

## **60. Sustainable construcción and materials in Andalusia.**

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### **Abstract**

In this paper, we describe the evolution of materials used in construction in Andalusia in the period 2007-2015 through analysis of the official databases, to assess sustainability. We study the envelope and exterior frames in residential and non-residential buildings and new buildings in general. We analyze housing according to their flooring and interior frame. We also analyze new buildings according to their envelope.

Wood is increasingly present in construction next to other materials such as stone and plastics. There is a tendency toward sustainability in Andalusia in terms of increased percentages of more sustainable material, especially in non-residential buildings.

Non-residential buildings have a greater presence of stone and less of continuous coating in external walls, and exterior carpentry shows a greater presence of wood (11% compared to 6%) and much less of aluminum (55% compared to 89%). The graphics indicate a turning point in 2014 that makes us wonder if this is a change of cycle.

The crisis in the construction sector has led to a greater sustainability that seems to be starting to get lost in the beginning of the recovery as it is evidenced in the promotion and increase of differences in 2014 and 2015.

### **Keywords**

Construction, Sustainable, Materials, Andalusia

## 1 Introduction

In the international scientific conference on climate change (Our Common Future Under Climate Change, UNESCO, Paris, July 2015) we have observed studies linking various sectors of the world economy and its environmental impact. From this approach we believe that construction in general should also be studied and analyzed in terms of this relationship and possible impact. "No other industry in the United States uses more material by weight than the construction industry" (Horvath 2004).

Efficiency and environment integrated in construction are a reality found in programs such as Leadership in Energy and Environmental Design (LEED) included in the US Green Building Council (USGBC), which is one example among many of Civil Engineering respectful with the environment.

In this line we have made our study, taking into account the publications of the Ministry of Development (2007-2015), Government of Spain, construction of buildings, Statistics and Economic Studies.

A baseline study was published in the United Kingdom in 2008, "Strategy for sustainable construction" as a guide for sustainable construction where it appears a chapter dedicated to materials, indicating among the general objectives that the materials used in construction industry have the lowest social and environmental impact since it is feasible economically and socially. In its introduction makes a call of attention to the coordination and wisdom in the construction since the sustainability.

In this paper, we describe the evolution of materials used in construction in Andalusia in the period 2007-2015 through analysis of the most significant aspects according to official databases to assess the use of sustainable materials and its trend. We studied the envelope and exterior frames in residential and non-residential buildings and new buildings in general (ceramic, stony, continuous coating and others). We analyze housing according to their flooring (ceramic, stony, wood and others) and interior frames (wood and others) and in case of new buildings according to their envelope. Each study is developed on a regional focus.

We make a comparison between residential and non-residential use. The study is carried out by entering in a worksheet the values of Andalusia and provinces, in paragraphs referred to in the introduction. Have developed different graphics that allow us to obtain an objective information and its valuation.

We obtained this data from the web page of the Ministry of Development, Statistics (2007-2015), Government of Spain. Construction of buildings, Economic Studies and Statistics.

Data has been loaded into spreadsheets for the obtaining of different types of graphics and meaning the results, which has enabled us to establish some conclusions.

The data for the study have been obtained from the questionnaire that the promoters or technicians responsible of a project must deliver in the corresponding town or city Council when someone applies for the license of major work for the construction, rehabilitation or demolition of buildings. Its fulfillment is compulsory in accordance with the law 4/190.

We take into account that any major work to perform accurate picture of the corresponding license of municipal works. This is a process that provides important information to the knowledge of the number and characteristics of the buildings and dwellings generated. Lets us know the buildings in new plant, the rehabilitation and the demolitions.

Excluded those works in which the municipalities do not require the technical project together with the license application.

Wood is a sustainable material to require fewer than 1000 kWh to produce a tonne of finished material, while the concrete is less sustainable to require approximately 2000 kWh. Far from the sustainability are steel (< 5000 kWh) and the aluminum (>20,000 kWh).

