P5 REPORT

Pietro Rovelli – 4508270

Msc Real Estate & Housing

6/2017

Student: Pietro Rovelli
4508270
Address: Noorderbeekdwarsstraat 186, 2562 XX, Den Haag
Phone: 0626442131
E-mail address: pietro.rovelli91@gmail.com

First Mentor: Ilir Nase
Real Estate Management
Second Mentor: Peter deJong
Design and Construction Management
External commissioner: Lidy Meijers
Building Technology

MBE Graduation Laboratory: Structural changes in the use pattern of offices

Title of the research: Differences in global economic development and skyscrapers development. A quantitative investigation of the relationship between skyscrapers and the economic cycle.

Date: July, 2017

Executive summary

This research aims at discovering which economic factors influence skyscrapers development around the world, and if there are notable differences between different countries. Buildings taller than 200 meters have been built since 1909, and since then, over 1500 have been built. Their development has followed unique trends in different areas of the world, with sudden surges followed by down periods. The property industry is a supplier of capital goods, so demand for property is inevitably linked to the demand for investment goods in the economy as a whole. It supplies space and is affected by the economic factors that cause more or less demand. From a global perspective, we can expect skyscrapers development to follow finance to some degree, especially by clustering most projects in locations with high accessibility and low cost of capital, targeted by foreign investment and with positive expectations of financial growth. The symbolism of tall buildings has stimulated height competitions throughout the world, while their iconicity has attracted different kind of users. New technologies have allowed to reach new heights as well as making prohibitive applications feasible through research and development. As time evolves, new systems and applications are made available to reach height easier and cheaper.

Over 70% of the world supply of skyscrapers have been built in the past 10 years, in an ever-growing pattern. In previous research, it has been suggested that there is a strong interrelationship between business cycles and skyscrapers development, yet this has never been measured at global level. This is the gap in existing knowledge this research addresses. The graph in figure 1 highlights the magnitude of growth in supertalls' construction.

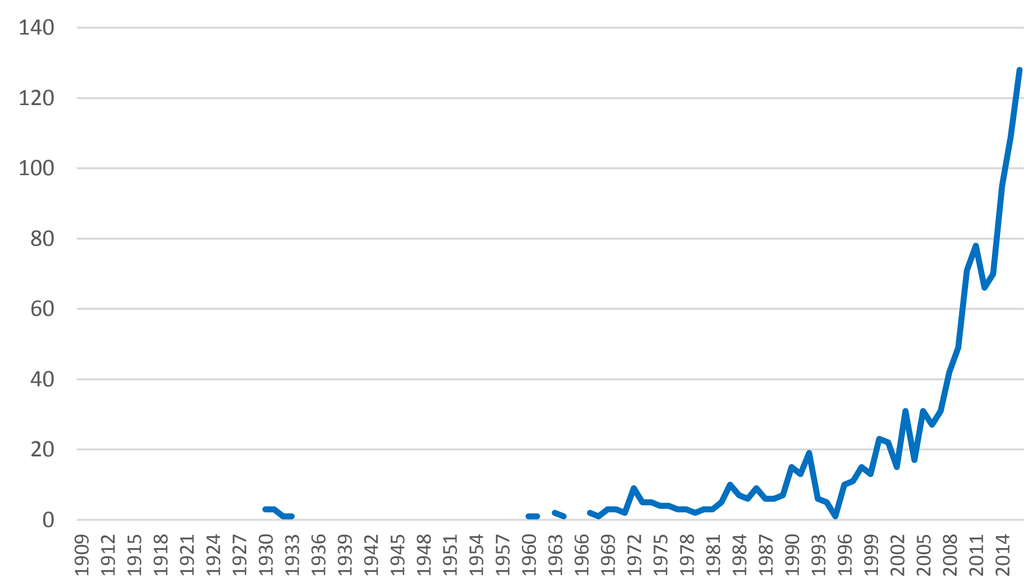


Figure 1: number of projects completed per year (1909-2016).

Problem Statement

The study of existing theory on the topic of skyscrapers development has highlighted the lack of a comprehensive, holistic view on the global phenomena. Previous studies tend to focus on one location, delimiting their research to a specific context. These approaches miss the unique interplay of demand and supply of skyscrapers at different scales, which leads to a specific geographical distribution of this typology worldwide. The specific gap in knowledge this research addresses is that of the relationship between economic development and skyscrapers construction.

Research Questions

To what extent are national, regional and international economic cycles correlated to skyscrapers' construction?

How are projects distributed globally, regionally and nationally?

To what extent does Vanity Height influence projects' height?

To what extent are specific functions employed? How are they distributed?

To what extent are specific materials employed in skyscrapers' construction?

To what extent do construction costs influence skyscrapers' construction?

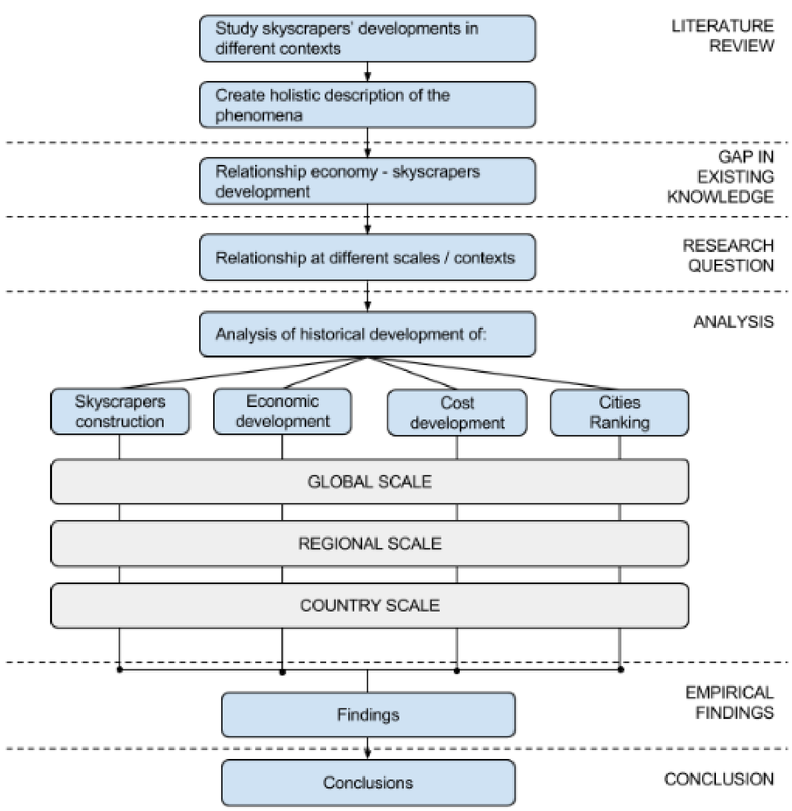


Figure 2: flowchart of research process

Methodology

This research is based on quantitative analysis of secondary data. The scope is global, to have a complete view of the phenomenon. To carry out analysis, data was collected, specifically regarding skyscrapers' construction, economic development, construction costs and global cities rank. In order to measure the developments, different indicators describing their evolutions were selected. Skyscrapers' construction is tracked through the collection of a time series regarding all projects ever completed. For each project, relevant characteristics are tracked, describing the buildings' physical and construction qualities, location, and function. The data regarding skyscrapers was acquired through the Council of Tall Buildings and the Urban Habitat (CTBUH). The business cycles are measured through several economic indicators acquired through World Bank databases. Global cities are measured through global cities rankings. Global city rankings are produced by the Globalization and World City department of the University of Loughborough (GaWC). The changes in costs of construction are tracked through residential and office cost reports produced by Turner and Townsend.

The analytical process is carried out with two methods. Data is analyzed statistically with Excel and SPSS software and represented graphically with Quantum GIS software. The database created allows statistical analysis and graphs, which are integrated in visualizations on the world map. Both processes are carried out at the same time, as one informs and guides the other. The scales employed to analyze are three. Global analysis is carried out over the total portfolio of existing projects. Regional analysis is carried out over six regions: East Asia and Pacific; Europe and Central Asia; Latin America and Caribbean; Middle East and North Africa; North America; South Asia. Analysis is carried out at country scale for specific countries: those having currently completed at least 30 projects. Currently, 12 countries qualify for the investigation: Australia, Canada; China; Indonesia; Japan; Malaysia; Philippines; Saudi Arabia; Singapore; South Korea; UAE; USA. The selected countries host 85% percent of projects ever started, making country-specific observations relevant. The analytical process is divided into the six topics that characterize the research. For each topic specific types of analysis were employed to fit the different data sets.

Conclusion

This research analyzes the relationship between skyscrapers construction and the economic cycle at different scales. Global, regional and country specific economic dynamics tend to be correlated to construction with similar strength, indicating that this typology is influenced by different levels of the economy similarly. Economic cycles influence the construction of skyscrapers through their different components. GDP level is the economic indicator that influences construction the most on multiple scales of observation. Foreign direct investments is the second economic indicator that influences construction the most, by influencing the overall capital capacity of countries and regions. Countries where developers react to changes in interest rates are also those in which development is correlated the most with both national and global economic changes. Annual GDP growth does not influence construction of skyscrapers at neither scale, as developers are not triggered to build by yearly changes in the economic growth. Countries that have the strongest correlations between construction and economic performance are developing countries with middle incomes. As the construction sector in these countries account for a large share of economic output, construction activity is more closely correlated with national and international economic cycles. The function of projects are influenced by global trends, such as the emergence of specific new industries, and local factors, such as cultural habits. A growing demand base and an aim for higher feasibility has increased function diversification in the last years. Projects are clustered in specific locations. 70% of projects built between 2000 and 2016 are located in global cities. Higher ranked cities, the more projects are located there. Locations have impacts on projects functions. Although the driving force for skyscrapers construction seems to be common worldwide, their use is influenced by cultural interpretations that vary from region to region. Projects distributions within countries follow specific models: primate city, rank-size rule and saturated.

The taller projects get, the less efficient they become at fitting floors within their height. Extreme heights are reached without a net increase in usable floors, meaning the extra height does not have a functional purpose, rather an image one. Regional levels of construction do not influence Vanity Height, instead culture does. Concrete has become the established material for skyscrapers' structures construction. Its recently improved mechanical characteristics and stable price through time have made concrete a preferred material over steel. The average time to deliver skyscrapers is highly influenced by local factors. National construction costs have an influence on delivery time, with developing nations experiencing lower construction costs and having longer construction periods; and developed nations experiencing high construction costs and having shorter construction periods.

Foreword

I think every graduate of the track Management in the Built Environment should have deep understanding of which factors influence demand and supply of real estate and how unique dynamics can emerge from different contexts worldwide. In this thesis, I try to explore one building typology in different contexts and from different perspectives, trying to employ all the knowledge and methods acquired during my master study.

I have always been fascinated with tasks that push human abilities to the limit, and in that sense, skyscrapers do so from architectural, construction and financial perspectives. With this research, I want to deepen my knowledge about the correlation between economic cycles and development of complex tall buildings.

Skyscrapers are a relevant building typology that could gain more importance in the future. Tall buildings can help densify global cities and offer a new way of living, in which structure and running costs are shared between occupiers. Advantages to businesses can be in the form of proximity to others and a representative space. Five different trends that will lead to the construction of more skyscrapers in the future have already been recognized: new technology, desire to live in the city, business clusters, limiting sprawl and the community city (Roberts, 2015).

Because of their cost and complexity, tall buildings appear in specific locations and their development is influenced by unique factors. With my work I aim at understanding this development process in different contexts worldwide, in the background of economic activity.

I want to thank all the people that assisted me in the creation of my thesis. In particular, I want to acknowledge Ilir Nase and Peter deJong, my mentors, for the enthusiastic assistance they have given me throughout the process.

Pietro Rovelli

Delft, June 2017

Table of contents

CHAPTER 1 – Introduction

1. Introduction

This research aims at analyzing the interrelationship between economy and construction of tall real estate. Specifically, the relationship between skyscrapers development and business cycle development, through quantitatively testing skyscrapers' construction throughout the world. This particular building typology, born at the beginning of the 20th century, has been subject of many studies, especially because of its tight relationship with economic activity. After all, skyscrapers are a symbol of success in capitalist economy. At the same time, tall buildings are a natural response to growing land prices and to create density in the urban habitat. Supertall buildings, like the ones considered in this research, cannot be explained as a mere answer to microeconomic factors. The uniqueness of the supplied space, presupposes a specific demand: the feasibility of such tall buildings is based on the assumption that occupiers will pay extra for higher floors and seek status from space.

The object of the research are buildings taller than 200 meters worldwide. As of January 2017, there are 1141 buildings completed in 37 different countries. By 2022, the number of buildings is going to rise to 1694, distributed across 46 countries. This fast production pace suggests that supertalls are a response to recently appeared dynamics driving the demand for the supplied space. The criteria behind delimiting the scope of the research to projects of a certain height is made to provide defining characteristics for the studied typology. Height is the biggest defining aspect for skyscrapers, being the material product of all the underlying forces driving its demand: finance, urbanization, cost, expertise, imageability. The deliberate choice of the specific height limit of 200 meters aims at including buildings whose construction entails difficulties from different perspectives: financial, physical and legal.

The analysis is divided into three scales: global, regional and country. This is done with two objectives in mind: draw a global narration of the evolution of skyscrapers development while uncovering countries and regions specific idiosyncrasies. Different theories were analyzed and integrated to make sense of what skyscraper development is and what influences it. For this reason, existing approaches were selected, each because of its contribution to the topic. The main concepts covered are: economic cycles, geographic distribution, height, functions, technologies and construction.

The property industry is a supplier of capital goods, so demand for property is inevitably linked to the demand for investment goods in the economy as a whole. It supplies space and must be affected by the economic factors that cause more or less demand. This might suggest that a cyclical pattern in the property market is just a reflection of a wider business cycle (Grover, 2013). The business or economic cycle is the sum of changes in economic performance, measured through specific economic indicators. In this research it is intended as the change in GDP level, GDP growth, interest rates and foreign direct investments. Cyclical movements in real estate development linked to the economic cycle have been studied for a long time. There are strong economic linkages between construction booms and financial busts (Thornton, 2005). In this sense, skyscrapers' development probably follows business cycles at different scales, both national, regional and global. The reason for this correlation is that GDP, interest rates and foreign investments are a big influence in the decision to construct real estate, as these factors determine the cost and potential success of the project. We can expect the volume of production of projects to be affected to some degree by some of these indicators. The relation between construction and its role within different economies is articulated through the analysis of countries' development, based on theories brought forward by Dlamini (2012) and Bonn (1992). The influence national, regional and global economies play on the construction of buildings is the main theme of this research.

The growing importance of cities as nodes in the global network has been highlighted in recent studies. These cities, because of their characteristics and the attraction they exert on business and people alike, exhibit faster growth than other urban settlement. Some of the characteristics of these settlements are the presence of international financial services and headquarters of multinational corporations; decision-making power at a global level; dominance of the region with international significance; multi-functional infrastructure offering some of the best legal, medical, and entertainment facilities in the country; high percentage of residents employed in the services sector; and presence of an extensive transportation network. From a global perspective, we can expect skyscrapers development to follow finance to some degree, especially by clustering most projects in locations with high accessibility and low cost of capital, targeted by foreign investment and with positive expectations of financial growth. These aspects align with the definition of global city, and as such, we can expect this urban typology to host most of the projects. Furthermore, because of the exponential growth higher-ranked cities have over lower-ranked ones, the pull the former have is proportionally stronger than the latter. Since businesses and capital tend to cluster in the most attractive locations, and skyscrapers' require both, we can expect skyscrapers to be exponentially polarized in the higher-ranked cities. Functions' distribution too might follow specific patterns, depending on locations' economic bases and specializations.

Skyscrapers were initially conceived as the perfect office space: compact, well located, secure, representative, and fit with telecommunication systems. Through time, this typology has attracted other functions as well as users, because of its spectacularism and services. The function of the buildings is a decisive factor for both the design as well as the feasibility of its construction. Different functions' demand and supply are dependent on the industries the functions are linked to, and their specific geographies. Functions offer different yields and returns depending on both time and place. The hypothesis is that, like other real estate typologies, the construction of skyscrapers hosting different functions follow different trends.

As previously stated, height is one of the key factors in the decision to build a skyscraper. For the developers of tall buildings, extra height can bring advantages such as rent premiums given by the exclusiveness of the space as well as increased marketability of the building as an architectural icon. For this reason, reaching prohibitive heights has become a central objective of developers, triggering height competitions throughout the world at different scales. This focus has led to the creation of Vanity Height, unusable space within buildings with the sole purpose of enhancing total building height (Ctbuh, 2013). The Council of Tall Buildings and Urban Habitat has been researching the phenomena on a building base, reporting interesting findings. In a research carried out on 72 buildings taller than 300 meters, it was found that on average, Vanity Height accounted for 15% of the height of buildings (Ctbuh, 2013). The hypothesis is that, on a global level, there are differences in Vanity Height depending on buildings' total height and location.

Skyscrapers being an extreme real estate typology, because of the application of unique building systems, their development has been highly influenced by technology cycles. The narrative and concept of technological revolutions and cycles are borrowed from Perez (2002), to comprehend and analyze changes in employment of structural materials. New technologies have allowed to reach new heights as well as making prohibitive applications feasible through research and development. One of the intrinsic reasons skyscrapers could be built was the introduction of the newly developed steel frame in the 1800s. As time evolves, new systems and applications are made available to reach height easier and cheaper. As other real estate typologies have been affected by technology, we can expect skyscrapers' construction to be influenced by these changes as well.

Construction costs and their fluctuations are a key factor in development cyclicality. Costs affect timing of projects and length of the construction process. As construction costs vary drastically between countries, we can expect development to respond differently in these contexts.

