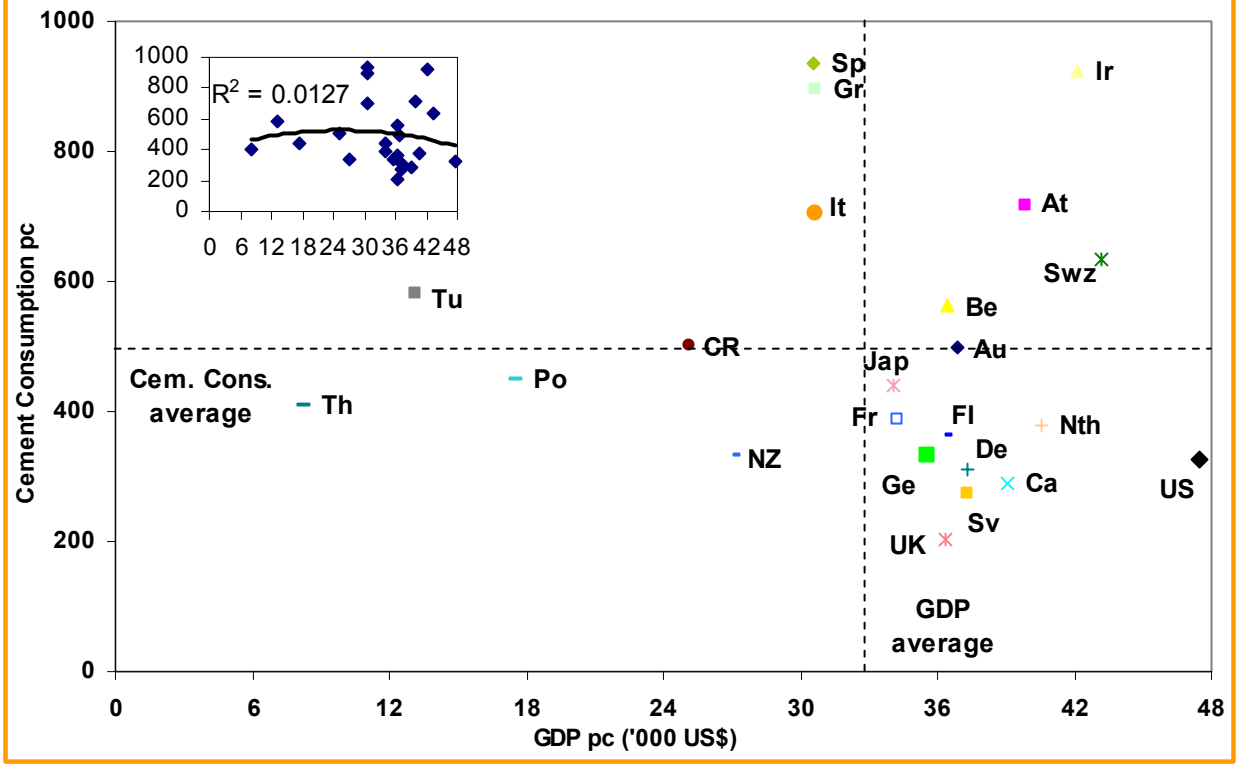
Graph 4 - **GDP pc at PPPs vs Cement Consumption pc - 1995**



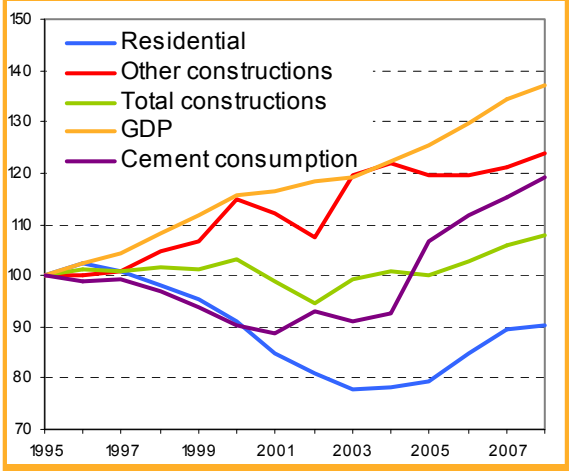
Graph 5 - **GDP pc at PPPs vs Cement Consumption pc - 2000**