If we add the possibilities for recycling and sanitation, wood is clearly highlighted as one of the most sustainable material going beyond its physical characteristics:

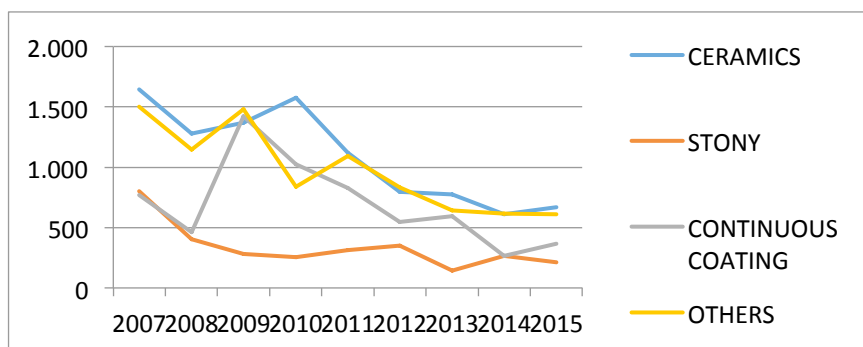
“Since wood has more diverse environmental characteristics than other common building materials such as concrete and steel, it would be important to consider a specific approach and use for wood in construction based upon the proper understanding of their characteristics as learnt from traditional buildings.” (Takano, 2015).

The second group of more sustainable materials are the stone, that have a lower environmental impact with regard to the derivatives of the cement and metals

Further away in the sustainability are steels and finally the aluminum. In order to weigh the values of the different types of materials used we have created a table using as a basis the environmental impact of the main construction materials according to their life cycle analysis of Ministry of Environment, to which we have added the cement as a contribution.

## 2 Buildings according to typology, non-residential use. Closings and exterior carpentry

In enclosures and from the statistical data obtained from the Ministry of Development, is performed a classification into four groups: ceramic, stony, continuous coating and others. From the point of view of sustainability, stony materials are the most appropriate.



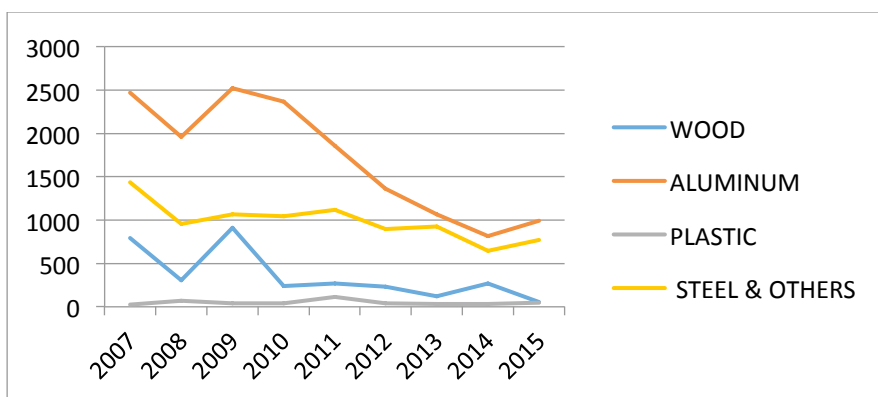
**Fig.1** Number of buildings under construction typology, Andalusia. Non-residential use. External enclosure.

The graph shows a downward trend in general due to the situation of the construction. The graph shows a downward trend in general due to the situation of the construction. The ceramic enclosure predominates in general and stony is more stable, relatively, tending all matched in recent years. In 2014 the stony arrived to equalize in percentage to continuous coating. We note that in 2015 there was a slight recovery in ceramic and continuous coating. In the horizontal axis represents the years for which data are available, and in the vertical axis represents the number of licenses of work granted by typology indicated.

It is interesting to note the proportion in percentages between stone materials and continuous coating. It notes the decrease in continuous coating on stony and rest in recent years.

In exterior carpentry and from the statistical data obtained from the Ministry of Development, is performed a classification into four groups: wood, aluminum, plastic and steel plate and others. From the point of view of sustainability, wood is a reference.

The graph in Figure 2 shows a downward trend in general. The aluminum carpentry predominates in general and the plastic is kept relatively, tending all matched in recent years. We note that in 2014, there was a slight recovery in wood. In 2015 slight recovery in aluminum and steel plate and other and sharp decline in wood. Stresses that plastic is increasing in percentage over the years, although since the sustainability may be arguably its benefit because construction involves the use of thermostable for those who still are not implemented recycling respect to thermoplastics.