1.1. Research Flowchart

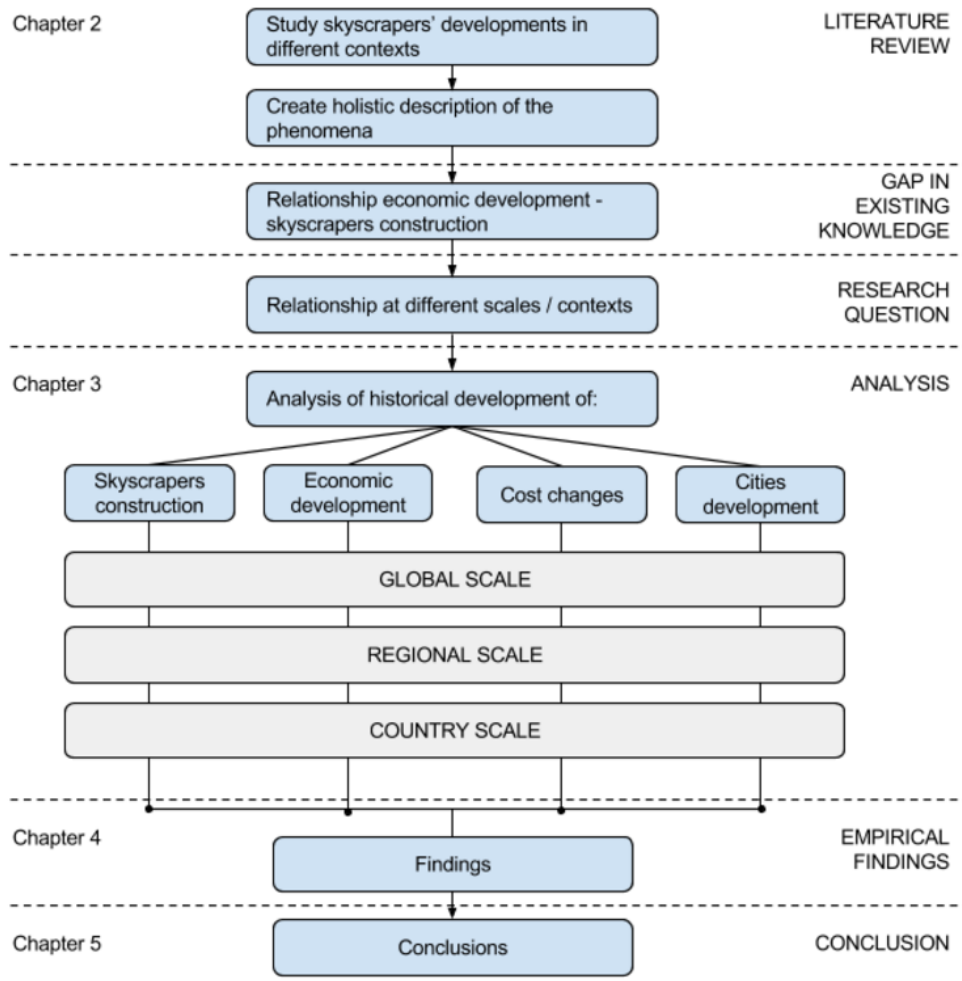


Figure 1.1: flowchart showing the process of the research.

1.2. Scientific Relevance

This research advances the existing knowledge about the interrelationship between economic development and construction, specifically regarding tall buildings. An existing concept that could be proved and enriched is the Skyscraper Index. This economic concept says that whenever a record-breaking building is built (height wise) the economy is about to hit a downturn, suggesting that the relationship between global economy and this typology is very strong. The underlying idea is that right before an economic crisis we can expect speculative behavior to be at its highest point by stakeholders deciding to build. Although the concept may seem farfetched, there are many notable examples that prove it right. The first case is that of the Home Insurance building completed in 1907, the same year of the panic of New York. The end of the 20s witnessed a surge of tall buildings in New York (Chrysler building, 40 Wall Street, Empire State building) which anticipated the Great Depression of 1929. The completion of the Twin Towers in 1972 matched with the oil crisis. In 1996 the Petronas towers were completed, just one year before the financial crisis that gripped East Asia in 1997. The current record holder, the Burj Khalifa located in the United Arab Emirates, was completed in 2008, the year of the global financial crisis and a year before Dubai defaulted on its debt. The Skyscraper Index is qualitative in nature, considering only few case studies and not considering the magnitude of each economic crisis and the corresponding height response.

This research highlights differences in development trends between different countries. The breadth of this research frees it from the constraints of approaching the topic of skyscraper development with a single theory applied to a specific context. The findings of this research could be employed to further advance knowledge about urban development based on economic performance, underlying country-specific idiosyncrasies. On a practical level, the research could lay the ground as a guide in syncing the development of skyscrapers with the cyclicality of economy. Until now, research on the topic has been carried out at city scale; focusing on few theoretical approaches at a time. The department of Management in the Built Environment, part of the faculty of architecture, has focused on tall buildings in recent years, with the creation of specific workshops, lectures, and thesis studies. This research will enrich the existing growing collection of studies on a relevant topic. The databases created for this research will be made publicly available, to stimulate further research on the subject by other academics.

1.3. Societal Relevance

Skyscrapers are being developed more intensely throughout the world as time passes: 70% of the current global supply has been built only in the past decade. The impact of these structures on the built environment is grand in every respect, covering all the PESTLE perspectives: political, economic, societal, technological, legal and environmental (Law, 2009). In case of successful projects, skyscrapers can bring long term benefits to the city where they are developed. At the same time, this typology has been criticized for its imposing nature and as symbol of raw capitalism. It is of importance to society to understand and study what the underlying forces driving the construction of these buildings are and their implications on the urban population.

The development of real estate must deal effectively and efficiently with the cyclicality of the economy at different scales for a smooth functioning of the economy and society. Real estate and its construction, as the crisis of 2008 proved, can influence economic systems deeply, both positively and negatively. To avoid future disruptions and have real estate development support economic cyclicality and reduce its swings, instead of amplifying them, more studies are needed, specifically into what strategies of development and policies have proved successful in the past. The management of the phasing of a project in relation to the outside environment is key for its success. The same is true for the global production of projects.

Tall buildings are an effective response to the current need of cities to densify, as current projections forecast world population to keep growing, reaching 10 billion people in 2050 (United Nations, 2015). The horizontal expansion of cities is becoming physically strained by natural borders, leaving no alternative but to build upward (Ali & Al-Kodmany, 2012). This indicates that one clear solution towards densification of cities is tall building development (Scheublin, 2008).

Most of growth in the future will be polarized in specific locations, defined by Sassen (2005) as global cities. As a response to urbanization, skyscrapers reduce sprawl by having small footprints. Modern tall buildings can prove ecological too, thanks to new technological systems. Aiming to measure these buildings' sustainability, a new LEED certification has been created specifically for skyscrapers (Bloomfield, 2011). Thanks to the large budgets usually allocated to tall buildings, new and innovative solutions can be pioneered in these projects.

Skyscrapers have become fundamental instruments for the operation of global trade and associated services. The development of dense tall buildings is an effective response for the need of corporations to be clustered in specific places. Furthermore, with their spectacular ambiance, skyscrapers can support occupiers' business by providing a strong image. Since it has become a relevant element in the built environment, this building typology needs further research. A clarification of what value these buildings add to the existing urban landscape could inform on the decision to build them in specific contexts in the future. This thesis, by shedding light on skyscrapers development from an economic perspective, could aid actors at different levels of society: policy makers, investors, developers, buyers and users.

CHAPTER 2 – Theoretical Background

2. Theoretical Background

In this chapter skyscrapers' development is described through different perspectives and theories. This knowledge is aggregated to create a theoretical background explaining these buildings through their articulations. Specific aspects explored are projects' height, location, economic and regulatory background. The understanding of the process of real estate construction, and the underlying forces driving it, is needed to carry out statistical analysis and interpret results correctly.

2.1. Literature review

Throughout the world, many factors influence skyscrapers' construction: economy, legislation, construction and design expertise, urbanization etc. Yet, this typology's demand and supply are not as different throughout the world, as the users and activities linked to them are engaged to some degree to the global network. This creates a common denominator influencing the dynamics driving supertall building's production. Supply tends to be homogeneous as well: few firms in the world have the capacity to design and manage these constructions. As a result, most projects are designed and built by the same companies.

These complex constructions are distinguished by peculiar traits (Kalita, Maclean, & Watts, 2007):

- Product of negotiated compromise;
- Integrated part of infrastructure network;
- Crafted over an extended period of time;
- Highly influenced by politics and culture;
- Complying across multiple regulatory frameworks;
- Large, irreversible commitments.

The links between these themes define demand, supply and delivery drivers influencing supertall towers development and economics (Kalita et al., 2007). Because of this interrelationship with international actors and factors, we can assume that skyscrapers development is more susceptible to global macro-economic trends than other sectors of the construction industry.

Authors in the past have tried to explain the phenomenon of supertalls with theories that could explain different development patterns in specific contexts. Since in this research the global realm is contemplated, different theories are employed to give a holistic overview of the phenomenon. Through the review of existing literature, five main perspectives are distinguished to explain skyscrapers development:

1. Economic cycles;
2. Geographic distribution;
3. Height competition;
4. Technology cycles; and
5. Construction costs.

The five topics are addressed and explained in the next pages in five sections.

1. Economic cycles

The business cycle or economic cycle is the downward and upward movement of gross domestic product (GDP) around its long-term growth trend (Madhani, 2010). Business cycles are usually measured by considering the growth rate of real gross domestic product. Despite the often-applied term cycles, these fluctuations in economic activity do not exhibit uniform or predictable periodicity. The length of a business cycle is the period of time containing a single boom and contraction in sequence. These fluctuations typically involve shifts over time between periods of relatively rapid economic growth (expansions or booms), and periods of relative stagnation or decline (contractions or recessions).

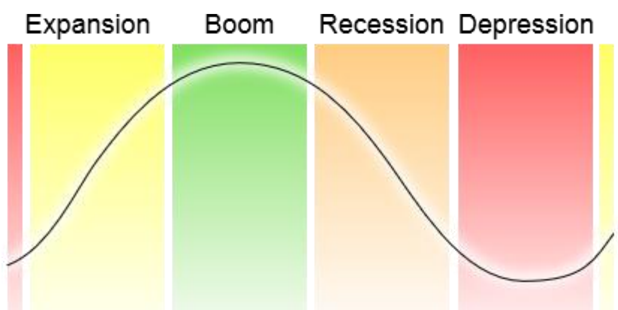


Figure 2.1: representation of the four stages of a cycle.
Source: boundless.com

Within a cycle, there are four different stages. The four phases coincide with several phenomena outlined below (Schumpeter, 1954):

- Expansion: early recovery, the economy starts expanding. Rising consumer expectations and industrial production. As interest rates bottom, the yield curve for starts getting steeper.
- Boom: late recovery, the economy expands to its limit. Shrinking customers' expectations and flat industrial production. Rapidly rising interest rates as the yield curve starts getting flatter.
- Recession: the economy passed its peak and starts contracting. Lowest customer expectations and falling industrial production. Interest rates are at their highest and yield curve is flat or even inverted.
- Depression: full recession, the economy contracts to its limit. Consumer expectations have bottomed and GDP has been retracting. Interest rates fall as the Yield curve is normal.

Cyclical movements in real estate development linked to the business cycle have been studied for a long time. Hoyt (1933) defined them as being the composite of the cyclical movements of a series of forces that were to some extent independent, but which communicate impulses to each other. These were cycles of population growth, rent levels and operating costs of existing buildings, new construction, land values and sub divisions of land parcels.

The property industry is a supplier of capital goods, so demand for property is inevitably linked to the demand for investment goods in the economy as a whole. It supplies space and must be affected by the economic factors that cause more or less demand. This might suggest that a cyclical pattern in the property market is just a reflection of a wider business cycle (Grover, 2013). In this sense, skyscrapers' development probably follows business cycles at different scales: national, regional and global. IPD (1999) found that GDP, consumer spending, and business activity were primary influences on rental values and that interest rates and inflation also affect some markets. McGough and Tsolacos (1995) found that GDP, business sector GDP, and output in business and finance lead the office building cycle, suggesting that the development industry anticipates the cycle and delivers space before rents reach their highest level (Grover, 2013). GDP seems to be the recurring factor influencing the construction industry. In the image below it is possible to understand how the different phases of the cycle influence the construction industry.

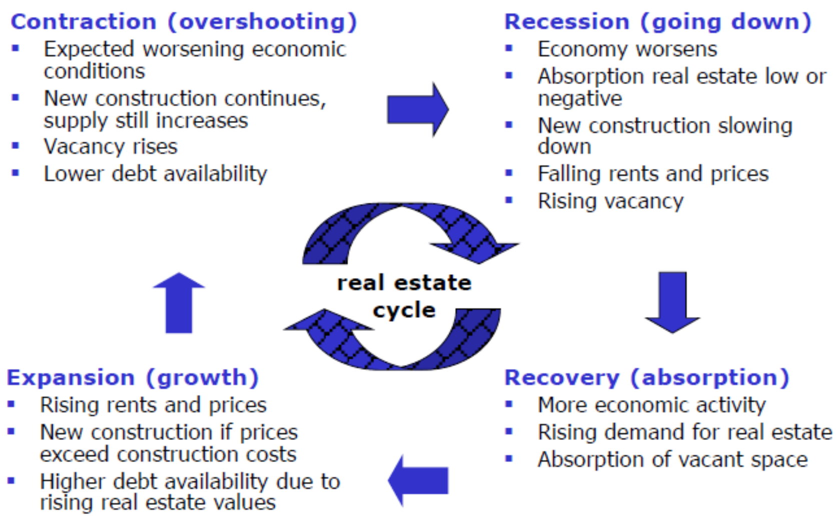


Figure 2.2: explanation of cyclicality of real estate development related to the business cycle.
Source: UvA University lecture, 2016.

Thornton (2005), similarly to Lawrence (1999), links the beginning of construction of projects with availability of finance and positive expectations. In his article, he describes how a period of easily accessible credit leads to a rapid expansion of the economy and a boom in the stock market. The ample availability of credit fuels a substantial increase in capital expenditures. Capital expenditures flow in the direction of new technologies which in turn create new industries and transforms the existing ones in terms of structure and technology. This is when the world's tallest buildings are begun (Thornton, 2005). At some point thereafter negative information ignites panicky behavior in financial markets and there is a decline in the relative price of fixed capital goods; unemployment increases, particularly in capital and technology-intensive industries (Thornton, 2005). This relationship between building height and the business cycle is widely reported in the media as an accepted fact, and some promote the idea that skyscraper height is, in fact, a 'bubble indicator' (Barr, Mizrach, & Mundra, 2014). **Figure 2.3** offers a summary of all the cases in which the completion of a record-breaking project coincided with a financial crisis.

BUILDING	LOCATION (COMPLETED)	SPIRE HEIGHT	FINANCIAL CRISIS
Singer	New York (1908)	187 meters	Panic of 1907
Metropolitan Life	New York (1909)	247 meters	Panic of 1907
40 Wall Street	New York (1929)	283 meters	Great Depression
Chrysler	New York (1929)	319 meters	Great Depression
Empire State	New York (1931)	443 meters	Great Depression
World Trade Center	New York (1973)	526 meters	'70s Stagflation
Sears Tower	Chicago (1974)	527 meters	'70s Stagflation
Petronas Towers	Kuala Lumpur (1997)	452 meters	Asian Financial Crisis
Taipei 101	Taipei (2004)*	509 meters	Tech Bubble
Burj Dubai	Dubai (2008/9)**	828 meters	Global Credit Crunch

Figure 2.3: record-breaking buildings and associated financial crashes. Source: Forbes.

Helsley and Strange (2008) see extreme height as a result from a contest of egos. Clark and Kingston (1930) concluded that extreme height is a rational response to high land values and cluster development. Barr (2012) finds evidence that in New York City, extreme height is mostly due to economic considerations, but during boom periods, height is also driven by non-economic consideration such as height competition. Four main types of cycles have been observed and described (Schumpeter, 1954):

- a 3-5 year inventory cycle (the Kitchen cycle);
- a 7-11 year major cycle associated with fixed investment (the Juglar cycle);
- a 15-25 year long swing associated with population changes or with transport infrastructure investment (the Kuznets cycle); and
- a 45-50 year long wave associated with major innovations (the Kondratiev cycle).

There might be offsets between business cycle and construction cycle. Delay in responding to market signals may be due to the state the development industry is left in by a previous recession. Many firms go bankrupt and those that survive are likely to have reduced capacity, including developments with voids and historic debts to be paid off. Banks too may still be grappling with the problems of previous loans so that the upswing has to be primarily funded by owner occupiers and institutional investors (Barras, 1994). Furthermore, real estate supply is very inelastic in nature. The result is that the next boom has a smaller speculative component and does not have the violent surge and collapse of the previous cycle but the one after does, as by then the property industry has recovered (Barras, 1994).

Developers are current price takers. Their expectations of profitability are inflated in the up-turn by the assumption that established trends in rental growth will continue so that development starts are higher than would have otherwise been the case (Antwi & Henneberry, 1995). The lack of knowledge of past cycles may mean that new recruits base their expectations on forecasts and market consensus but the profitability of failure is underestimated (Grover, 2013). During recovery of the economy, businesses tend to employ many new recruits, enhancing this effect. We can conclude that the GDP of a country and the expectations toward its changes, influence real estate development.

Another factor that influences real estate development is the lending interest rate. The impact on demand for real estate by business and changes in interest rates can come either from market reaction or government policy. Interest rates influence the cost to borrow finance as well as increasing the risk for the borrower. Foreign investments play an important role as a source of finances for the construction of skyscrapers. Since the 1990s, an increase and acceleration in investment flows into the construction of infrastructure and urban services in general, and in commercial real estate in particular, has been observed (David & Halbert, 2010). Unique markets are targeted by global investors because of the profitability and security they offer. Investments in supertall luxury buildings have been by ultra-wealthy international investors, who both enjoy the cachet of owning Manhattan real estate, and who seek to invest their wealth outside of their home countries (Barr, 2010). For example, 77% of condo buyers of the newly-completed One57, a 75-story tower near Central Park South, have been purchased by shell corporations to shield the names and assets of the owners (Barrionuevo, 2012). London as well, in recent years, has witnessed a surge of foreign investment, in the attempt to secure assets in the city. Global cities grow faster than lower tier cities, yielding greater profit. This tends to polarize investment in real estate in the former rather than the latter. From a financial perspective, we can expect skyscrapers development to follow finance to some degree, especially by clustering most projects in locations with high accessibility and low cost of capital, targeted by foreign investment and with positive expectations of financial growth.

The importance the construction sector has within an economy, is related to the maturity of the economy itself (Dlamini, 2012). This theory has been developed by Bon (1992) and Crosthwaite (2000). The classification consists of less developed countries (LDCs), newly industrialized countries (NICs) and advanced industrial countries (AICs). Bon (1992) observed that the share of construction in GNP (Gross National Product) first grows and then declines with the level of economic development, meaning NICs are the countries in which the construction sector has the highest influence on the economy and vice-versa. A representation of this relationship can be observed in **Figure 2.4**. The reason for this development is that construction is an important part of the development and modernization process of a country. In the Keynesian sense, increased spending in the construction sector stimulates economic growth: as the construction sector deals mainly with the provision of capital infrastructure, it has an impact on economic growth. The delivery of such infrastructure creates significant employment opportunities for the population, which generates further investment in other sectors of the economy through the multiplier effect (Dlamini, 2012). As countries evolve from developing to industrialized, the construction sector acquires lower importance as a share of the value added to the overall economy. As an economy matures, the focus of the construction industry shifts from intense development to careful management and maintenance. For this reason we can expect developing countries to exhibit levels of construction more aligned with their economic performance than developed countries.