Graph 6 - **GDP pc at PPPs vs Cement Consumption pc - 2008**

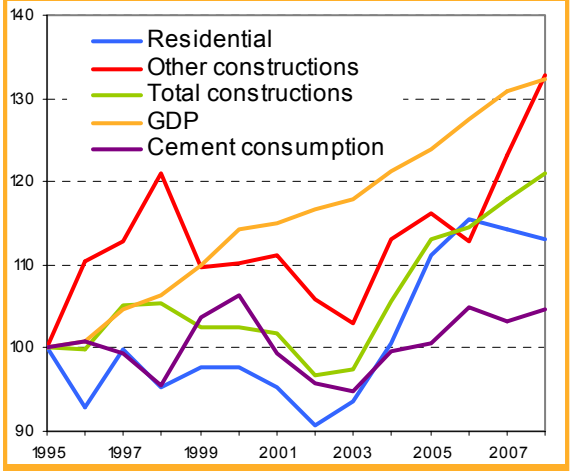


Graph 7 - **Austria** (index 1995=100)



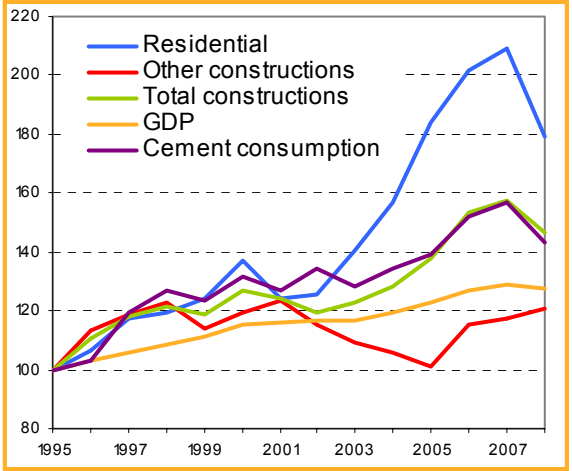
Source: OECD, QNA; yearly data

Graph 8 - **Belgium** (index 1995=100)



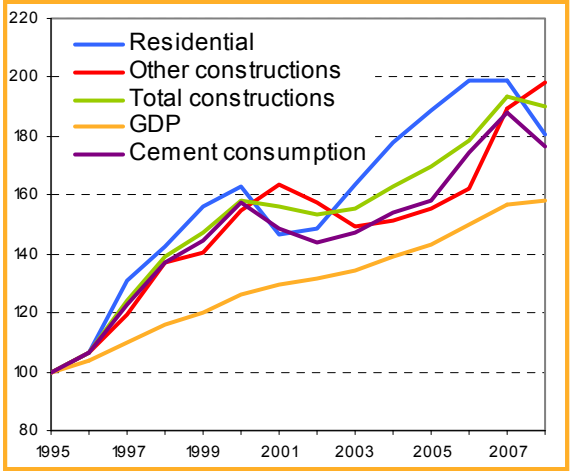
Source: national statistics; yearly data

Graph 9 - **Denmark** (index 1995=100)



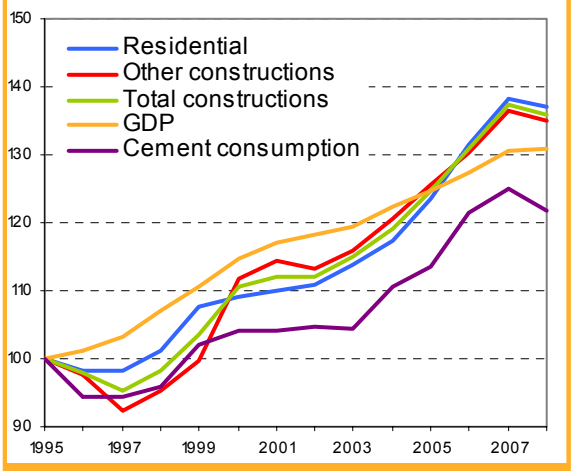
Source: OECD, QNA; yearly data

Graph 10 - **Finland** (index 1995=100)