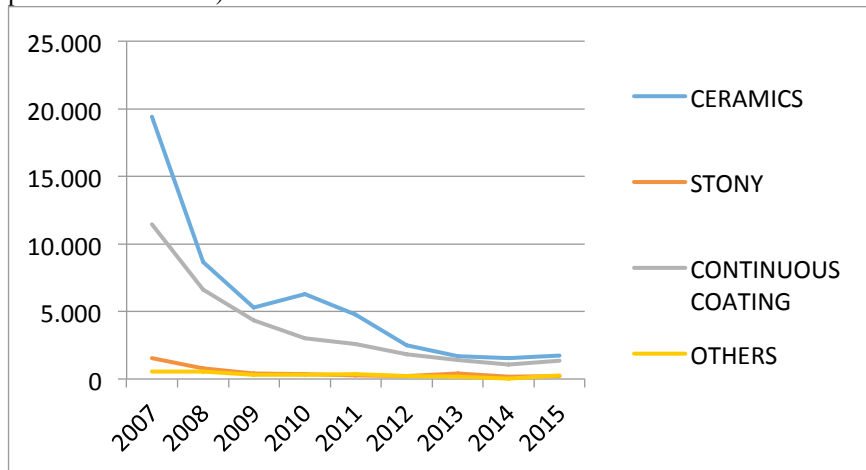


**Fig.2** Number of buildings under construction typology, Andalusia. Non-residential use. Exterior Carpentry.

In exterior carpentry, aluminum predominates being increasingly important the presence of wood (20% in 2014) and plastics (7% in 2011). At the national level the results are similar to those of Andalusia, in external enclosure, being in Andalusia slightly higher percentages of ceramic and stony, respect of continuous coating and others. Years 2007, 2010 and 2014: Andalusia stone % 17, 7, 15 Spain stone %: 14, 10, 12. Ceramic Andalusia % 35, 43, 35. Ceramic Spain%: 24, 34, 30.

### 3 Buildings of new plant, according to type. Residential use. Closings and exterior carpentry

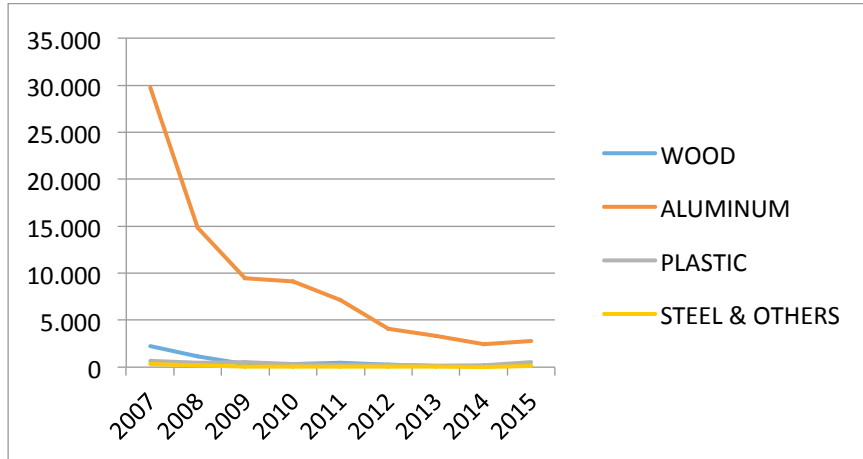
In exterior enclosure the graphs of buildings in new plant in general have similar characteristics to those of residential use since non-residential are a minority (< 10 per cent of the total).



**Fig.3** Number of buildings under construction typology, Andalusia. Residential use. External enclosure

The graph shows a downward trend in general due to the situation of the construction. The ceramic enclosure predominates in general and the stony is more stable. The percentage of stone materials is low and the continuous coating is high in non-residential use. Buildings of non-residential use are slightly more sustainable in terms of the external enclosure with respect to the buildings of new plant in residential use.

In exterior carpentry is performed a classification into four groups: wood, aluminum, plastic and steel plate and others.



**Fig.4** Number of buildings according to typology, residential use, Andalusia. Exterior Carpentry. The graph shows a downward trend. Aluminum carpentry predominates in general and plastics is kept relatively, tending all matched in recent years. Aluminum highlights on the rest and more significantly than in non-residential use. In 2014, there was a slight recovery in plastics. Stresses that plastics are still increasing in percentage over the years with a second maximum in 2015. Important decrease of wood in 2015.