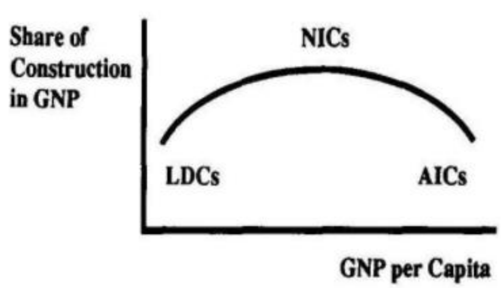


Figure 2.4: Bonn's curve. Source: (Dlamini, 2012)

2. Geographic distribution

The phenomenon of urbanization is an underlying force driving height, in the sense that growing demand (caused by population movements) causes prices to rise. Regulation tends to aim to higher densities by allowing permits for taller buildings, triggering developers to build tall. Hoyt (1933) concluded that without the exogenous cause of population movements there would be no property cycles. This suggests that countries with higher urbanization and population growth would experience stronger cycles. Current projections forecast that by 2050, over 80% of the world population will live in urban areas, when the world's population is expected to reach 9 billion (Ali & Al-Kodmany, 2012). At that time, all major cities of the world, particularly those in Asia, Africa, and Latin America, will have enormous populations, ranging from 30 million to 50 million (Ali & Al-Kodmany, 2012). Land consumption and the will to restrain sprawl, pushed many governments to actively support the development of tall buildings, especially in Asia and Latin America. The phenomena of urbanization in developing countries today is different from that experienced in developed countries in the past century, making historic analysis a poor method for understanding the matter. Expertise and financial capital availability can accelerate the process, producing different urban forms and elements from those produced in the past. Furthermore, different governmental forms restrain or support the market forces responding to these inputs, influencing their outcomes.

Globalization, the process of international integration arising from the interchange of views, products and ideas, has affected urban development world-wide. The characteristics of globalization that directly influence urban development today are (Harvey, 2005):

-a concentration of ownership and control of vast segments of economy in the hands of a smaller number of multi-national corporations;

-a financialization of capital, reducing any work-product or service to an exchangeable financial instrument;

-a shift in power relations between firms and governments, leading to the adoption of neo-liberal policies by most developed countries;

-a commitment of local governments to compete among cities world-wide for economically profitable businesses;

-a development of technologies linked to communication, transportation and networking allowing wider spans of control and networking among firms;

-a relocation of manufacturing and rise of services sector; and

-after the collapse of the Soviet Union, the domination and influence of the United States economically, militarily, financially and culturally throughout most of the world.

In this research the concept of global city defined by the GaWc is going to be adopted (Beaverstock, Smith, & Taylor, 1999). The global city is an important node having direct and tangible effect on global affairs through socio-economic means. Sheer size doesn't put a city automatically on the list, it is its integration in the world network that matters. Cities are ranked based on the services they provide: global capacity is defined empirically in terms of aggregate scores and interpreted theoretically as concentrations of expertise and knowledge (Beaverstock et al., 1999). These characteristics have been influencing cities as whole in the process of urbanization, through the impact on specific aspects of the built environment. In capitalist globalization, the nature and scale of iconic buildings and of what they symbolize, has been transformed by world trade and the interests of multinational corporations (Pashley, 2000).

Global cities can also be defined as the winners in the competition among cities. These cities can be described through a set of characteristics (Pashley, 2000):

-presence of international financial services;

-headquarters of multinational corporations;

-presence of financial headquarters and stock exchanges;

-decision-making power at a global level;

-dominance of the region with international significance;

-multi-functional infrastructure offering some of the best legal, medical, and entertainment facilities in the country;

-high percentage of residents employed in the services sector; and

-presence of a network of transportation combining different modes and ranges.

Centralization of businesses and residencies have become vital in the spatial displacement of the city: the benefit of being near other activities in the same business sector is of great importance and leads to the clustering of activities in metropolitan areas. For firms the advantages come in the form of being close to clients and the exchange of ideas; in the other hand, the advantage for residents is the provision of facilities and services. Skyscrapers are also demanded for reasons of efficiency, effectiveness and image provided to the occupier. Goals such as attraction and retention of talent, as well as marketing, can be achieved from a representative space. If the unit cost of horizontal travel exceeds the unit cost of vertical travel, a tall building will economize on intra-building travel costs, and may be efficient even if the price of land is relatively low (Sullivan, 1988).

Because of the high rents driven by the demand within global cities, the latter tend to become denser. A response to this phenomenon is to build tall. While urbanization is a cause for the rise of tall buildings, microeconomic factors are the underlying forces driving height. According to traditional microeconomic theory, building height increases as a function of the economic size of the cities where they are located (Garza & Lizieri, 2016). The largest economic clusters should have the highest land rents and, as a consequence, the tallest built structures. Since global cities compete on a global level, we can expect the most successful ones to attract the highest number of people and, therefore, to have the tallest buildings. The quality of urban space has become a critical prerequisite for the economic development of the city. In this sense, through their spatial layout and architectural elements, cities try to attract tourism and investment. The connection between iconic architecture, architects and globalization has developed thanks to both the electronic revolution, which has provided architects the tools to design such ambitious projects, and the mass media, which has given visibility to both architects and buildings (Seah & Sklair, 2012). This process has been labelled as boosterism: the promotion of a city to improve its public perception. The idea that a city’s position in global networks benefits its economic performance has resulted in a competitive policy focus on promoting the economic growth of cities by improving their network connectivity (Pain, 2015). Within the CBD and other areas, the skyscraper remains the symbol of progress, modernity and political and corporate power (Khan, 2014). Global cities’ officials have been supporting in different measures spectacular projects, in the form of incentives, political support, or deregulation, in order for the city to gain international resonance. On their part, developers around the world have proven eager to sign up starchitects in hopes of convincing reluctant municipalities to approve large developments, of obtaining financing or of increasing the value of their buildings (Nastasi & Ponzini, 2011).

The system of global cities is articulated by the spreading geographical network of operations of corporations (Sassen, 2005). The spread of skyscrapers since the 1950s has followed that of corporations. Outsourcing produces clusters of different firms, rather than large headquarters. At the same time, outsourcing reduces the importance of headquarters location. As a consequence, the notion that the number of headquarters specifies a global cities may be unfit for some locations (Sassen, 2005). While developing countries might offer too few integrated locations, advanced countries offer locations where the advantage of being agglomerated is outweighed by tax or legal benefits. This phenomenon coincides with the appearance of supertalls in second tier cities in developed countries.
Because of global competition between cities, fueled by the will of companies to be in the most favorable cluster, we assume that projects compete at a global scale as well, beyond the limits of cities. The attractiveness of a skyscraper must then be inherently influenced to some degree by the attractiveness of the city where it is located. This is a consequence of the fact that more successful cities will face higher demand, which in turn will create high rents and the supply of taller buildings. The ease of moving capital between different countries nowadays, will drive investors and developers to focus on specific international locations. Again, this concept aligns with Sassen's (2005) theory of a shift from national to intra-cities competition.

Two urban theories were explored regarding the distribution of populations between cities of the same country. The first one is the Rank-size Rule by Zipf, the second one the Law of Primate City by Jefferson (1939). The rank-size rule applies when the population sizes of the cities in a country is inversely proportional to their rank. Zipf believed that a rank-size distribution is the result of a balanced system for cities, as the rule applies to several natural systems of distribution. Countries that exhibit a distribution concentrated in one main city instead, are said to have a "primate city". This type of distribution opposes that of the rank-size rule, with one city dominating over the others. Countries showing primacy are typically small, have a colonial history, have an export oriented economy, exhibit simple economic and political organization and unplanned development (Berry, 1961). Large and decentralized countries such as China and the United States, tend to favor a pattern in which more large cities appear than would be predicted by the rule. By contrast, small countries that are connected to the global network will exhibit a distribution in which the largest city is much larger than would fit the rule, compared with the other cities. The excessive size of the city theoretically stems from its connection with a larger system rather than the natural hierarchy that central place theory would predict within that one country. If skyscrapers are effectively engaged in the global economy as hypothesized, according to these urban theories we can expect their distributions within cities to follow patterns like those defined by Zipf or Jefferson.

We can expect further differences in development between cities because of their unique economic base: this is the engine that drives and underlies all real estate activity and values in the region (Clayton, Eichholtz, Geltner, & Miller, 2007). Cities tend to be specialized in few fields. The industries present in a city, with their specific demands, tend to shape the urban environment to some extent.

An approach to categorize cities is to classify them into specific groups (Mueller, 1993):

- Farm;
- Finance, Insurance, Real Estate (FIRE);
- Government;
- Manufacturing;
- Military;
- Mining;
- Service;
- Transportation; and
- Diversified.

Cities, depending on their specialization, develop more or less tall buildings. Cities with industries that benefit from being clustered and having an iconic space should present the highest number of skyscrapers: in USA, although Chicago has 30% less GDP than Los Angeles, it presents almost three times as many skyscrapers. The reason is that the city's specialization in services provision and finance sustain the development of dense offices. These conclusions further prove that a context-based research on skyscrapers can be biased if the economic forces driving height are not discovered.

3. Height competition

If only the economic theory was to be taken in consideration, buildings like the Burj Khalifa couldn't be explained. The latter is the tallest building in the world, yet it is located in Dubai, which presents low density (645 in/sq km). In comparison, New York City has 7045 in/sq km, yet its tallest building is almost 300 meters shorter than the Burj Khalifa. Furthermore, Dubai is not nearly as integrated as New York in the global network. To understand what prompts developers to build extra tall, we have to comprehend Game theory, and the added value that comes from economically inexplicable height.

The game theoretic approach of Helsley and Strange (2008) was developed to comprehend the underlying strategies behind cases of record-height races, such as the Chrysler building vs 40 Wall Street and the Sears Tower vs Twin towers. In the game, the incentive to add height above the optimal comes from a 'prestige prize' that exactly offsets the losses/additional costs. This, in real life, would be the added value coming from a highly-marketed/known building. From the application of the game, Lizieri and Garza (2016) drew two conclusions from this approach:

- In order to be certain to win a skyscraper race, a contestant must over-build beyond optimal height and not just follow the urban economic fundamentals of economic and geographic size. It has to build to its pre-emption height (the height that guarantees the exact equalization of profits + prestige prize).
- Even when pre-emption might guarantee winning the contest, long-term economic growth will increase optimal height until the city catches up with the building.

This approach suggests that the prestige coming from extra height plays a big role in the decision of projects' height, disassociating with the idea that height is simply a response to microeconomic factors of the location. The game considers only record-breaking buildings though. Barr (2013) replicated the game, without focusing on record-breaking buildings. He too, found that prestige could be the reason for extra height. He divided buildings' height demand into two sources: economic and prestigious. The first is determined by traditional theory of urban economy standards, while the second is determined by the availability of taller, more spectacular locations.

This approach can be further enriched with the concept of Vanity Height. The term, coined by the Council on Tall Buildings and Urban Habitat, indicates the height between the last floor of a skyscraper and its architectural top. This built unusable space has the sole purpose of increasing the height (and aesthetic beauty) of the building. Since buildings' height is measured from the architectural top, several buildings appear higher in the rankings than they otherwise would, thanks to unusable pinnacles. In a study carried out by the CTBUH in 2013 on 72 supertall buildings, found that the average Vanity Height was 15%. Again, the cost of construction to reach certain heights is offset by the prestige that height brings. A remarkable fact is that the current record holder for Vanity Height (244 meters of unusable space) is also the current record holder for total height: the Burj Khalifa (Ctbuh, 2013). Among the analyzed countries, the research found that UAE is the country with the highest average Vanity Height: 19%.
From this perspective, it's interesting to analyze projects names as well. Different regions of the world present different habits:

- In North America, projects' names are usually their address;
- In China the name is usually taken after the city where the project is located. The name sometimes describes the building's function (financial center, hotel, store et);
- In Middle East many projects bear the name of a person.

It seems that the prestige and status that comes from a tall building is very important and influences its construction as much as microeconomic factors. The tall building as monument and expression of corporate or individual power is still evidenced today, as one can quickly discern from the gold-plated "Trump" insignia on many buildings that Donald Trump and the Trump Organization have constructed and from the continued demand for corporate branding of "trophy" properties in prestigious business districts (Kontokosta, 2013). The measurement of impact of prestige on the decision of height hasn't been measured by research yet, although we can reasonably expect it to depend on developers' expectations of extra profit by creating an iconic building or yearn for personal fame.

4. Technology cycles

Theory suggests that business cycles and technological innovation are intertwined: they are interrelated and interdependent phenomena; they share the same root cause and are in the nature of the system and its working (Perez, 2002). This relation originates from the fact that technology evolves through revolutions, which create huge earnings potential, and the fact that financial and production capital are functionally separated. Financial capital plays a huge role in the revolutions: it first supports the development of the technological revolution, it then contributes to deepen the mismatch leading to a possible crash, it later becomes a contributing agent in the deployment process once the match is achieved and, when that revolution is spent, it helps give birth to the next (Perez, 2002). As a technology matures through its development, the most advanced products will be created towards the end of the phase.

In the case of skyscrapers, technology plays a big role in the evolution of their development. Since their conception, technology evolution has defined skyscrapers' limits. First with the invention of the elevator, through the evolution of structures and to the introduction of unique building systems, tall buildings have come a long way since the early projects. Technology has also enhanced the marketability of skyscrapers by integrating special demanded features. The whole height view typical of skyscrapers with a glass façade for example, is one of the most sought after features of this typology (deJong, 2016). The expertise, both for design and construction, is now readily available worldwide, making the erection of these structures possible in many countries. This phenomenon surely plays a role in the surge of skyscrapers taller than 200 meters in countries that didn’t develop such a typology since recent.

The major technological revolution that opened the way for skyscrapers was that of steel. Although there is evidence it had been produced since the 11th century (Needham, 2008), Henry Bessemer first invented the process for mass-producing steel efficiently in 1855. Putting in use the new product, George Fuller in 1889, designed the Tacoma Building. Fuller created steel frames that supported all the weight from inside the building. Traditional buildings supported their internal floors through their walls, but the taller the building, the thicker the walls had to be: buildings of any substantial height lost their lower floors occupied by brick or masonry (Condit, 1968). Steel was a major innovation, and as such is recognized as the propeller of the third technological revolution, associated with a Kondratiev cycle lasting 40 years (Perez, 2002).

The next step toward building high-rise buildings was the development of the elevator. In 1853, Elisha Otis, an American inventor, developed a safety device that kept elevators from falling if a cable should break. This invention, coupled with electric motors made the elevator the perfect solution to the problem of vertical mobility. Skyscrapers and elevators evolution are tied: the taller the building, the faster the elevators must be. In a period of about one and a half century, the elevator’s speed was increased about 100 times-testifying impressive technological advancement (Al-Kodmany, 2015).

In 1958, Ludwig Mies van der Rohe designed the Seagram Building, the first building employing a glass façade. This design solution has been adopted in many skyscrapers since then. In the 1960s, Fazlur Khan envisioned a new structural system: the tube. Technically the building becomes a hollow cantilever perpendicular to the ground. This system allows the building to take on various shapes and grants a greater economic efficiency. Almost every skyscraper surpassing 40 stories in height built after the 1960s, has adopted this structural system. Thanks to Khan's innovations which allow skyscrapers to be cheaper to build, cities have experienced a huge surge in tall buildings construction.

Advances in construction techniques have allowed skyscrapers to narrow in width, through the employment of special structures. This aspect positively influences the GFA/LFA ratio, which would otherwise decrease with height. Some of these new techniques include mass dampers to reduce vibrations and swaying, and gaps to allow air to pass through, reducing wind shear.

Heating and cooling of skyscrapers can be efficient, through centralized HVAC systems, heat radiation blocking windows and the relatively small surface area of the building. LEED certification is now available for skyscrapers, and even older structures can be made efficient: the Empire State Building, after going through a $550 million renewal, received a gold certification for Leadership in Energy and Environmental Design in September 2011 (Bloomfield, 2011).

It is important to point out another technological revolution, the fifth one, that of information and telecommunications (Perez, 2002). Although steel is the physical element that rendered possible the construction of such tall buildings, its telecommunications that lay the ground for the creation of a network economic system that led to the creation of clusters. In the next paragraph, it will be illustrated how these dynamics led to the creation of decentralized, information-based network structures: the skyscrapers.

5. Construction costs

Skyscrapers re an extremely expensive real estate typology. The complexity of construction, coupled by the high land costs which spurred vertical development, drive the total cost. There are three main variables regarding the decision of how tall to build (Sullivan, 1988):

- Base price.
- Height premium.
- Construction cost.

The base price refers to the cost of land. High land prices are the main reason tall buildings started being built in Chicago and New York in the middle of the 19th century. As land values rise, developers have an incentive to build taller to recoup costs. The height premium is the amount by which income rises with building height. This is linked to the fact that customers of skyscrapers are willing to pay more to occupy higher floors, attracted by better views and status. The third variable, construction costs, rise at an increasing rate with the density and height of the building. The geographic location of projects highly influence construction costs, especially labor and materials. The two, in turn, depend both on availability of supply and regulation. A key factor influencing cost of construction is the length in time of construction. The longer it takes to build, the higher the financial costs of debt employed to build, as well as site management and labor costs. In this sense interest rates play a key role in the timing of projects: high interest rates stimulate quick construction, while low interest rates stimulate borrowing. The time it takes to build a skyscraper also depends on many other factors: technology, expertise, regulation, availability of labor and development strategy. These factors are dependent on the financial case of the developers. Design and construction expertise are virtually available worldwide, with multinational corporations specialized in high-rise construction present in every continent. The cost of the design is less volatile than that of labor and materials between countries. The cost of the latter two is also dependent on the business cycle: as it will be introduced in the following section, depending on the phase of the cycle, cost of construction vary widely. Builders reduce production of skyscrapers when construction costs rise (Sullivan, 1988). This time coincides with the expansion and boom phases of the business cycle. We can conclude that construction costs deeply influence skyscrapers development, and that these change deeply depending on time and location. Because of the cost of time, the speed of construction is a key factor in the feasibility study of skyscrapers.