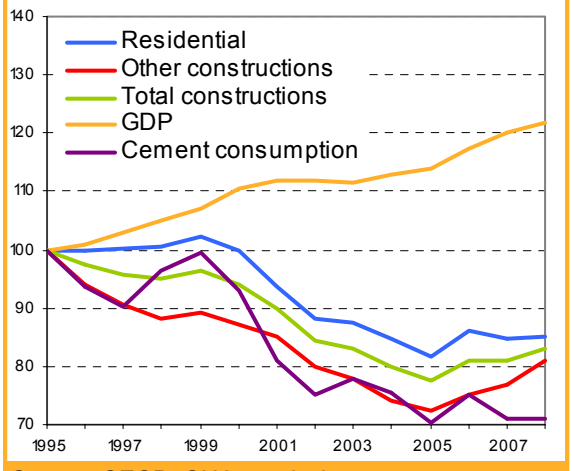
Source: OECD, QNA; yearly data

Graph 11 - **France** (index 1995=100)



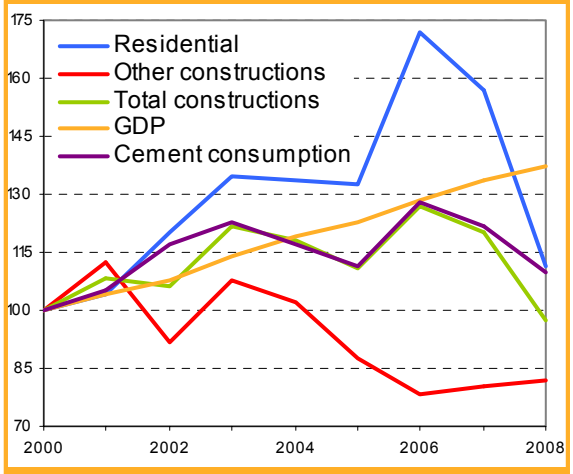
Sources: OECD, QNA, Eurostat; yearly data

Graph 12 - **Germany** (index 1995=100)



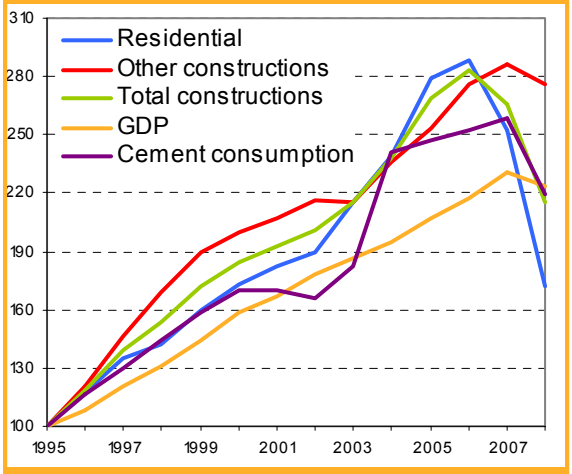
Source: OECD, QNA; yearly data

Graph 13 - **Greece** (index 2000=100)