In exterior carpentry and level interprovincial emphasizes the use of wood and aluminum in the provinces of Malaga and Granada (although not as much as in non-residential use). In exterior stony enclosure highlights Seville. In ceramic highlight Malaga and Granada.

#### **4 Buildings of new plant, according to type. Closings and exterior carpentry**

In enclosures is performed a classification into four groups: ceramic, stony, continuous coating and others. From the point of view of sustainability, stony materials are the most appropriate.

Graphics of enclosure and exterior carpentry are similar to those of residential buildings to be these more numerous than non-residential.

Graphs shows a downward trend in general due to the situation of the construction. Ceramic enclosure predominates in general, while relatively, stony is more stable, tending all to match in recent years.

In exterior carpentry is performed a classification into four groups: wood, aluminum, plastic and steel plate and others. The graph shows a downward trend. Alu-

minum carpentry predominates in general and plastics is kept relatively, tending all to match in recent years. There was a slight recovery in wood and plastics in 2014.

Stress that plastic is still increasing in percentage over the years with a second maximum in 2015 and a significant decline in wood in 2015.

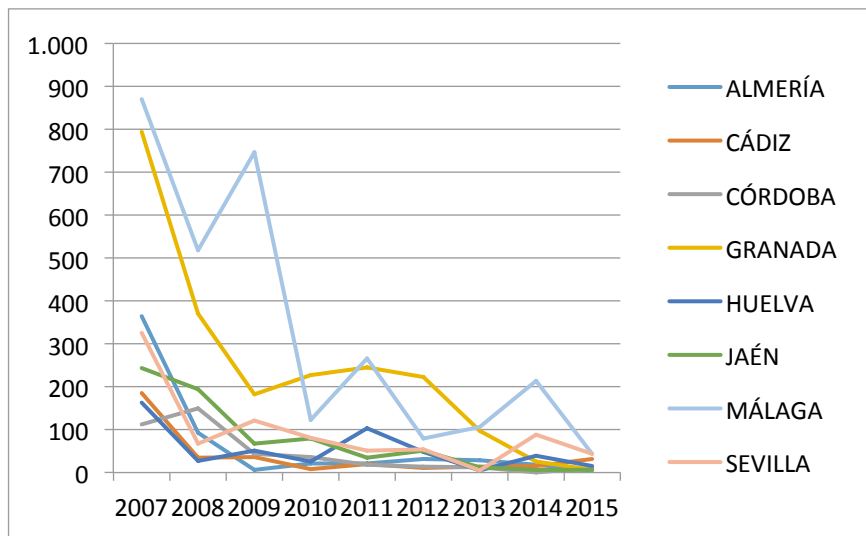


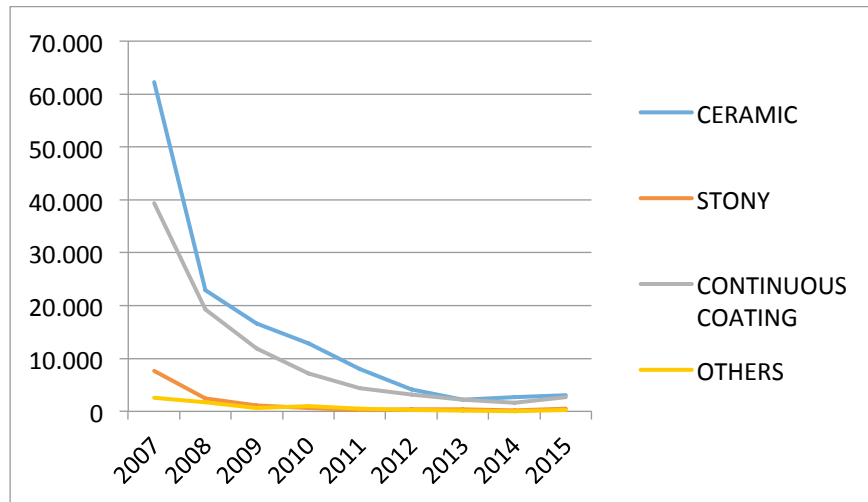
Fig.5 Number of buildings under construction typology and provinces. Exterior Carpentry (Wood)

In exterior carpentry emphasizes the use of wood in the provinces of Malaga and Granada. In Malaga highlights the ceramic external enclosure. In exterior carpentry, aluminum predominates being increasingly important the presence of wood.