Further considerations: Regulation and cultural habits

Buildings taller than 200 meters have a strong impact on the built environment on different levels. Because of this, they tend to be subject to regulation varying from place to place. Most of the regulation impacting high-rise has to do with their uncommon height, for different reasons: impact to the skyline and urban identity, fire safety, air flight safety, obstruction of views, casting of shadows and more. Projects of such scope, both during construction and operation phase have to comply to multiple regulatory frameworks. The pressure such buildings puts on existing infrastructure, coupled with the needed permits to build them, entail a close communication and coordination between governmental bodies and developers. As learnt from the global cities theory, the will to support spectacular and iconic projects by local and national government, in order to capture some of the value created, eventually decides the restrictions imposed on tall buildings.

Zoning, the act of dividing land to separate different uses, was actually prompted by the development of tall buildings (Dolkart, 2003). As tall building construction flourished in major U.S. cities, issues of light, ventilation, and public health, as well as encroachment of incompatible uses, began to capture the public's attention (Kontokosta, 2013). In the years leading to the 1916 Zoning Resolution in New York, tall buildings' lack of regulation caused trouble to multiple stakeholders. This time, not only to population and public officials, but also to real estate investors and developers: the construction spree became speculative in nature; buildings would become obsolete quickly and rents would grow slowly because of the over-supply of space. Where tenement reform laws had addressed residential overcrowding, owners, architects, and public officials viewed building regulations as a means to minimize the negative impacts of increasingly massive structures on surrounding property values and public space (Kontokosta, 2013). The Zoning Resolution divided the city in areas with three different possible uses and five different height districts, which defined maximum heights in proportion to street width (Dolkart, 2003).

The evolution of cities, both in physical form and production, has made some of the old regulations inadequate to respond to modern needs. Zoning policies have begun to evolve from prescriptive standards to performance-based codes, driven by increasing flows of information and a more comprehensive understanding of the nexus between land-use regulations and their effects (Kontokosta, 2013). The involvement of governmental bodies in the development processes of large projects in recent years worldwide has made strict restrictions limiting, while a mediated solution might bring more advantages to all. Further regulation influence could come from safety measures applied to construction work: given the specific nature of these constructions, hazards to workers are numerous.

The unbalanced proportion of projects between countries with similar economic output further suggests that skyscrapers, although may be a mere response to economic factors, have to be culturally accepted in order to be built. Where regulation doesn't allow them, whether the economic factors that drive height are present or not, skyscrapers simply won't be constructed. When analyzing the phenomenon at global level it shouldn't be forgotten that regulation is probably the biggest determinant in skyscrapers' development. Restrictions can stem from cultural habits and taste, as exemplified by the case of London. Although 400 high-rises are currently proposed, approved or under construction, surveys show residents want numbers curbed (Davies, 2016). Back in 2013, the envisioned developments provoked an array of responses, including a signed statement by some of the city's top architects, artists and designers demanding the mayor create a commission to oversee and control the quality and number of new towers being built. In this case, the citizens believed the skyscrapers would disrupt the existing skyline of London. Other reasons can align public opinion against skyscrapers. Other notable cases are Japan's aversion to high-rises following the 2011 earthquake (Buerk, 2011) or the fear of terrorist reprisals following the attack of 9/11. These cases prove that even when regulation is not present, public opinion can have a significant weight in the decision to develop tall.

2.2. Problem statement

The theoretical foundation drawn until here is what this research is based upon. Through the study of existing research on the topic, it became clear that there is a lack of a global view of the phenomenon of skyscrapers development. Previous research is strictly context-based. By focusing on one location, these perspectives fail to recognize several aspects intrinsic of skyscrapers development. If projects were considered through their physical characteristics as products of a process, in the background of local conditions, a global comparison could be made. Skyscrapers are the complex product of multi-scales global dynamics. There is a unique interplay of demand and supply in delivering supertalls. The demand is dependent on the development of global trade; the same development that has been driving the surge of Global cities (Beaverstock et al., 1999). Supply instead depends largely on local factors: local economic conditions, expectations, regulations and developers' behavior.
Although capital can be moved, every location presents unique risks, which in turn make investors and developers demand specific returns. Another aspect that must be considered are exogenous causes, such as migration and urbanization, which can interest entire regions. Building tall can be a modern effective way of creating dense housing for developing countries experiencing massive urbanization. Regulation and culture too are to be considered. The level of involvement and support of government and public opinion, as showcased through the literature review, influence existing restrictions and future plans. The popularity of projects depends on the acceptance of the population to live and work in tall buildings.

After the study of literature review, the hypothesis is that skyscrapers' development, in the background of their locations' characteristics, follows different trends and responds differently to the economic cycle, both at national and global level. According to existing theory, the expectation is that there should be lag between the skyscraper cycle and the economic cycle. In fact, against the backdrop of global economic crisis, 2008 has witnessed probably the most successful year of skyscraper construction ever, with more - and taller- skyscrapers constructed globally within a single year than any other time (Oldfield, 2009). Until here it may seem skyscrapers development just followed the real estate bubble, yet, since 2008, 65% of the current existing skyscrapers' stock have been built, suggesting that skyscraper development is mostly influenced by local factors rather than global. The trend is probably influenced by the difference in development between countries and how the latter's developers respond to global economy.

2.3. Research questions

Trying to create a global perspective about skyscrapers development and its relation with economic activity, I formulated a main research question and several sub-questions. These are intended to focus the research on specific aspects.

To what extent are national, regional and international economic cycles correlated to skyscrapers' construction?

Sub-questions:

How are projects distributed globally, regionally and nationally?

To what extent does Vanity Height influence projects' height?

To what extent are specific functions employed? How are they distributed?

To what extent are specific materials employed in skyscrapers' construction?

To what extent do construction costs influence skyscrapers' construction?

2.4. Expectations

The outcome of the analysis is the outline of the correlation between the selected economic indicators and skyscrapers' construction. It is of interest to see if skyscraper developers are more inclined to build during boom periods (higher finance costs with high expectation of growth), during recessions (low finance and construction costs with low expectations) or without regards to economic performance. Furthermore, the employed data allows recognition of which specific economic indicators influence output the most. We can expect different development patterns depending on location, describing differences in developers' strategies in responding to different exogenous causes. The projection of the development of all the different trends allows for the observation of their cyclicality and to connect changes in trends with concurrent exogenous causes.

Following Global cities theory, international investments focus on specific cities (and their products) because of their performance (Beaverstock et al., 1999). Foreign investments, as introduced in the business cycle theory, influence overall capacity and tend to focus on this typology. For this reason, we can expect a correlation between foreign investment and skyscrapers construction.

Several differences might be noted between developed and developing countries. Demanded yields in relation to risk, access to capital, regulations, differences in costs of land, labor and materials all influence real estate development and its cyclicality. Furthermore, countries in which governments have a proactive role in economy and development, might react differently to the global business cycle because of the distortions created through policies and economic regulations.

We can expect higher ranked global cities (through the GaWc definition) to host more and taller projects. The geography of supertalls could follow the development of Global cities, reflecting the network of global business (Sassen, 2005). As introduced through the explanation of global cities in the previous chapter, these will present the highest return of investment, because of the intensity and diversification of demand.

The specialization of cities influences the typologies of real estate demanded (Mueller, 1993), and in this sense, we can expect different cities to develop functions in different proportions depending on their economic base. Financial centers deeply involved in global trade probably develop mostly offic function. Touristic capitals are probably developed in a more diversified manner. Because of the importance of iconicity to attract, touristic cities might have the highest amount of Vanity Height. The dichotomy between the location of a project and the status of the location is a mutual one and could have a multiplier effect: the more projects are clustered, the higher the attraction on demand, the stronger the pull to further supply. In this sense, it could be hypothesized that the more projects a city has, the more it will have relatively over other locations: a polarization of projects that leads to an unequal distribution worldwide. From a governmental point of view, we could say that cities presenting more projects might be the ones whose governments are seeking more boost of image. This aim could be reached through ease of regulation or support of projects in financial and marketing terms.

Specific aspects uncovered during the literature review, regarding the decision of projects' heights, describe a possible speculative behavior of developers. Lizieri and Garza (2016) have shown how developers in South America compete to build taller buildings than their competition. An even more comprehensive view on the phenomena, is the surge and occurrence of Vanity Height in skyscrapers. The goal to surpass competition's height might have distorted the way these buildings are designed, putting more emphasis on the iconicity of buildings over their functionality. These observations suggest that the feasibility of this typology might go beyond economic valuations.

The analysis of the cyclicality of functions employment as well as their correlation with economic indicators might uncover specific idiosyncrasies of specific industries and the way they shape the built environment. The response of these industries to exogenous economic forces can be recognized through trend analysis. The same type of analysis is carried out regarding materials' employment. The goal is to see how the skyscrapers development industry has adapted to changes in application of materials through time.

CHAPTER 3 – Methodology

3. Methodology

This chapter describes the operationalization of the research. The following will be elaborated: data mining, research strategy and analysis. The first section describes what data was collected and in what way it is employed to answer the research questions. The second section describes how data was combined and structured. The research strategy section explains why qualitative analysis was chosen along with the planned statistical tests. The last section explains how the collected data is analyzed with the selected statistical tools.

3.1. Data mining

To carry out analysis, data was needed, specifically regarding skyscrapers' construction, economic development, construction costs and global cities rank. Data mining is an analytical tool to analyze data from many different dimensions, categorize it, and summarize the relationships identified. Technically, data mining is the process of finding correlations or patterns among dozens of fields in large relational databases. Since the sources for the data employed in this research are multiple and different, there is a need to organize the information in one single organized database: to employ certain analytical software in the research, specifically formatted digital libraries must be created.

In order to measure the developments, different indicators describing their evolutions were selected. Skyscrapers' construction is tracked through the collection of a time series regarding all projects ever completed taller than 200 meter. The criteria behind delimiting the scope of the research to projects of a certain height is made to provide defining characteristics for the studied typology. Height is the biggest defining aspect for skyscrapers, being the material product of all the underlying forces driving its demand: finance, urbanization, cost, expertise, imageability. The deliberate choice of the specific height limit of 200 meters aims at including buildings whose construction entails so many difficulties, that they are mostly supplied and demanded by global players. The research is carried out at global level, to have a complete view of the phenomenon. For each project, relevant characteristics are tracked, describing the buildings' physical and construction qualities, location, and function. Most of the information about buildings was retrieved through the Skyscraper Centre, a website part of the CTBUH. This website allows users to create and download personalized databases in Excel format from their servers. The geographical coordinates of projects were found through the website latlong.net. For the 1694 considered projects, the following definitions are gathered:

-Name; the official name of the building as given by the developer or the owner.

-Geocoordinates location; coordinates for each city expressed as latitude and longitude.

-Height in meters; indicates the architectural top of buildings expressed in meters.

-Country; indicates the nation where a project is located.

-Number of floors; expresses the effective number of usable floors in the building.

-City; indicates the metropolitan area where a project is located.

-Function; expresses the function(s) of the building.

-Structural material; expresses the structural material of the project. There are three categories: steel, concrete and composite.

-Date of proposal; year in which the project fulfills the following: have a specific site with ownership interests; have a design beyond the conceptual stage; and have obtained formal legal permission for construction.

-Start of construction; year in which the construction permit is obtained.

-Date of completion; year in which the occupancy permit is obtained.

The business cycles are measured through several economic indicators: annual GDP growth, annual GDP level, deflated annual GDP level, lending interest rate and foreign direct investments. GDP is a good indicator as it plays a significant role in decision-making for construction (IPD, 1999). As explained previously, GDP is the indicator typically used to trace the business cycle. It indicates the gross product in dollar value for a specific year. GDP growth is tracked to see whether sudden changes in the growth of economy trigger developers. The level of GDP in current dollar value is an expression of the absolute value of production per year. This data is collected to check if high market values in economies trigger tall buildings construction. The deflated GDP level is calculated by deflating the GDP level to a common year, thus eliminating the influence of inflation. Deflated GDP is employed to see if production aligns more with the inflated economy or the deflated one. This allows the recognition of speculative behavior on the part of developers. Lending interest rates are different for each nation, as produced by their national bank. Skyscrapers development, being so capital intensive, is sensitive to changes in interest rates, as these influence the cost of finance. GDP and interest rates are interrelated: when the GDP grows fast, interest rates are typically high, while when GDP growth slumps, interest rates tend to be lower to favor investment. Because of the explored relationship between globalization and capital movement (Harvey, 2005), we can expect to see a correlation between skyscrapers construction and capital movement: the high returns of some global cities tend to attract investments, which more than often are sunk into real estate. This is the reason why direct foreign investments are tracked.
The evolution of these developments describes the reaction of developers to the business cycles, both at global, regional and national scales, exposing differences in underlying strategies or habits in different areas of the world. All the data regarding the economic indicators, namely GDP and its growth, interest rates and foreign investment, was acquired through the databases of World Bank. The latter provides these publicly available databases on their servers in Excel format. These have a long timeframe, covering from 1960 to 2015, and are considered a reliable benchmark. The data regarding GDP and foreign direct investments is given in current dollar value, also called nominal dollars, the face value at a given point in time, meaning not revalued to account for inflation or the time value of money. The fields defining economic performance are:

-GDP %_Year; expresses the GDP growth for different years as a percentage.

-GDP Level_Year; expresses the GDP level for different years as a number.

-GDP Level_Year_Deflated; the GDP level for different years deflated to a common year (2010) as a number.

-Interest rate_Year; expresses the interest rates for different years as a percentage.

-FDI_Year; expresses the Foreign Direct Investment for different years as a number.

Cities ranking is employed to see whether location plays an important role in the decision to build. For this reason, data regarding global cities and their integration within the global network was acquired from the Globalization and World City department of the University of Loughborough (GaWC). A roster of world cities is ranked in the bulletins published through the years, in which cities are ranked based on their connectivity through four "advanced producer services": accountancy, advertising, banking/finance, and law (GaWC, 1999). The measurement of these four factors, through 47 different indicators, allows the department to measure cities' integration. The GaWC inventory identifies three levels of global cities (Alpha, Beta and Gamma) and several sub-ranks. Their bulletins have been produced from 2000 to 2016 every two years, with the exceptions of 2002 and 2006. In this timeframe, 226 global cities have been indexed. In the database, the field defining cities ranking is:

-City_Rank; expresses the global rank for different years as a number.

The last indicator employed is the cost of construction of skyscrapers. Depending on location and regulation, cost of construction can change dramatically. To investigate the relationship between cost of construction and development at global level, different costs will be converted to one currency, allowing comparison. Costs are heavily influenced by currency fluctuations, yet multinational corporations would explore investments in different countries the same way, making this type of index good to investigate the relationship. The data for construction costs was retrieved from a commercial party: Turner & Townsend. Since 2008, T&T has compiled a global construction cost survey every year. These reports specify construction cost with a common unit of measurement for different typologies in different countries and cities. The costs employed are specific for high-rise with differentiation between residential and office prestige. Not all the countries contained in the projects' database are tracked for construction costs. Data is available for 21 countries, yet the most relevant (the ones with most projects) are tracked. The data published is elaborated from surveys on costs based on the experience of actual projects within different regions. Turner & Townsend has agreed in sharing their existing databases in Excel format, to facilitate the data collection process. Their reports cover a timeframe of 9 years, from 2009 to 2017. The definitions of the field are:

-Office Cost; expresses the cost of construction per sqm of office high-rise.

-Residential Cost; expresses the cost of construction per sqm of residential high-rise.

DEVELOPMENTS	SOURCE	TIMEFRAME	INDICATOR	MEASUREMENT UNIT
Skyscrapers construction	Council of Tall Buildings and Urban Habitat	1909 - 2016	Project name	String
			Country	String
			City	String
			Coordinates	Latitude and longitude
			Height	Continuous
			Number of floors	Continuous
			Height / n. floors	Continuous
			Function	Categorical
			Material	Categorical
			Date of proposal	Continuous
			Start of construction	Continuous
			Completion	Continuous
Economic development	World Bank	1960 - 2015	GDP Level	Continuous
			GDP deflated	Continuous
			GDP growth	Continuous
			Interest rates	Continuous
		1970 - 2015	Foreign direct investment	Continuous
Cities ranking	GaWC	2000 - 2016	Rank	Continuous
Construction cost	Turner & Townsend	2009 - 2017	Residential high-rise	Continuous
			Office high-rise	Continuous

Table 3.1: summary of indicators' sources, timeframes, and measurement units.

3.2. Research strategy

The analysis is carried out through a quantitative statistical data analysis. The relation between the theory and research can be classified as inductive. An inductive approach is the relationship between theory and research with a bottom-up logic in which empirical research (specific observations) leads to generalization. Aiming to draw global trends, a large sample size is considered. Given the fact that the research is based on a database containing every project ever built belonging to this typology, answers from statistical tests yield high significance. This research is based on a secondary analysis, as it uses data collected by other institutions, namely World Bank, the CTBUH, the GaWC and Turner & Townsend.

The decision on the types of tests to carry out comes from different reasons. Regarding studies on tall buildings, existing literature is divided between investigations based on case studies and those based on statistical analysis. Again, as set out at the beginning, a global study would have been superfluous if carried out through few case studies. For this reason, analysis was based on the total global supply. Previous analogous investigations, part of the literature produced by other authors analyzed in this research, helped set up the analytical framework. The Game Theory approach developed by Helsley and Strange (2008) is employed to approach the analysis of Vanity Height. The paper 'The economics of Manhattan skyscrapers' features models of distributions and means which are replicated in this research (Barr, 2015). Finally, the global perspective regarding skyscrapers development advanced by Thornton (2005) was here employed to support the narrative guiding the analysis.