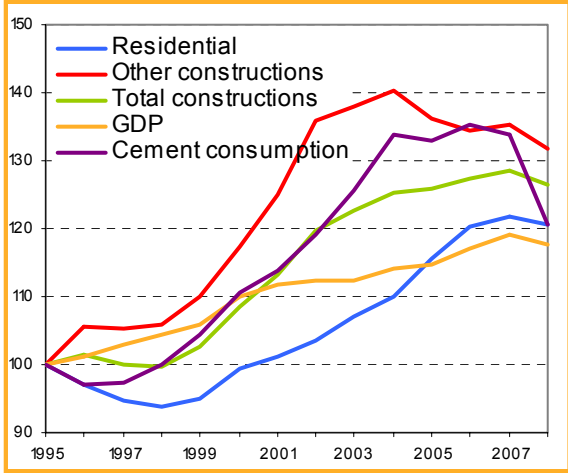
Source: OECD, QNA; yearly data

Graph 14 - **Ireland** (index 1995=100)



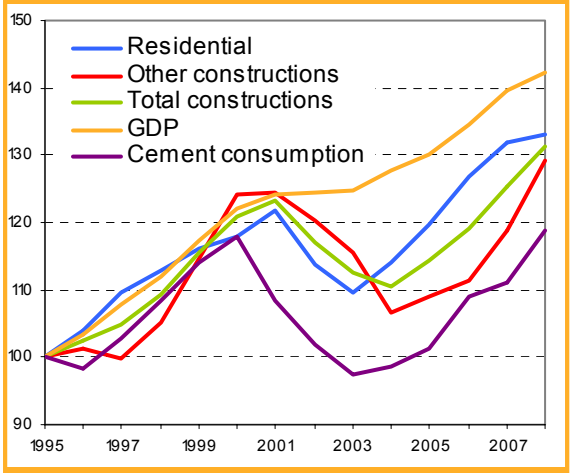
Source: Eurostat; yearly data

Graph 15 - **Italy** (index 1995=100)



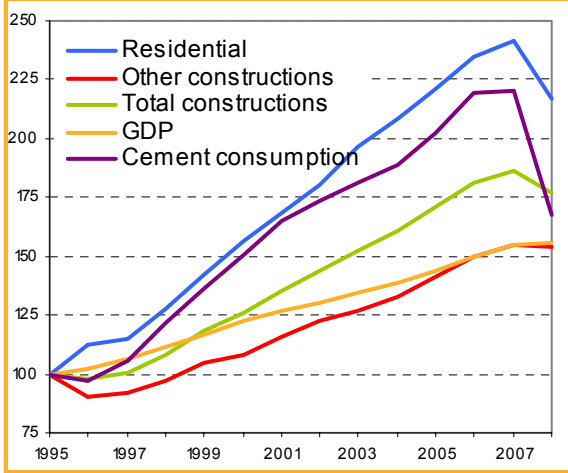
Source: OECD, QNA; yearly data

Graph 16 - **Netherlands** (index 1995=100)



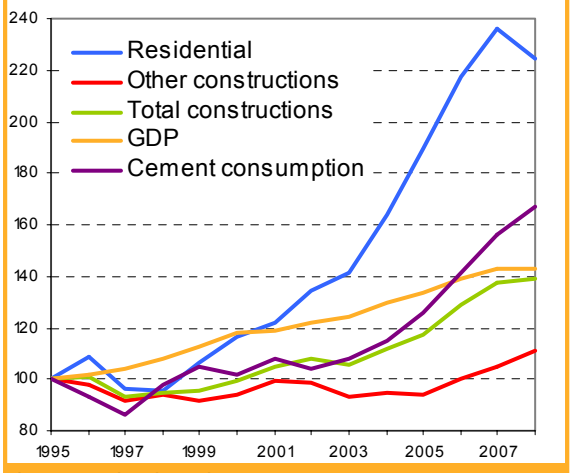
Source: Eurostat; yearly data

Graph 17 - **Spain** (index 1995=100)