### 5 Housing in buildings of new plant, according to type. External enclosure

In enclosures and from the statistical data obtained from the Ministry of Development, it has been performed a classification into four groups: ceramic, stony, continuous coating and others.





**Fig.6** Number of dwellings in buildings according to typology, Andalusia. External enclosure.

Downward trend in general and slight recovery in 2015. Ceramics predominates in general, even increase, and stony decreases relatively, tending all to match in recent years. In 2013 continuous coating is slightly higher than ceramics.

The percentage of ceramic material is increasing over the years and descend the stony. At this point residential buildings are slightly away of sustainability. Granada highlights in stony enclosure especially in 2007. Seville has a certain presence and regularity.

In the province of Malaga highlights the external ceramic enclosure and increases the continuous coating in recent years. Slight recovery in 2014 in stony. In general lines appears a slight recovery in 2015 which leads us to wonder whether this is an end of cycle and therefore a stage of growth.

## 6 Housing according to interior finish. Pavement and interior carpentry

In pavement or flooring and on the basis of the statistical data obtained from the Ministry of Development it performs a classification into four groups: ceramic, stony, wood and others. Wood increases in percentage in recent years although ceramic flooring predominates in general. They tend to be equal in recent years. Slight growth in ceramics in 2015 which suggest an end of cycle.

Ceramic flooring predominates and is constant in percentage. Wooden floors have a rebound maximum percentage in 2014, which is about to sustainability. Stony flooring decreases slightly. Interior carpentry and from the statistical data ob-

tained from the Ministry of Development, is performed a classification into two groups: wood and others. There is a downward trend in general.

Wood is the great protagonist, although there was a slight decline in percentage. Emphasizes the use of wood in the province of Granada.

## 7 Comparison between residential and non-residential uses

The number of buildings of residential use is much higher than that of non-residential use in enclosures. In the total percentage we observe a 77% compared to a 23%.

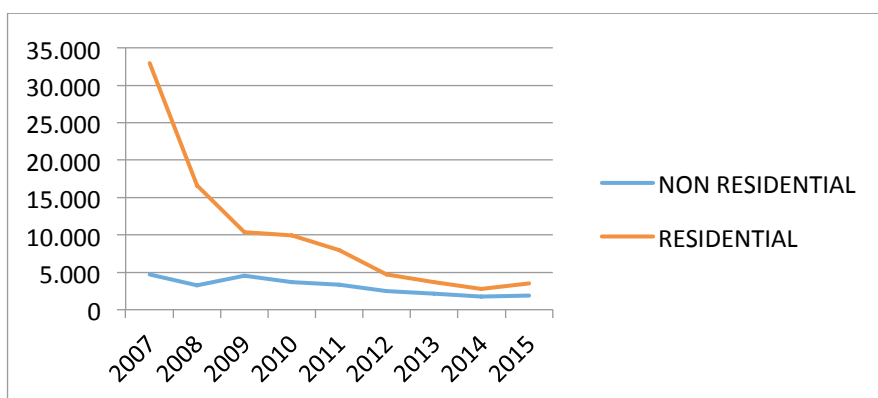
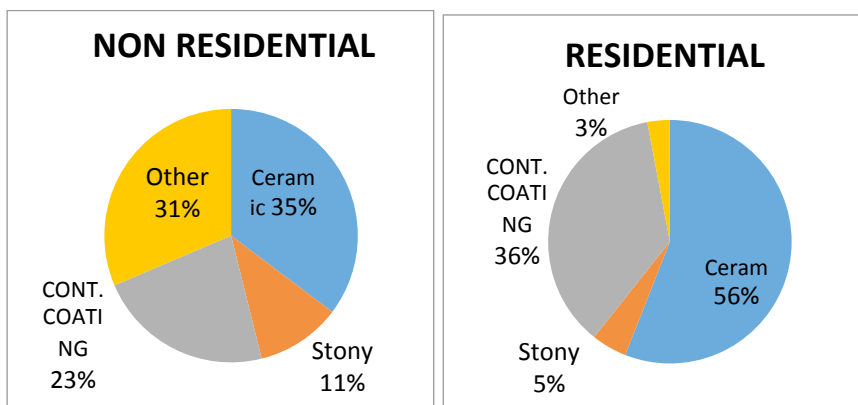


Fig.7 Buildings according to typology, external enclosure, totals (Andalusia 2007-2015)

It is significant that the difference of relative percentage is decreasing over the years taking its closest approach in 2014, seeming to have a turning point in this year that could be indicative of a process of slight recovery or cycle start ascending as seemed to indicate in other graphics view above.