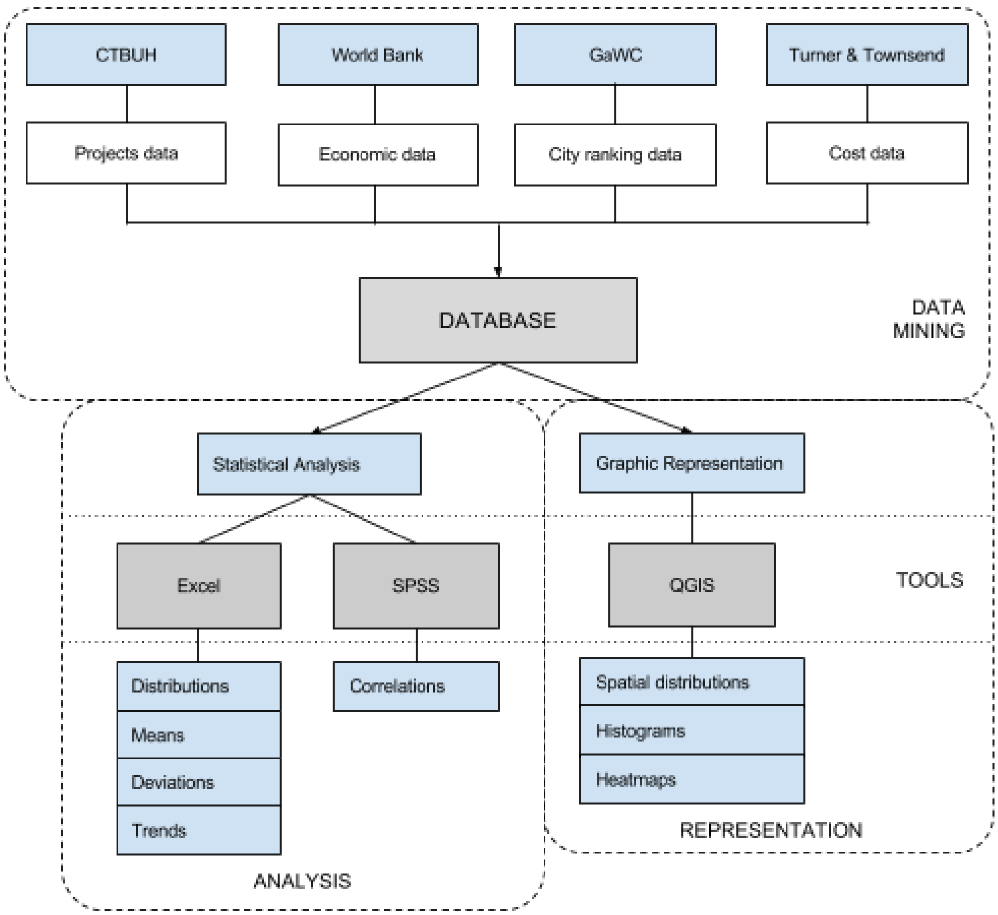


Figure 3.2: flowchart representing the development of the research.

The analytical process is carried out with two methods. Data is analyzed statistically with Excel and SPSS software and represented graphically with Quantum GIS software. Both processes are carried out at the same time, as one informs and guides the other. Excel is adopted to carry out distributions, averages and means, as well as the creation of graphs. Distributions are used to weight populations in different categories, differentiated through their characteristics.

Mean calculations are used to see the tendency of multiple trends, while deviations allow us to see the difference between single projects (or groups of them) and the average. The size of the database allows for subgroup analysis, such as specific countries, regions and cities (Bryman, 2012). SPSS is employed to carry out correlations, specifically Pearson two-tailed correlations. Different types of statistical tests are employed, namely distributions, means, deviations, and correlations. Correlations are employed to measure the relation between different developments. The correlation coefficient is a standardized measure of an observed effect, it is a commonly used measure of the size of an effect: values from ±0.1 to ±0.3 represent a small effect, from ±0.3 to ±0.5 a medium effect and larger than ±0.5 a large effect (Field, 2009). Significance is another important factor: when it is below .05 it indicates a strong relationship.

In part of the analysis is employed Quantum GIS, a graphic software. The reason a graphical software is employed is that specific dynamics can be shown more effectively through images than text and numbers. Spatial representation is used to guide and represent the analytical process. The software allows the importation of large databases and their mathematical analysis. These operations can be represented on a map using geographical coordinates. Multiple developments can be represented at once on a scaled map, with the possibility to represent their characteristics quantity. Through tools specific of Quantum GIS, further analysis can be carried out through charts, histograms and heatmaps. Visual representation allows to show the changes in projects' construction and business cycles around the globe. Because of the available data, small videos can be created, tracing the history of particular features (e.g. trends in use of materials, height, functions) by taking snapshots of maps through time.

To import all the data onto the software, a specifically formatted database was created. The first step was to add information to the projects' database by adding geographical coordinates to each city. These are inserted as latitude and longitude expressed using the WGS84 projection system. This allows for the projection of projects' location on a map. Furthermore, some data about the projects which was given in words (specifically materials and functions) was coded, to allow mathematical statistical analysis. The next step was to transform all the databases from an xlsx format to a csv (comma delimited text) format. Once all the databases were converted, they were imported in QGIS in csv format. Quantum GIS software allows for their automatic combination into one database, by linking each country with its economic data. The final comprehensive database was finally converted to a single shapefile.

3.3. Analysis

The analytical process is divided by topic: economic cycles, distribution of projects, height, technology cycles and costs. Each aspect is analyzed at multiple scales to discover both global and local developments and their reactions to exogenous causes, as well as to learn which of the three scales' indicators influence development the most. Global analysis is carried out over the total portfolio of existing projects. Regional analysis is carried out over six regions: East Asia and Pacific; Europe and Central Asia; Latin America and Caribbean; Middle East and North Africa; North America; South Asia. Sub-Sahara Africa region was excluded from the analysis. As it contains only two projects, analysis based on it would not carry any significance. The definition and size of the regions was borrowed from the World Bank. This simplified analysis with the existing economic indicators provided for the same regions. Analysis is carried out at country scale for specific countries: those having currently completed at least 30 projects. This choice was made to be able to carry out correlation tests that carry significance through multiple observations. Currently, 12 countries qualify for the investigation: Australia, Canada; China; Indonesia; Japan; Malaysia; Philippines; Saudi Arabia; Singapore; South Korea; UAE; USA. The selected countries host 85% percent of projects ever started, making country-specific observations relevant.

Economic cycles

The relationship between skyscrapers' construction and economic cycles was analyzed through correlations between skyscrapers construction and economic indicators at different scales. Correlation analysis allows the recognition of which indicators plays the biggest influence on construction. Global economic indicators are: world GDP growth, world GDP level and global investments (it measures the sum of all FDI worldwide). These are correlated with global construction output through projects' start of construction date. The economic developments and the construction volumes are plotted in graphs to allow for cycles recognition through the analysis of peaks and troughs. Construction volume is divided by country to recognize each nation's contribution to total output.

The analysis of functions highlights how the construction of different functions is affected by economic cycles. Functions employment cycles and their relationship with economic development are measured in two ways. First the four functions historical development between 1960 and 2015 was correlated with global economic development through the three indicators GDP growth, GDP level and investments. The trends of the functions were then plotted on a graph, in order to observe cycles in functions' employment, through the recognition of peaks and troughs. The calculation of each function's standard deviation allowed to recognize their volatility. These analyses contributed to answer to the fourth research question.

At regional scale the economic indicators (GDP growth, GDP level and FDI) are correlated with projects' start of construction. In this analysis are included global economic indicators as well, to see region's alignment with the global economy. Analysis at country level is carried out by comparing single nation's construction with their specific economic indicators: GDP growth, GDP level, deflated GDP level, interest rates and FDI. These analyses contributed to answer the first research question.

Geographic distribution

The geographic distribution of projects is analyzed in different ways. First projects are projected on global and regional maps to discover locations and functions distribution. Through the analysis of the distribution of projects and their functions among different locations, different cities' specializations can be observed. Projects' distribution among global cities is analyzed by relating cities' ranking, through the categories created by GaWC, with the number of projects built. Finally, distributions within countries are analyzed by comparing them with existing urban models, specifically the rank-size rule and city primacy. These tests contributed to answer the second research question.

Height competition

To measure Vanity Height a specific indicator was employed. The ratio between buildings' number of floors and their height is used to measure buildings efficiency, by measuring how much height of the building is actually employed to fit floors. To check if efficiency in buildings is dependent on height, differences in average height-floor ratios for different height categories were measured. Vanity Height for different locations was measured through the average deviation of single regions and countries from global average. These tests contributed to answer the third research question.

To these analyses is added a further one, regarding projects’ names. The recurrence of specific names in different regions of the world can highlight trends in the way developers and owners relate to their projects and what image they want to portrait.

Technology cycles

The analysis of materials highlights the relationship between construction and technological advancements, related to the described technological cycles. The response of development to specific changes is measured in two ways. First, the relationship between materials employment and global economic development is measured through a correlation analysis between single material’s historical employment between 1960 and 2015 and the economic indicators GDP growth, GDP level and investments. To analyze the cyclicality of the development, trends were plotted on graphs. The analysis of the standard deviation of each trend allowed to recognize volatility for each material’s employment. These tests contributed to answer the fifth research question.

Costs

Analysis on the relationship between construction costs and development is focused on national level. The main aim is to see the reaction of developers to changes in costs, both for residential and office buildings. Analysis is carried out through a correlation between construction cost developments and economic indicators for each country. Furthermore, the changes in the time to complete projects are analyzed in the background of changes in technologies, through the analysis of the average time to complete projects per year. These tests allows to answer the sixth research question.

CHAPTER 4 – Empirical Findings

4. Empirical findings

4.1. Economic cycles

Global scale

Correlations

		Started	Completed	Avg Height	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,908**	-,006	-,231	,921**	,911**
	Sig. (2-tailed)		,000	,964	,103	,000	,000
	N	52	50	52	51	52	45
Completed	Pearson Correlation	,908**	1	,086	-,280*	,898**	,802**
	Sig. (2-tailed)	,000		,551	,044	,000	,000
	N	50	53	50	52	53	46
Avg Height	Pearson Correlation	-,006	,086	1	-,118	,016	-,042
	Sig. (2-tailed)	,964	,551		,409	,913	,783
	N	52	50	52	51	52	45

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

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

Table 4.1: correlations between projects construction (start date, completion date and average height) and economic development at global scale.

Analysis has shown that, at different scales, skyscrapers' development and economic cycles have a relationship. At global scale was found that the year of start and completion of projects is strongly correlated with global GDP level and volume of foreign investments (visible in **table 4.1**, for full results consult **Appendix 1, Figure 1.1**). Löffler (2013) noted that construction starts of skyscrapers predict subsequent stock returns. The predictive ability exceeds that of alternatives such as the historical mean, predictions based on dividend price ratios, and recently suggested combination forecasts. Furthermore, he found that the construction of large towers is correlated with both investor sentiment and credit market conditions (Löffler, 2013). The rational asset pricing explanation is that during periods of low risk aversion, financing of large-scale projects such as skyscrapers is easier, as expected returns are higher. A long-term growth in levels of GDP worldwide since the early 90s, has coincided with a surge in tall construction. Both trends, growing economic size and construction of skyscrapers, coincide and are the result of globalization. Part of the capital coming from high levels of GDP was invested in supertall construction, which serves for global interaction. Globalization also coincided with a strong growth in level of investments worldwide. Accompanied by the rise in the internationalization of capital as the driving force in the world economy, capital mobility became an integral part of the new international division of labor (Khan, 2014). The financial deregulation of the last quarter century has meant large flows of funds around the world seeking the highest risk-adjusted return for investors (Tiwari & White, 2014). The explanation lays in the fact that as countries increased trade, production grew around the world, with GDP levels following accordingly. Profitable countries attracted foreign investments, which once invested further increased GDP levels. This relationship is proved by the fact that Global GDP levels and FDI have shown to have a high correlation between themselves. Global GDP growth plays no influence on global construction output. Construction does not contribute to economic growth, it rather follows it (Balsa, Lopes, & Nunes, 2011). GDP growth is not correlated to construction. As it can be observed in **Appendix 1**, **Figure 1.3** and **Figure 1.4**, GDP growth both at global and country level fluctuates yearly between alternating values. Since skyscrapers' construction takes years to be planned, it would be extremely difficult for developers to time beginning of construction with a period of growth (because of their short length). Furthermore, while it is relatively easy to measure GDP growth after a period has ended, it is impossible to do during a period, because of the infinite amount of risks that can arise changing the final value of GDP before the period has ended, hence changing the growth value completely. Average height does not have any correlation with economic indicators, indicating no relationship with the business cycle. These findings contradict from those of Barr (2014), whose research was focused solely on record-breaking skyscrapers. Although the value of average height changes every year, the average height of projects has grown very slowly in the past 30 years. As projects reach new heights, many more projects are built at lower heights, keeping the growth of the average height value slow. The standard deviation for average height changes between 1960 and 2015 is 29 meters. Global skyscrapers construction has had five major cycles since the 1960s. The first visible peak was hit in 1982, with the beginning of construction of 9 buildings. The second peak was reached shortly after, in 1988 with 11 buildings started. The following cycle started in 1991 and peaked in 1999-2000, with the initiation of 26 buildings for two consecutive years. After a reduction in output, growth started again in 2002, eventually reaching another peak in 2008, with 93 buildings started. Between 2008 and 2009 there was a reduction of more than 50% of new construction. In 2010 a new cycle started, reaching the peak in 2013 with 154 buildings started. Countries experience different surges of construction activity: developed countries with high urbanization levels, such as the United States, Singapore, Japan, Australia, Malaysia and Canada have been developing projects in a steady and continuous trend, exhibiting less influence of economic cycles on construction. Developing countries in the Pacific region and in Middle East, such as Indonesia, China, Saudi Arabia and the UAE, started developing projects later, with strong surges coinciding with peaks of the economic cycles.

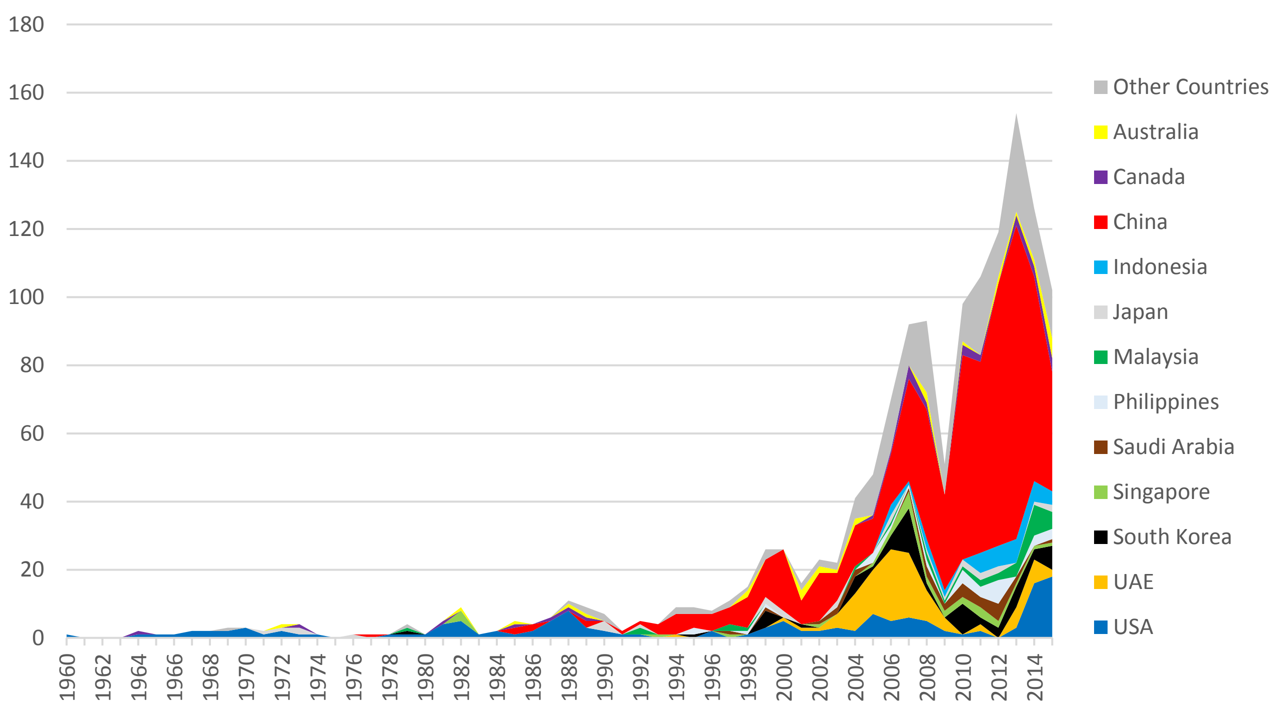


Figure 4.2: number of projects started by country between 1960 and 2015.

The global surge of construction of skyscrapers coincides with a shift in capital and investments from the geographical and cultural west to the east. As eastern countries entered the global market, unleashing their potential of growth and earnings, they attracted investments from across the world. Part of the earnings coming from production, as well as foreign investments, were employed to develop the built environment. Catering to the needs of modern business, dominated by financial services needing proximity and representative spaces, many cities started being developed vertically. As technologies were readily available and cultures inclined to tall buildings, skyscrapers started being constructed with unprecedented magnitude. The trends of capital movement and consequent attraction of investments driving tall buildings construction are represented in **Figures 4.4 and 4.5** through a series of snapshots through time.

China, hosting the largest supply of skyscrapers in the world, accounting for 43% of the global total, is a good representative of the trend. The growth in revenue, followed by the attraction of capital in the form of foreign investments towards China, and the construction of skyscrapers are highly correlated as it can be observed in **Figure 4.3**. Starting in the late 90s the movement of the three developments started being particularly correlated. Capital flow to the fast growing economy of China coincided with a strong growth of skyscrapers' construction. This finding further highlights the tight relationship between globalization and the response to it of constructing skyscrapers, and the growing importance of China as a player in the financial global market and the attraction of capital it exerts.