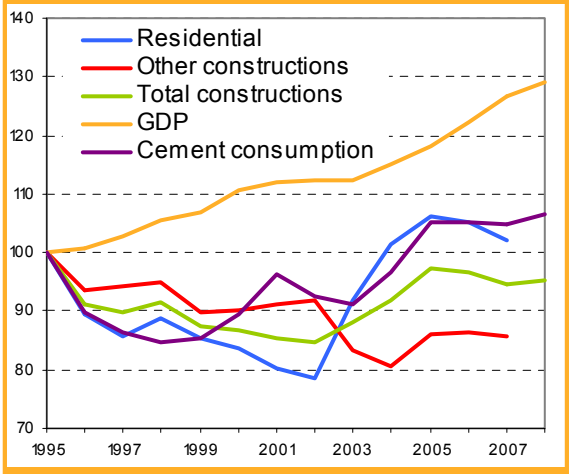
Source: OECD, QNA; yearly data

Graph 18 - **Sweden** (index 1995=100)



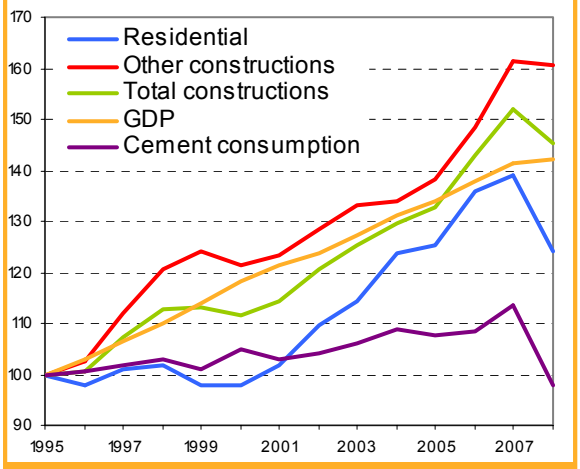
Source: OECD, QNA; yearly data

Graph 19 - **Switzerland** (index 1995=100)



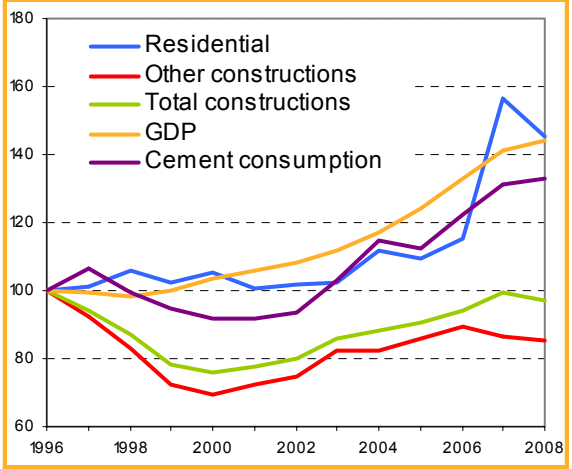
Source: Eurostat; yearly data

Graph 20 - **UK** (index 1995=100)



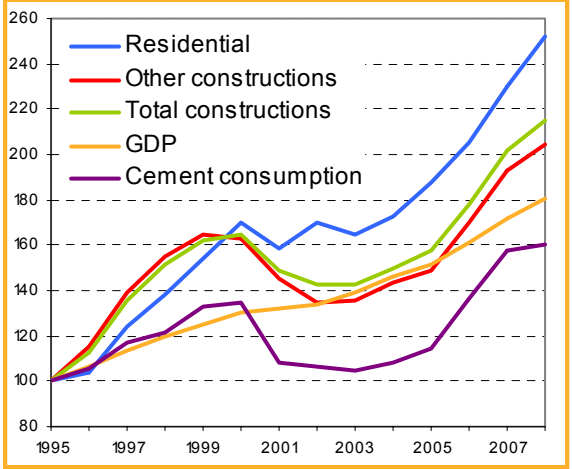
Source: OECD, QNA; yearly data

Graph 21 - **Czech Republic** (index 1996=100)