The fall in non-residential is more moderate probably due to the support of the construction with purposes or public investment. In 2015 there was a greater increase in residential. With regard to the comparative percentage by groups, we observed a greater presence of sustainable materials in non-residential coming to duplicate in stony (11% compared to 5%) and very significantly in others (31% compared to 3%), being remarkable the lower use of continuous coating (23% compared to 36%). Continuous Coating (CONT. COATING).



**Fig.8** Buildings, exterior enclosure comparative, totals % (Andalusia 2007-2015)

The exterior enclosure has a greater presence of ceramic expected in residential (84% compared to a 16% in non-residential) when compared with the general data (77% compared to a 23%). The difference in relative percentage is similar in ceramic and in totals, decreasing over the years and seems to have a turning point in 2014.

In recent years (2013-15), ceramic enclosure in Andalusia, differences diminish and kept the percentages between non-residential and residential. Stony enclosure has a smaller presence of the expected in residential (59% in residential with respect to a 41% in non-residential) when compared with the general data (77% compared to a 23%).

Most significant is the presence of stone in non-residential because in spite of having a lower volume in total (41% compared to a 59%), however there are periods where even the non-residential outweigh the residential (2011, 2012 and 2014). The difference in relative percentage is similar in stone, ceramic and in totals, decreasing over the years and even reversing in the years in question.

Continuous coating enclosure has a greater presence in residential use and curiously maintains the same rates as in ceramics (84% residential respect to a 16% non-residential). The difference in relative percentage is similar in continuous coating, stony, ceramic and in totals, decreasing over the years.

The group "Others", in exterior enclosure, has a greater presence in non-residential use (76% residential respect to a 24% residential). In exterior carpentry the number of buildings of residential use is much higher than that of non-residential use (77% compared to a 23%).

With regard to the comparative percentage by groups we observed a greater presence of sustainable materials in non-residential almost doubling in wood (11% compared to 6%) and very significantly in steel and others (32% compared to 1%), being remarkable the lower use of aluminum (55% compared to 89%). Highlights the increased use of plastics in residential (4% to 2%).

In exterior joinery timber, highlighted in percentage by volume the residential use in respect of non-residential (84%-16%), however, it is observed that the trend is to decrease the difference in the period 2007-15.

In exterior carpentry aluminum, also highlights in percentage by volume the residential use in respect of non-residential (84%-16%), it is also noted that the trend is to decrease the difference in the period 2007-15. The graphics are similar to those of wood. In exterior joinery plastic, highlighted in percentage by volume the residential use in respect of non-residential (89%-11%), it is also noted that the trend is to increase significantly in the last years of the period 2007-2015.

## 8 Conclusions

Wood is increasingly present in construction next to other materials such as stony and plastics . There is a trend toward sustainability in the use of materials in the construction in Andalusia, more present in some types of buildings that in others (non-residential use). In the period 2007-2015 there is a tendency to sustainability in terms of increased percentages of materials more sustainable. Non-residential buildings are more sustainable than the residential because in enclosures have greater presence of stony and less of continuous coating (less sustainable). In addition, there is a great presence of wood (11% compared to 6%) and much less of aluminum (55% compared to 89%) regarding exterior carpentry.

Some years, residential buildings have fallen far in the graphs of sustainability from non-residentials, which leads us to think of solutions such as government taxes for those buildings less sustainable. Graphics indicate a turning point in 2014 that leads us to wonder whether it is a change of cycle and if construction will repeat the same mistakes as it can be seen that the separation of graphics of sustainability begins to increase (we should observe the coming years to confirm those next cycles). The crisis in the construction sector has led to a greater sustainability that seems to be starting to get lost in the beginning of the recovery as checked in the rise in 2014 and 2015.

We shall now proceed to continue the study with regard to the renewable energy installed in this period as well as the rehabilitation of buildings that guide us to confirm these trends and conclusions.

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