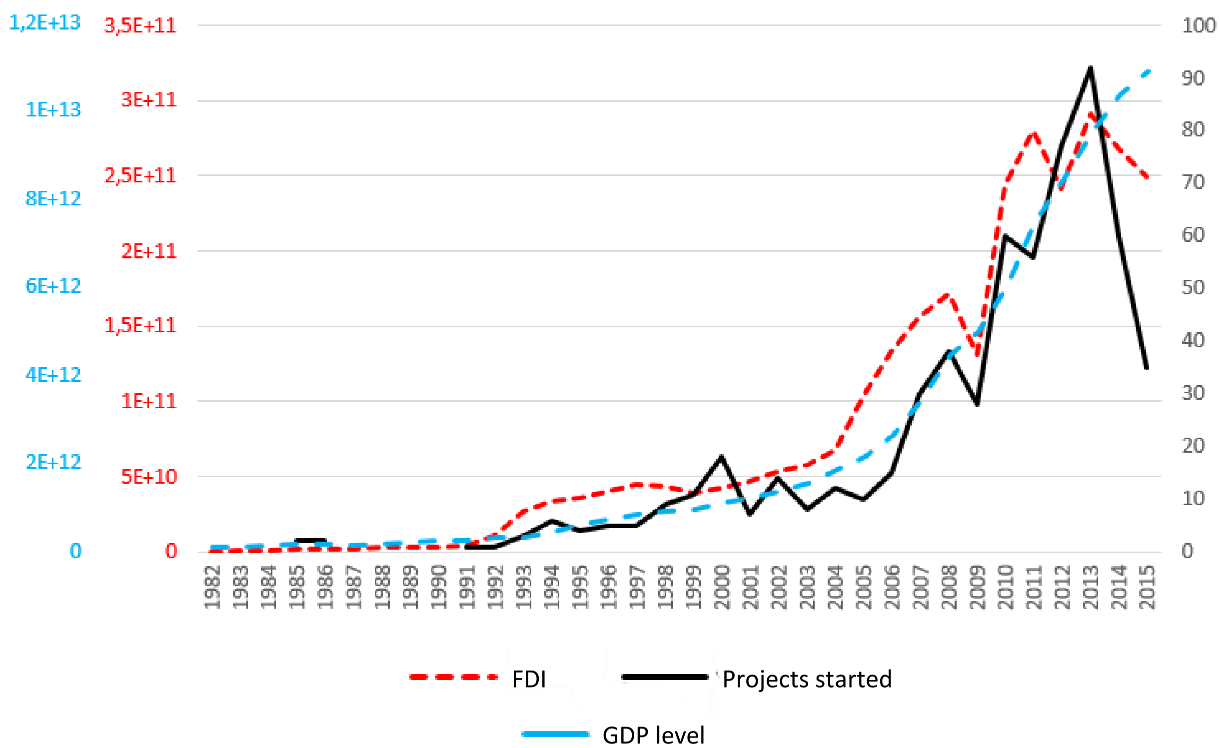
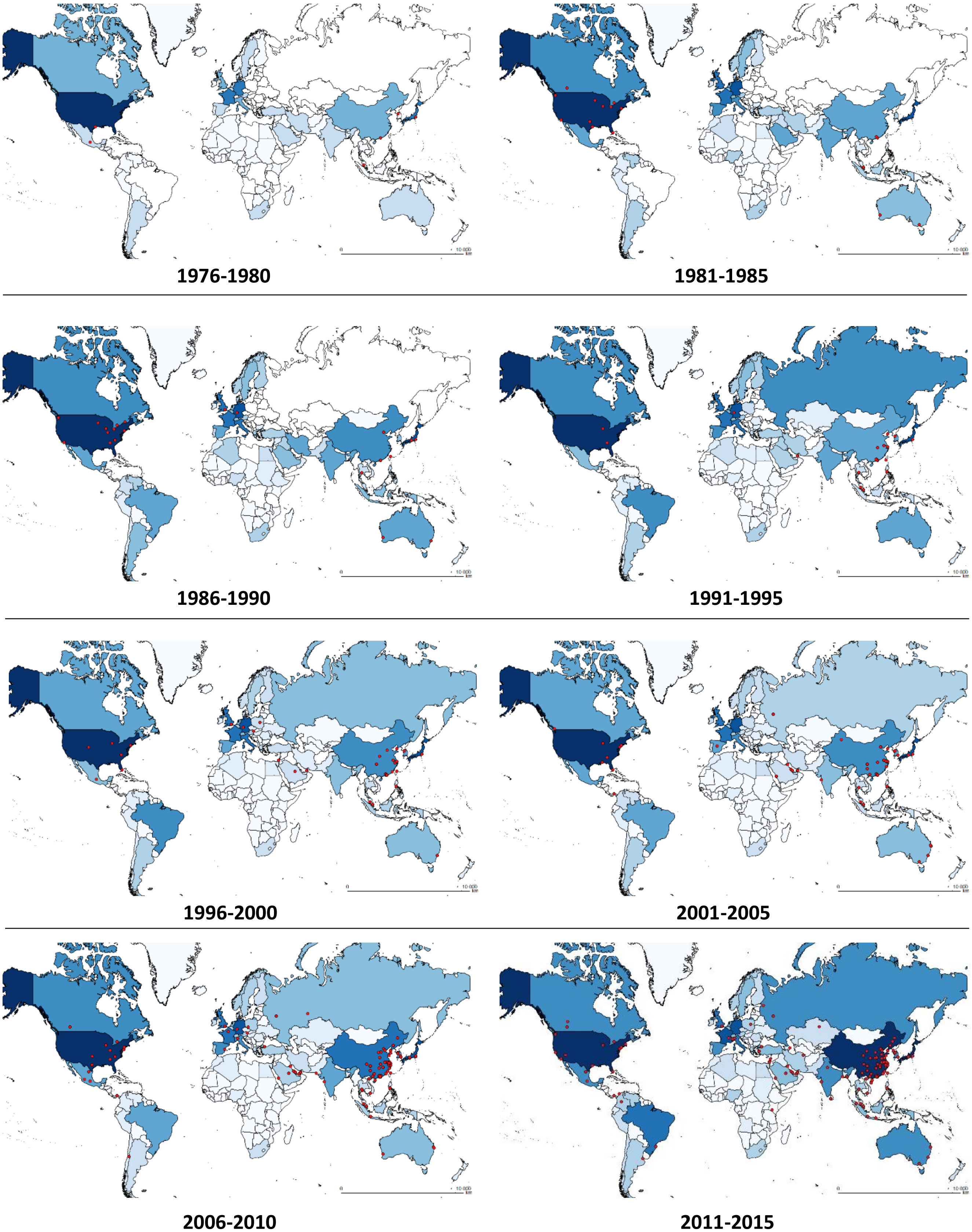
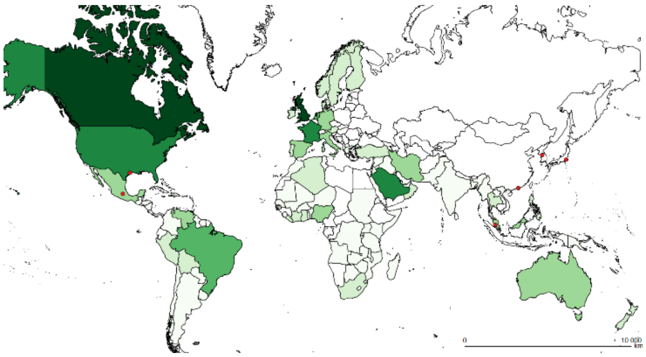


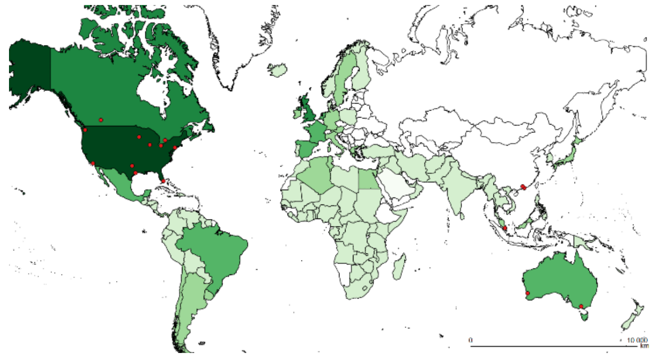
Figure 4.3: changes of GDP level and foreign direct investments and number of projects started in China between 1982 and 2015.



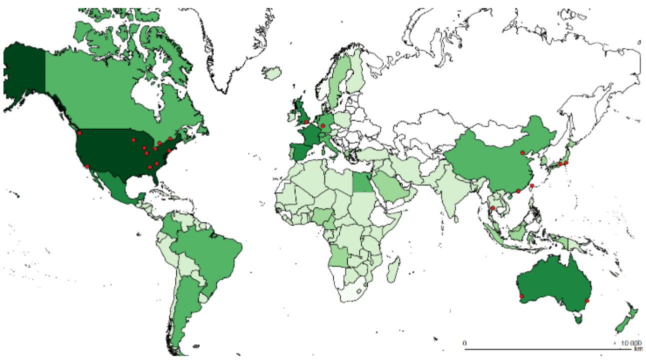
Figures 4.4: movement of capital and development of projects between 1976 and 2015. Darker blue means higher level of capital. Red dots are projects' locations.



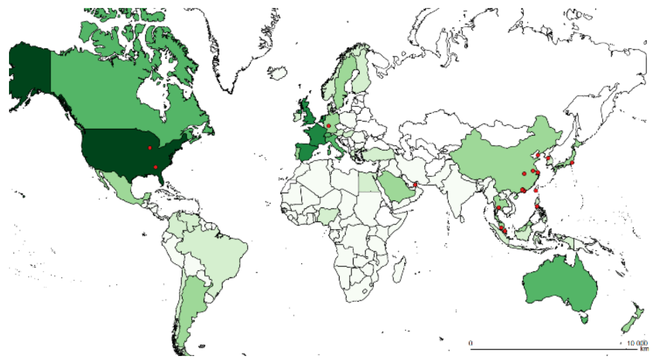
1976-1980



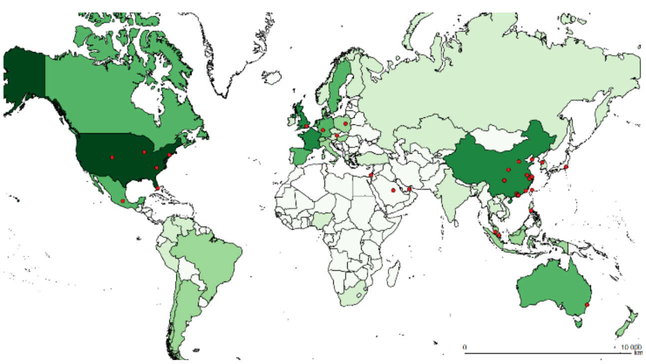
1981-1985



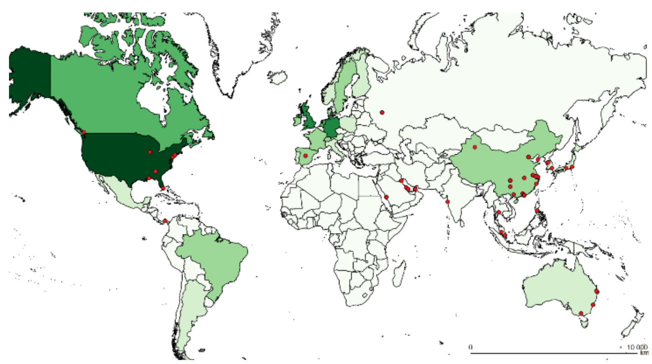
1986-1990



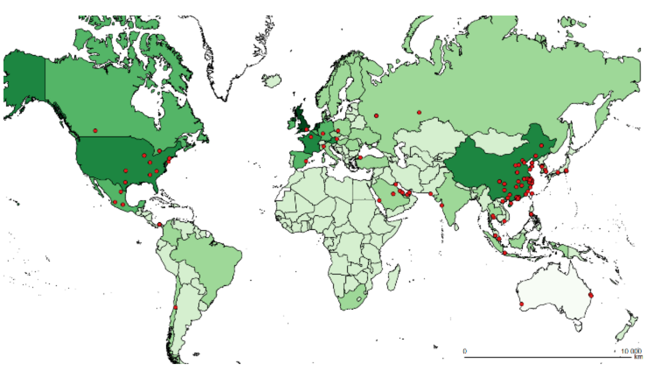
1991-1995



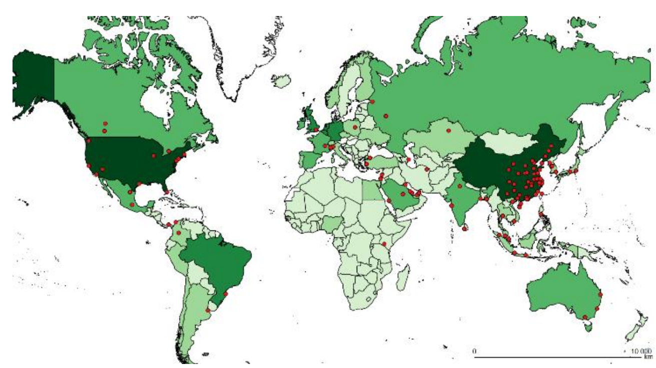
1996-2000



2001-2005



2006-2010



2011-2015

Figures 4.5: movement of capital and development of projects between 1976 and 2015. Darker blue means higher level of capital. Red dots are projects' locations.

Different functions of projects exhibit relationships of different strength with global economic cycles. Construction of residential skyscrapers has a medium correlation with world GDP level and a strong one with global investments. Hotel function has a medium correlation with global investments. Office function has a strong correlation with both global GDP level and investments. Mixed function has the strongest correlation with both global GDP level and investments of all functions. There are correlations between functions themselves (to consult full results of correlations, consult **Appendix 1, figure 1.6**). Specifically, mixed function construction has a high positive correlation with office and a medium positive correlation with residential. The reason is that mixed function, by including multiple functions in one building, is partially influenced by the same dynamics that influence the single functions it includes. There is also a medium positive correlation between residential and office construction. Hotel is not correlated to any of the other functions.

Correlations

		Residential	Hotel	Office	Mixed	World GDP %	World GDP Level	Global Investments
Residential	Pearson Correlation	1	,283	,641**	,750**	,227	,791**	,837**
	Sig. (2-tailed)		,288	,001	,000	,309	,000	,000
	N	23	16	23	23	22	22	22
Hotel	Pearson Correlation	,283	1	,418	,322	,110	,435	,628**
	Sig. (2-tailed)	,288		,060	,155	,645	,055	,003
	N	16	21	21	21	20	20	20
Office	Pearson Correlation	,641**	,418	1	,921**	-,268	,867**	,805**
	Sig. (2-tailed)	,001	,060		,000	,065	,000	,000
	N	23	21	50	50	48	49	43
Mixed	Pearson Correlation	,750**	,322	,921**	1	-,235	,908**	,896**
	Sig. (2-tailed)	,000	,155	,000		,096	,000	,000
	N	23	21	50	53	51	52	45

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

Table 4.6: correlations between functions construction and economic development at global scale.

As visible in **Figure 4.7**, different functions go through similar cycles, yet their response to exogenous causes are of different magnitudes. While single function office is still the most common type of skyscraper built, making up 41% of the total supply, different uses and users have emerged. Modern skyscrapers address issues of population growth, urbanization, and rapidly depleting nonrenewable resources. Accordingly, they are driven by ideas about energy and ecological and environmental sustainability (Gray & Merril, 2012). These emerging trends led to the surge of skyscrapers being employed for residential and commercial purposes as well. While the early peaks of 1982 and 1988 were dominated by office buildings construction, the dot-com bubble stimulated both residential and office construction starting in 1997 and peaking in 1999. In 2002 a new cycle started, with a surge in construction of all functions. Single function hotel skyscrapers have been started only in the early 2000s and, although in small proportion, hotel skyscrapers development has been uninterrupted since then. As confirmed by the correlations, hotel function construction is independent from other functions' construction and it is not influenced by the same drivers. Residential function peaked in 2007 with 38 projects started, a new record in number of projects started for any function in history. Mixed peaked in 2008 with 29 projects. Both functions were negatively affected by the financial crisis, which led to the reduction of residential projects by 90%, and a reduction of 50% of mixed projects by 2009. Office function was minimally influenced by the financial crisis and its construction kept growing until 2013, when it peaked with 63 projects started. All functions' construction took a downturn beginning in 2013, with office reducing production by 70%, taking output to the 2006 level. Office has the highest volatility of all functions with a standard deviation of 15.4. Residential function has the second highest standard deviation at 14.3. Mixed has a standard deviation of 11.9. Hotel has the lowest standard deviation at 1.5.

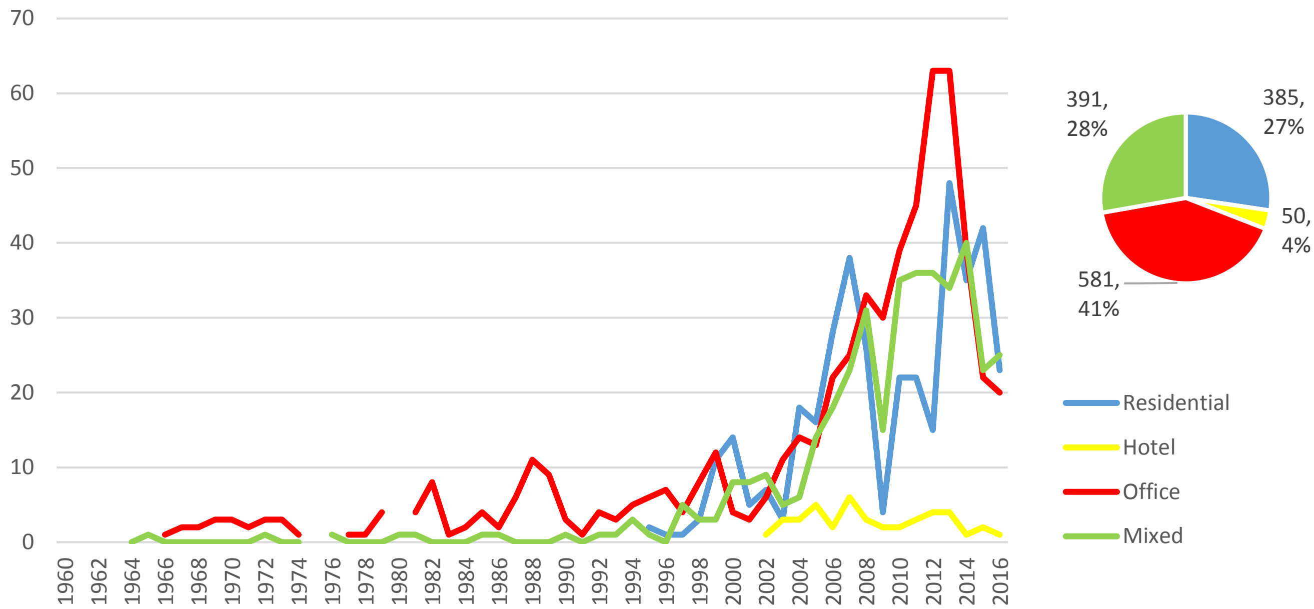


Figure 4.7: number of projects started per function between 1960 and 2016.

A wide collection of uses is simply driven by the business case of the owner (Davis, 2012). As the employment of supertall buildings have expanded among different users, so have their specific functions. It is clear that a major limitation on the practical development of ultra-tall buildings is the selection of a physical manifestation for the project which might allow different business cases to be delivered during a long construction period (Davis, 2012). Because of the length of construction of supertalls, they risk of being initiated in a moment of boom, and delivered in a moment of bust, adding to the problem of oversupply of space. Multifunctional projects can achieve higher feasibility and resilience than single function ones: by offering different types of space, demanded by industries influenced by different dynamics, the portfolio of space supplied is more diversified, hence less exposed to unsystematic risk.

Regional scale

		ECONOMIC DEVELOPMENT					
		REGIONAL			GLOBAL		
		GDP GROWTH	GDP LEVEL	FDI	GDP GROWTH	GDP LEVEL	FDI
PROJECTS STARTED	EAST ASIA & PACIFIC	**0**	**+ + +**	**+ + +**	**0**	**+ + +**	**+ + +**
	EUROPE & CENTRAL ASIA	**0**	**+ +**	**+ +**	**0**	**+ +**	**+ +**
	LATIN AMERICA & CARIBBEAN	**0**	**0**	**+**	**0**	**+**	**+ +**
	MIDDLE EAST & N. AFRICA	**+**	**0**	**+ +**	**0**	**0**	**+ +**
	NORTH AMERICA	**0**	**+ +**	**+**	**0**	**+ +**	**+**
	SOUTH ASIA	**0**	**0**	**0**	**0**	**0**	**0**

Table 4.8: summary of results of correlations by region.