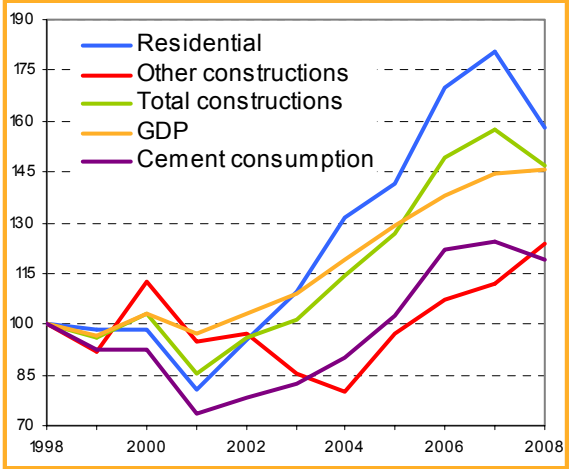
Source: OECD, QNA; yearly data

Graph 22 - **Poland** (index 1995=100)



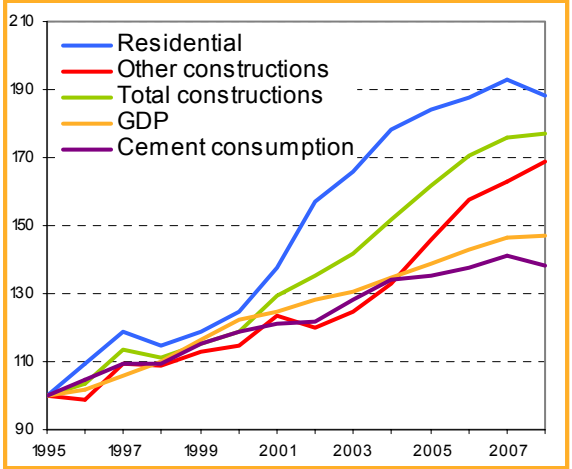
Source: Eurostat; yearly data

Graph 23 - **Turkey** (index 1998=100)



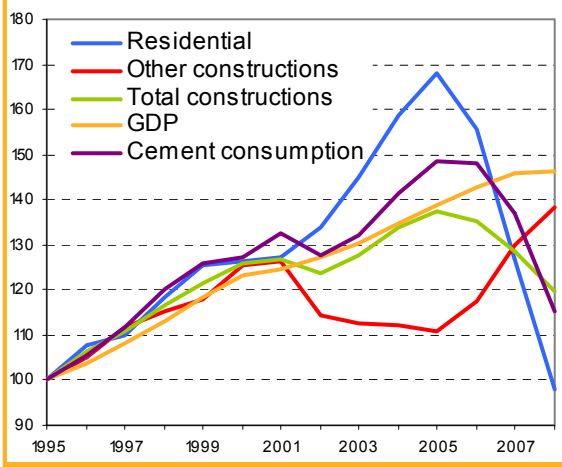
Source: national statistics; yearly data

Graph 24 - **Canada** (index 1995=100)



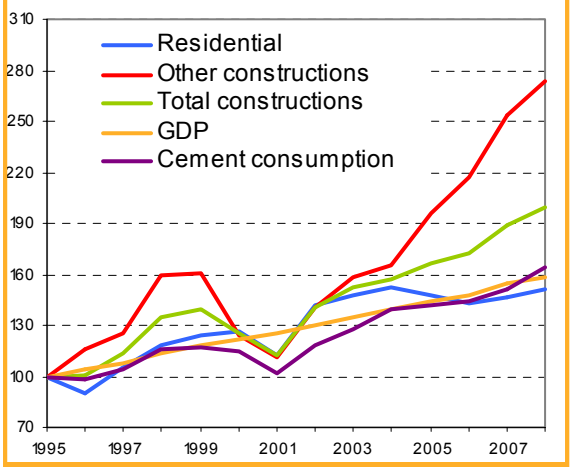
Source: OECD, QNA; yearly data

Graph 25 - **US** (index 1995=100)