At regional scale more correlations were found between construction and economic cycles. Each region has almost identical correlation results between its construction and economic indicators at both regional and global scale (specifically GDP level and FDI). This means that regional and global economies exert influences of similar strength on this typology. The more skyscrapers regions build, the closer the correlation between construction and economic cycles, with the exception of Middle East. East Asia and Pacific region is the one with most projects (954) and the closest correlation between projects started and both regional and global economic development. South Asia, the region with the least projects (35) does not have any correlation between construction and economy at any scale. At regional scale the economic indicator that plays the biggest influence is FDI, indicating that movements of capital definitely fuel supertall construction. International capital follows an investment opportunity granted by a specific market, taking into account the political stability of the location, the volatility of the individual market, and the legal and tax hurdles involved (Volckens, 2011). Of all regions, East Asia and Pacific is the one whose supertall construction industry relies on international investments the most. North America, regardless of the large amounts of foreign investments it attracts, has a small correlation between development and foreign investments. The region has the highest GDP of all regions, meaning it has enough capital of its own to invest in supertalls. Latin America and Caribbean at regional scale exhibits only a low correlation with foreign investments. As the countries within this region present very different stages of development in their economies, the overall result is very different cyclicality in their construction output. Middle East and North Africa is the only region that has a correlation between construction and GDP growth (although a low one). No region has any correlation with global GDP growth.

Correlation tables for each region are available in **Appendix 1, figures from 1.7 to 1.12**.

Country scale

		ECONOMIC DEVELOPMENT							
		NATIONAL					GLOBAL		
		GDP GROWTH	GDP LEVEL	GDP LEVEL DEFLATED	INTEREST RATES	FDI	GDP GROWTH	GDP LEVEL	FDI
PROJECTS STARTED	AUSTRALIA	0	0	0	0	0	0	0	+
	CANADA	- -	+ +	+ +	-	+ +	0	+ +	+ +
	CHINA	0	+ + +	+ + +	-	+ + +	0	+ + +	+ +
	INDONESIA	0	+ + +	+ + +	- -	+ + +	0	+ + +	0
	JAPAN	0	0	0	0	-	0	0	0
	MALAYSIA	0	+	+	0	0	0	0	0
	PHILIPPINES	0	+ +	+	-	0	0	+ +	0
	SAUDI ARABIA	0	+	0	NN	0	0	+	0
	SINGAPORE	0	0	0	0	0	0	0	0
	SOUTH KOREA	0	0	0	0	0	0	0	+
	UAE	-	0	0	NN	0	0	0	0
	USA	0	+	+	0	+	0	+	+

Table 4.9: summary of results of correlations by country.

The countries that have the strongest correlations between construction and economic performance are those with lower-middle and upper-middle income economies. According to the World Bank classification, lower-middle income countries are those with a GDP per person between $1.026 and $4.035; upper-middle income countries are those with GDP per person between $4.036 and $12.475; high income nations are those with GDP per person above $12.476 (World Bank Group, 2017f). According to this classification, Indonesia and the Philippines belong to the lower-middle income group. China and Malaysia belong to the upper-middle income nations group. All the other countries belong to the high income group. Only two countries belonging to this last group exhibit multiple correlations between construction of supertalls and economic cycles: Canada and USA. The observed correlations are given by the importance that the construction sector has in the analyzed economies. The importance of the construction sector is not only related to its size but also to its role in economic growth (Dlamini, 2012). Most developing countries employ construction as a catalyst for employment and attraction of investments. Policymakers in developing countries are advised to introduce policies that guarantee the development and long-term viability of the market by focusing on lowering the cost of lending and spurring the development of the market by creating a mortgage finance agency that enhances the markets' access to capital (Al-Rasheed, 2011).

Results from analysis align with those of Dlamini (2012): countries with the highest correlations between construction and economic activity are those belonging to the newly industrialized group (NIC): China, Indonesia, Malaysia and Philippines. As construction activity adds a considerable part of value to the overall economy, the development of the two is intertwined.
Unlike regions, countries that develop more do not necessarily exhibit a stronger correlation between construction and economic performance. Countries tend to have the same strength of correlation between national and global GDP level. This means that national and global GDP levels exert influences of

similar strength on this typology. With the exception of the Philippines, all countries exhibit the same strength of correlation for both normal and deflated GDP level. This indicates skyscrapers' building does not occur more intensely during periods of high inflation. This finding partially disagrees with the Skyscraper Index concept theorized by Lawrence (Lawrence, 1999), by showing that moments of high inflation, which usually precede an economic downturn and coincide with high speculation, do not stimulate more supertalls construction. The countries whose construction of skyscrapers is mostly correlated with national economic development are China and Indonesia. They both have high correlations between construction and both GDP level and FDI. Both countries have experienced fast growth of their economies in recent times, fueled by foreign investments, attracted by the prospect of economic growth itself. Part of the capital produced through the years has been invested in supertall construction with a pace similar to that of economic expansion. China presents a low negative correlation with interest rates while Indonesia has a medium negative correlation with interest rates. The latter has experienced very high levels of interest rates, on average 16.8 in the last 20 years (World Bank Group, 2017c). With such high rates, developers become cautious in planning expensive construction, waiting for rates to be lowered. China experienced lower levels of interest, 6.43 on average in the past 20 years, yet developers rely on debt to build tall and are sensitive to changes in its cost. Both countries show no correlation between construction and GDP growth at either scale. Canada presents medium correlations between construction and GDP level and FDI, both at national and global scale. The country presents a low negative correlation with interest rates, although levels have been relatively low (average of 4.7 in the past 20 years, 3.6 in the past 10) (World Bank Group, 2017b). This indicates developers in Canada are sensitive to changes in the cost of debt. Malaysia shows only a low positive correlation with national GDP level. Saudi Arabia has a weak correlation with GDP level both at national and global level. Interest rate analysis was impossible for both Saudi Arabia and United Arab Emirates as interest rates are not applied in these countries. The United Arab Emirates presents no positive correlations with any of the economic indicators at both national and global scale. It presents only a low negative correlation with GDP growth. The United States has a weak positive correlation with GDP level and FDI, both at national and global level. No correlation was found with interest rates, indicating either developers are not very sensitive to changes in cost of debt, or private equity is being used to construct supertalls. No correlations were found between construction and national economy for 3 out of 12 countries: Australia, Singapore and South Korea. All these three countries have common characteristics in the cyclicality of their development: they started developing early, towards the end of the 70s; construction output was modest but continuous, with relatively low volatility; low influence from exogenous events, such as global financial bubbles. In these countries supertall development is separated from economic performance. Japan's construction showed no correlation with any of the economic indicators, except a low negative correlation with foreign investments. Both skyscrapers and economic developments are unique in Japan compared to other countries. Although it started building supertall early in the 70s, most of the completions happened after the year 2000. The national economy, unlike the rest of the world's, was disrupted by the advent of globalization, exhibiting continuous high peaks followed by low troughs starting from the early 90s (World Bank Group, 2017d). Instead of adapting to the changing economic conditions, skyscrapers development was carried out regardless of national economic performance.

Correlation tables for each country are available in **Appendix 1, figures from 1.13 to 1.24**.

4.2. Geographic distribution

In this chapter are presented the findings from the analysis of projects' distribution worldwide. The findings are first articulated through the presentation of the global geography by showing projects locations through maps. In these maps are shown projects' functions too, to see if different locations tend to develop specific functions. Afterwards, the findings regarding the relationship between global cities and supertall constructions are presented. At last are introduced the findings from the analysis and comparison distributions among cities within single countries.

Figure 4.10: locations of all projects completed between 1909 and 2016.

As it can be observed from the map above, projects are mainly localized in the northern hemisphere with high concentrations in North America, Europe, Middle East and Pacific Asia. The map simply shows locations, without taking into account the number of projects located in one place. The clusters of projects were analyzed at regional scale. As it can be seen in **Table 4.11** on the next page, the share of projects by both region and country worldwide is disproportionate, with a strong polarization of projects in the East Asia and Pacific region, and more specifically in China, which holds 43% of the world supply.

Region	Country	Projects started
East Asia and Pacific		954
	Australia	34
	China	651
	Indonesia	40
	Japan	28
	Macau	1
	Malaysia	37
	North Korea	3
	Philippines	33
	Singapore	28
	South Korea	63
	Taiwan	7
	Thailand	18
	Vietnam	11
Europe and Central Asia		63
	Austria	2
	Azerbaijan	1
	France	3
	Germany	5
	Italy	3
	Poland	4
	Russia	19
	Spain	5
	Turkey	12
	United Kingdom	9

Region	Country	Projects started
Latin America and Caribbean		43
	Argentina	1
	Brazil	6
	Chile	1
	Colombia	4
	Mexico	11
	Panama	20
Middle East		173
	Bahrain	7
	Iran	1
	Israel	3
	Kuwait	9
	Lebanon	1
	Qatar	15
	Saudi Arabia	28
	UAE	109
North America		195
	Canada	30
	USA	165
South Asia		35
	Bangladesh	3
	India	28
	Pakistan	1
	Sri Lanka	3

Table 4.11: summary of projects started per region and countries between 1909 and 2016.

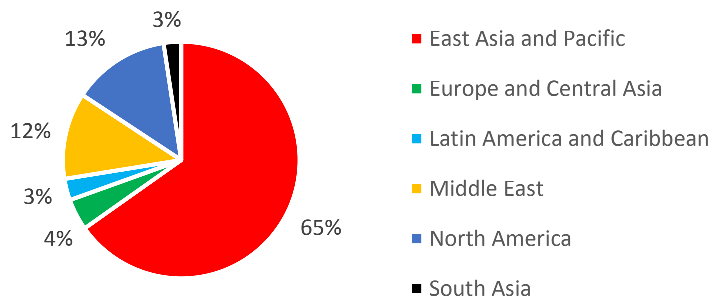
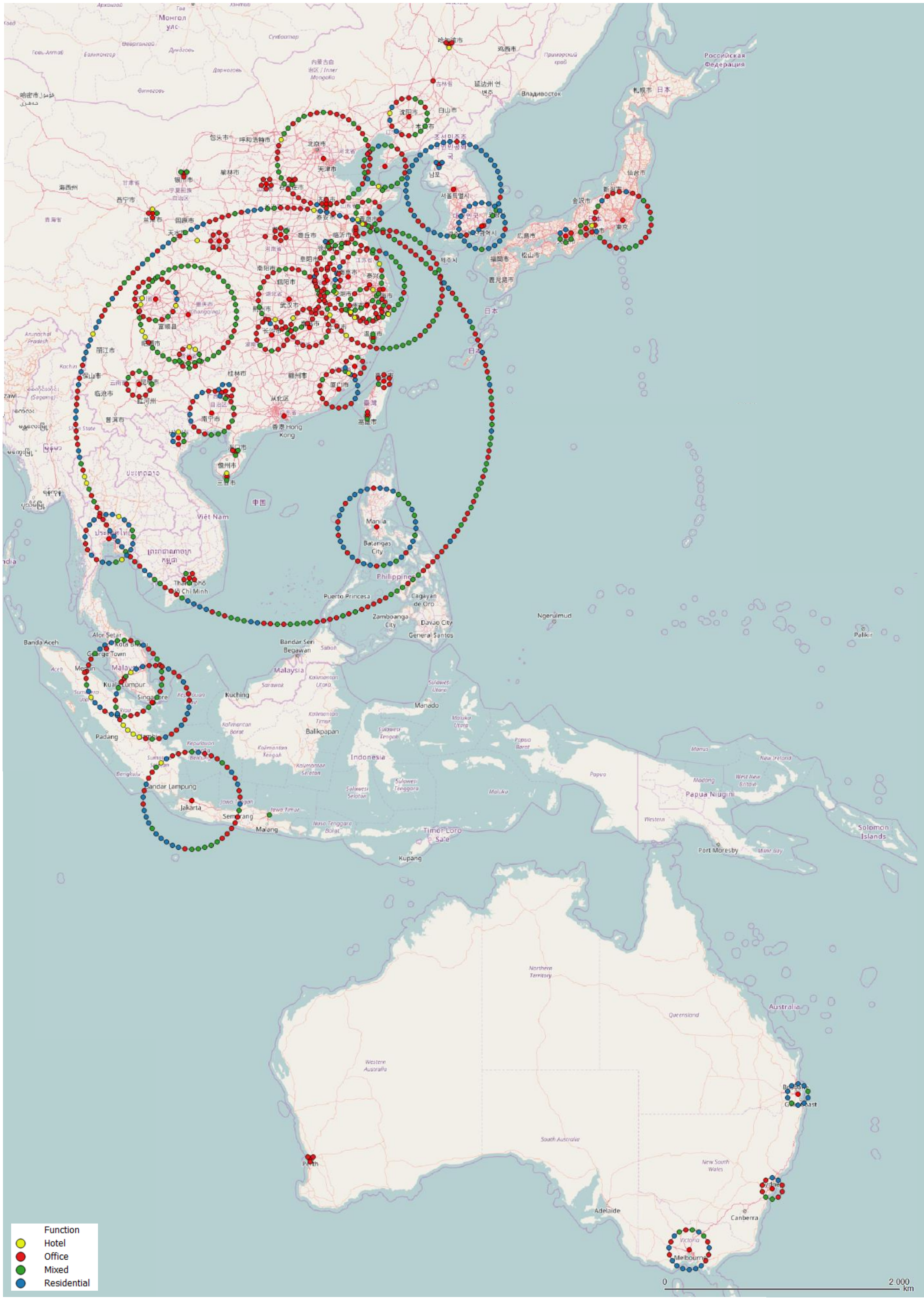


Figure 4.12: share of projects per region.

Each region is presented in the next pages on maps, with the representation of number of projects per location, as well as specific building functions. The maps' scales have been adapted to fit the pages. A ruler scale and a legend is present for each image. When a location has multiple projects, a circumference containing all projects is drawn around the point. Regions show very different development patterns because of their characteristics. These differences were highlighted through the study of projects' location, concentration and function.

(next page) Figure 4.13: projects location and functions in East Asia and Pacific region


Function
Hotel
Office
Mixed
Residential
0
2 000
km

East Asia and Pacific

In East Asia and Pacific region, projects are distributed between many locations, yet we see extreme concentrations in particular areas. Financial and governmental centers are the most developed locations, although in China second-tier cities too can exhibit high levels of development. Countries in the region tend to polarize skyscrapers in few locations except to China, exhibiting a ramified network of localizations linking different nodes. The region presents different functions' distributions depending on country. In Japan, mainly office and mixed function buildings have been built. South Korea, with Seoul having the highest concentration, tends to develop mostly supertall residencies. The country is highly urbanized, densely populated and culturally accustomed to tall buildings in urban areas. Philippines, Malaysia, Indonesia and Singapore have high levels of primacy, with one primate city capturing most of the development of the country. Singapore is the second city in the world with the highest number of single function hotel: 5. Australia has projects distributed throughout its major cities, with the highest concentration in Melbourne. The city is the major seaport of Australia, specialized in several industries such as finance, manufacturing, transportation and tourism. The Australian portfolio is diversified in its functions, with a slight propensity for residential projects.

Tall buildings did not start being developed until the mid-80s in this region, with the exception of Japan and Singapore, which started the previous decade with modest numbers. Single countries react differently to exogenous causes, exhibiting unique cyclicality in projects' development. The first peak of production this region hit was in 1999-2000 with 20 projects started. China, South Korea and Japan developed cumulatively 73% of the world total output over the two years. The next peak of the cycle was in 2007 with 51 projects started. The region accounted for 58% of global production for that year. Except for South Korea and Japan, the other countries of the region were not impacted by the 2008 financial crisis in terms of output. The next peak was reached in 2010 with 83 projects started. China, South Korea and the Philippines were the ones developing the most, respectively 60, 9 and 4 projects. The next peak in production was reached in 2013, with 112 projects started. China reached its highest level ever with 92, Indonesia followed with 7, South Korea with 6 and Malaysia 4. Since then, almost all countries in the region reduced production with the exception of South Korea, which started 7 projects in 2015. Overall regional production was of 68 projects started in 2015, a reduction of almost half in two years. Australia followed a pattern of its own, independent from exogenous causes. Except for few projects started in the 80s and 90s, development started in the early 2000s with an almost discontinued production of 3 projects per year.

The factors that led countries in this region to build tall are different, and this can be deducted by how the countries react differently to external forces as well as the difference in timing of their development cycles. In the northern area of the region, Japan and South Korea's development of tall buildings share some factors: high GDP levels; deep involvement in global trade; high urbanization rates; cultural inclination towards high density and vertical development. South Korea has developed more intensely than Japan in the last decade because of the sluggish economic growth of the latter as well as its widespread fear of earthquakes, which has reduced the Japanese cultural acceptance for supertalls. In the southern area of the region, Indonesia, Malaysia and Philippines share some factors that led to the construction of supertalls: fast growing economies; high levels of primacy of their cities; very recent urbanization process; fast demographic growth. The main factors leading Australia to build tall are: high levels of GDP; high involvement in global trade; high rate of urbanization.

China, because of its size and level of development, needed to be analyzed on its own. The images below portray the two areas in the world with the highest concentration of projects: the Shanghai area in the East and the Shenzhen/Hong Kong area in the south. In these two areas are located more than 350 projects, making up for 55% of China supply and 30% of the world supply. The reasons for these concentrations are multiple.