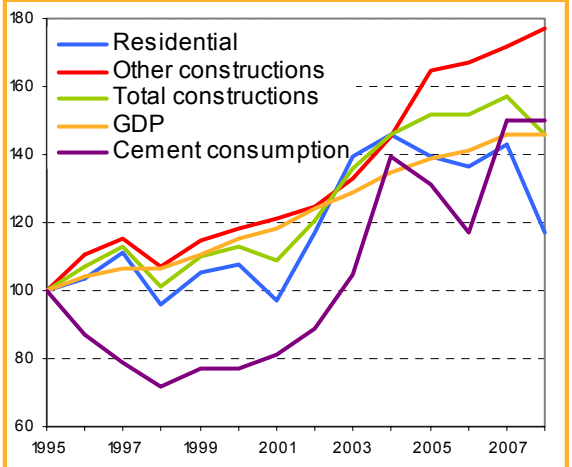
Source: OECD, QNA; yearly data

Graph 26 - **Australia** (index 1995=100)



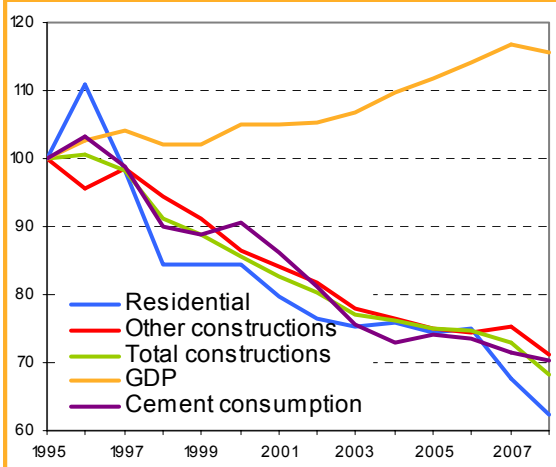
Source: OECD, QNA; yearly data

Graph 27 - **New Zeland** (index 1995=100)



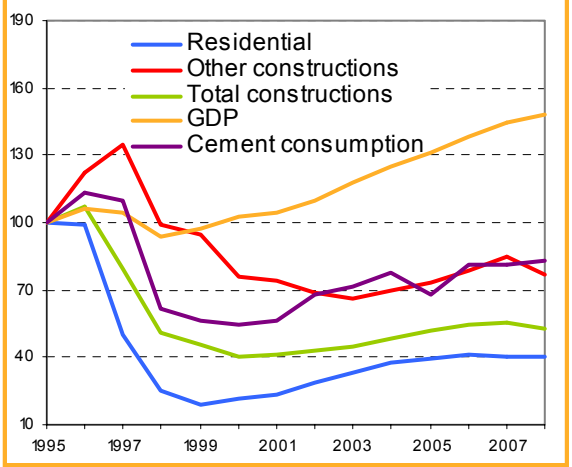
Source: OECD, QNA; yearly data

Graph 28 - **Japan** (index 1995=100)



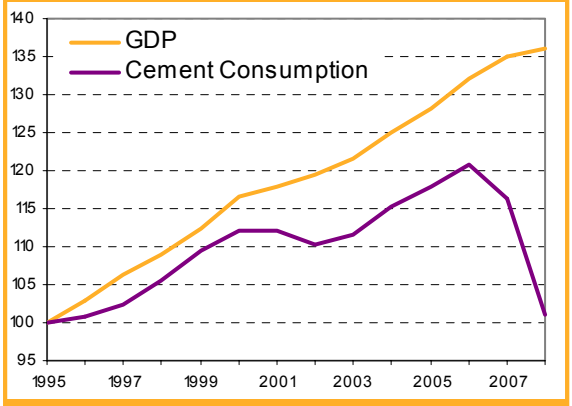
Source: OECD, QNA; yearly data

Graph 29 - **Thailand** (index 1995=100)



Source: national statistics; yearly data

Graph 30 - **GDP and Cement Consumption: EU15+US+Japan** (index 1995=100)



Sources: IMF, US Geological Survey, Cembureau, ICR; yearly data