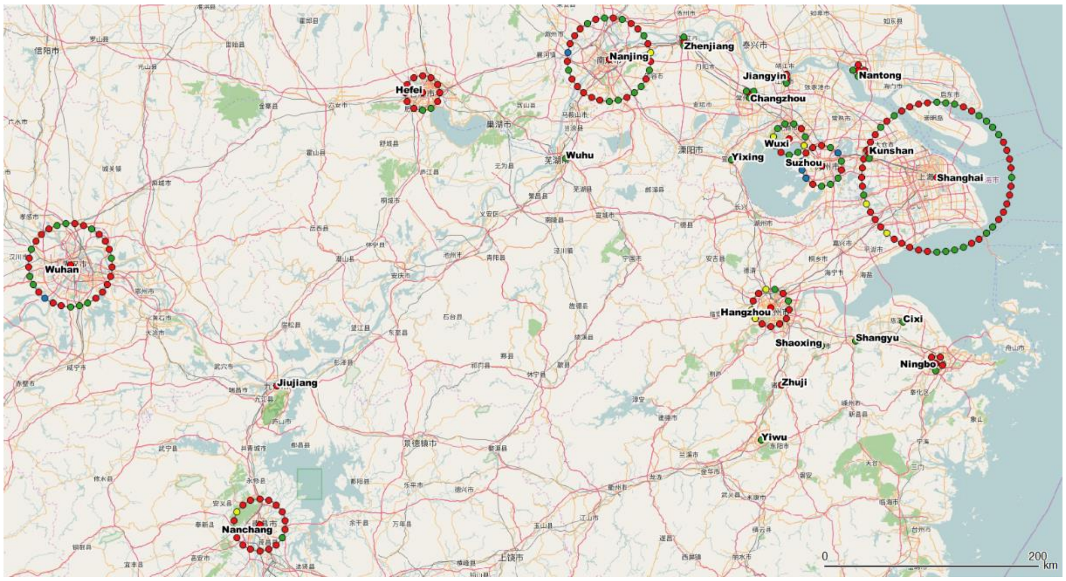


Figure 4.14: Shanghai area.

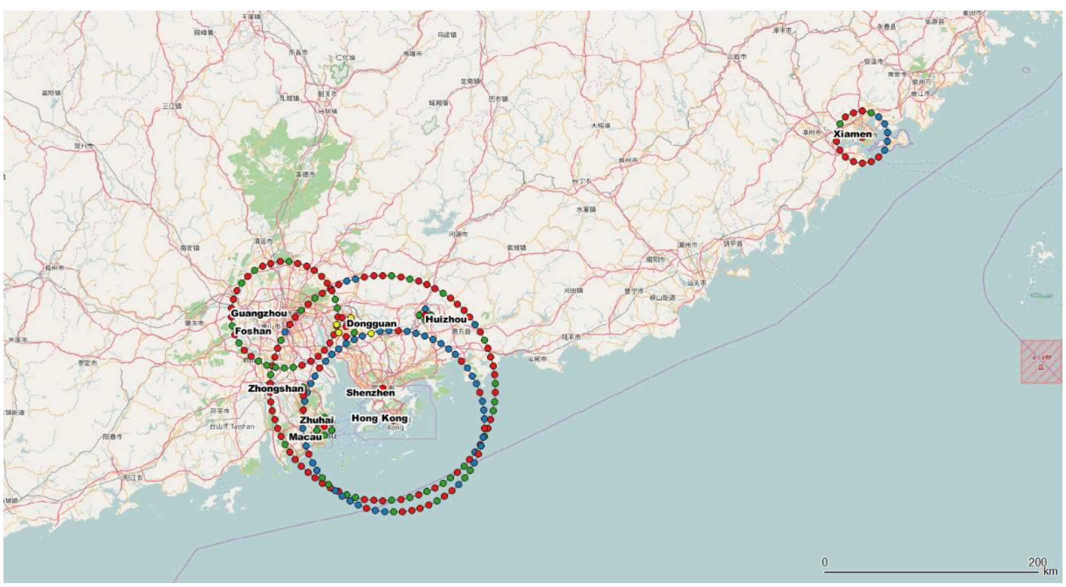


Figure 4.15: Hong Kong area.

These areas have the highest levels of urbanization in the world, with the concentration of very populous cities in relatively small space. Urbanization now plays a crucial role in the interconnected network of multinational firms and urban settlements (Lo & Yeung, 1998). Hoyt (1933) first associated movements of people and urbanization with real estate cycles. Both areas are deeply involved in world trade, with each cluster specialized in multiple fields: finance, logistics, government, transportation, real estate, manufacturing and more. The real estate demand has been growing and diversifying in the past decades, following the development of the economy. The establishment of Chinese cities in these areas (for the exception of Hong Kong) as global nodes has developed much later than western cities. China started only in the early 2000s being engaged deeply in world trade, resulting in a fast growth of its GDP and attraction of international investments. At the same time, the central government stimulated the economy by offering very low interest rates and stimulus packages for several industries involved in real estate construction, such as steel and concrete manufacturing. Chinese large cities that engaged in global trade have experienced a strong urbanization growth, with an extreme growth in demand for space for multiple functions. This means these urban areas have developed very quickly in the past 20 years. As a response to the growing pressure of population growth, and with a large amount of capital, both domestic and international, to invest, these areas started building tall intensely. As building technologies were readily available, and demand was strong, the only limit to the supply of tall real estate was regulation. Local governments, under the guidance of the central government to foster and support development, have stimulated tall buildings' construction through different perspectives: as regulators, users and investors. The central government saw real estate development as a strong tool for the creation of jobs, increase production and to renew the image of China as a modern nation. The two areas considered here, include most of China's Special Economic Zones (SEZs). In these areas, special economic policies and flexible government measures apply. These areas have as main objectives to foster economic development, through the attraction and employment of foreign capital and the stimulation of global trade (Leong, 2013). Building regulations as a result, tend to be more adaptive and flexible to achieve the aforementioned aims. The afore described trends started changing in 2012, when the central government decided to restrain annual GDP growth and reduce it from a double digit figure to a more sustainable 7%. At the same time, interest rates were slightly increased to restrain widespread investments (World Bank Group, 2017a). In the same period, multiple overly-ambitious projects all over the country experienced having their permits denied, signaling a change of direction of the central government to a more long-term considerate investment policy. The biggest example of this change of direction was the withdraw of planning permits from Sky City in 2013, a project located in Changsha which was set to beat the existing world record of height with a construction process lasting only 90 days (Holloway, 2012). Regardless of availability of capital and demand, the government saw the project as speculative in nature. The result of the aforementioned changes in governance, was a reduction in production of skyscrapers construction in China: from 92 buildings started in 2013, to 39 in 2016, a reduction of 60%. These findings disagree with Thornton's (2005) observations, as there was no financial depression following the construction boom. The factors that led to the intense development of supertalls in China can be summarized through few key points: fast economic growth, providing the capital for construction and stimulating demand for real estate; attraction of international investments; strong government support and influence in regulating both economy and the built environment; fastest urbanization process in history; cultural inclination towards high density and vertical development.

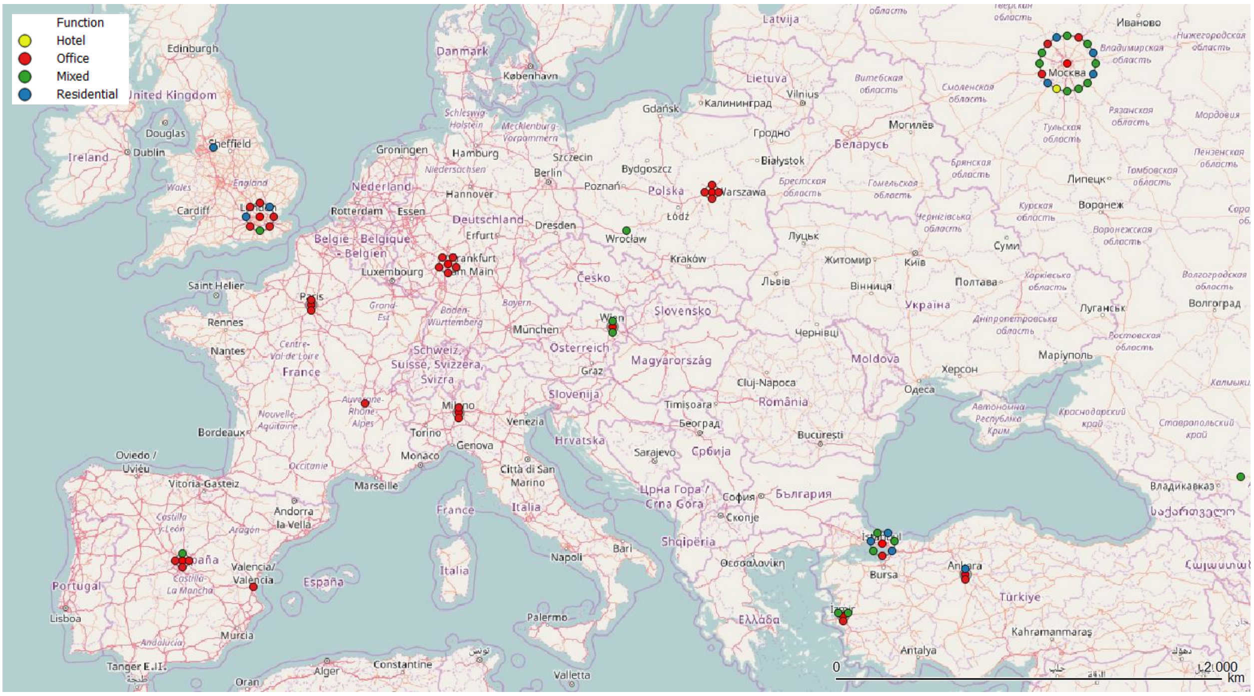


Figure 4.16: projects location and functions in Europe and Central Asia region

Europe and Central Asia

Europe hosts a small amount of projects compared to the rest of the world, in relation to its economic development or engagement in global trade. The region's construction of skyscrapers has been sporadic through the years, increasing only in the early 2000s. Peak of production was reached in 2011 with only 6 projects completed. Most projects are single function offices located in the financial capitals of the region. Each country's projects are situated in one location. These buildings serve as high-end spaces for businesses engaged in global financial trade. As Europe has a stable demographic growth and its global cities have been established as global nodes for centuries, the continent is not experiencing the strong urbanization phenomena that drives tall construction in other locations. Instead tall buildings in Europe are the result of the clustering of specific economies in tight business districts within historic built environments. As a result, few projects in Europe have a residential function. Only cities that develop several projects, present diversification in functions, such as London and Moscow. There is only one single function hotel in the whole continent, located in Moscow. The reasons why development has been only modest in Europe are multiple: urbanization happened in the past; demography grows slowly; heritage of the built environment prevents vertical development; capital is not polarized in the hand of few; central and local governments do not use iconic modern architecture to attract in a large extent.

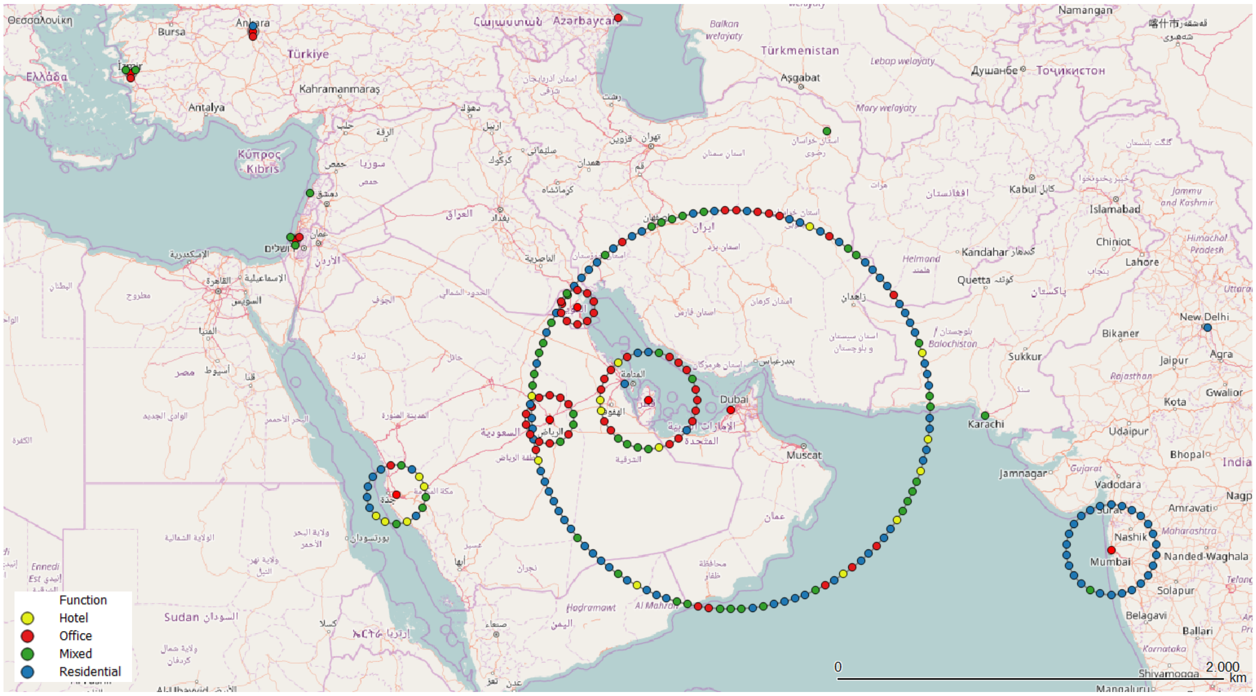


Figure 4.17: projects location and functions in Middle East and North Africa region.

Middle East

Projects in the Middle East tend to be polarized in few locations were development is very intense. These locations usually coincide with countries' capitals and most populous agglomerations. The establishment of these settlements as global cities is very recent, and was partially fueled by the investments made in their built environment. Spectacular architecture is seen in the region as a way to allocate earnings and an attraction for tourism. The phenomena of intense real estate development in the region has been part of a strategy to diversify economies from their main source of income: oil. Construction of skyscrapers in UAE and in smaller scale Saudi Arabia started in the early 2000s, with a strong growth over the next few years. In 2006 the peak was reached, with UAE being the country in the world developing the most for that year: 21 projects started. Production started reducing the next year, continuing shrinking until 2009, when the city of Dubai defaulted on its debts. Since then, production has been of a much lower volume but more steady, with a less volatile trend. Saudi Arabia started developing later than UAE, with a more paced and less volatile output volume. Dubai is the city in the world with most projects completed: 71. It is also the city with the most single-function hotels: 9. Dubai presents a high level of primacy: the number of projects located there is disproportionate with the amount developed in surrounding cities. Projects' functions in Middle East tend to be more diversified than in other regions. Hotel function appears often. In general little presence of office, especially in Dubai and Abu Dhabi. This makes sense as the two are touristic capitals and not financial centers, hence supertall real estate is employed as high-end residential and hotel space, not office space. The drivers that led to the construction of such a large amount of supertalls in little time in Middle East are: large availability of capital to invest; support and initiative by government to develop intensely and spectacular; capital and rule rest in the hands of few.

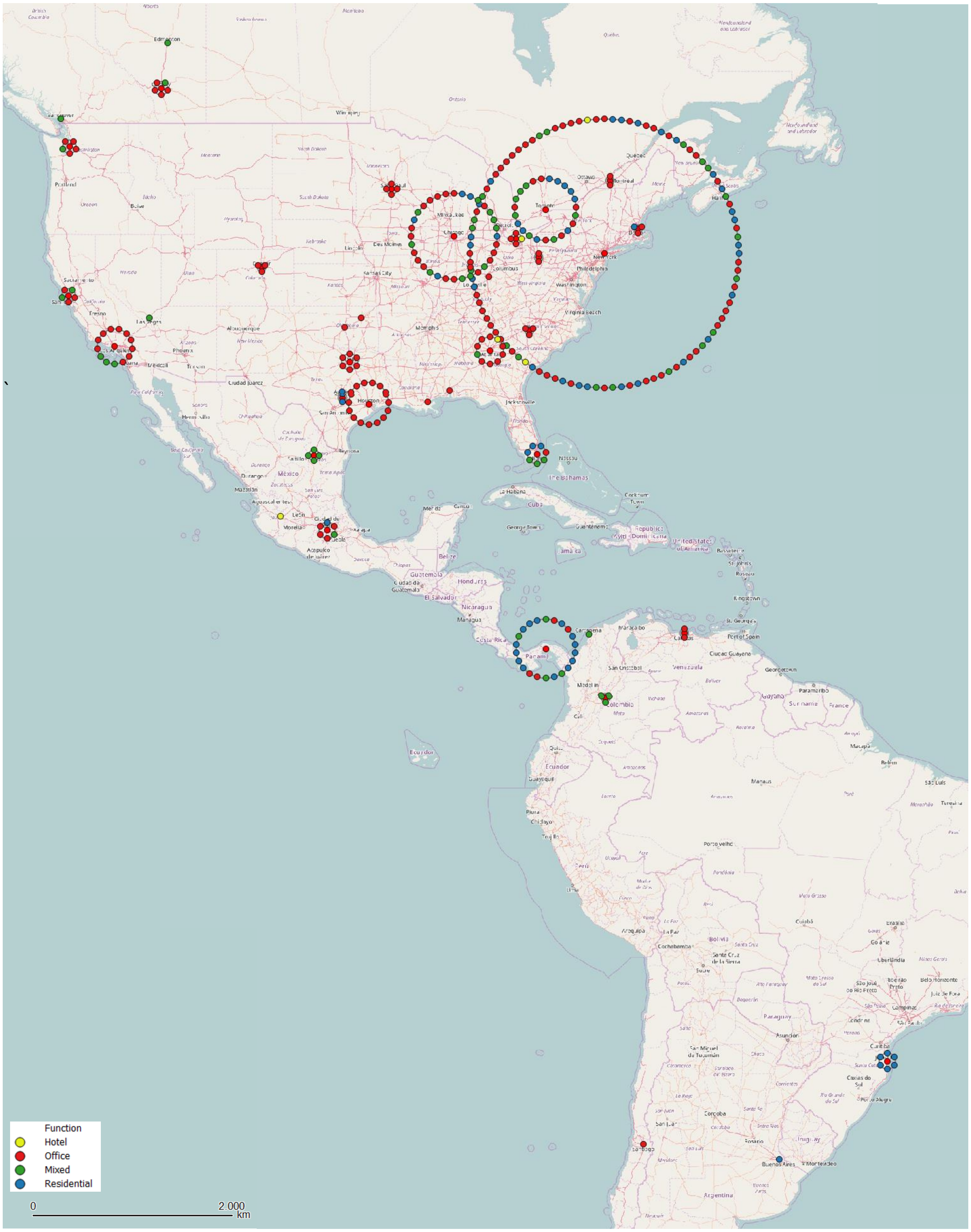


Figure 4.18: projects location and functions in North America and South America & Caribbean regions.

North America

North America has built many projects distributed over a large territory. This region has been developing projects for the longest timeframe, since 1909. Projects in North America tend to be mostly offices clustered in the established global cities of the region. Miami is the only city in the United States that has more residential and mixed function projects than office. Regardless of the cities' specializations in different industries, functions distributions are homogeneous throughout the region. The only cities that have a truly diversified portfolio are the ones that construct the most: New York, Chicago and Toronto. New York captures a disproportionate amount of projects compared to the surrounding cities. Except few exceptions, single-function hotels are not developed in North America. As for the rest of the world, the few existing hotels are situated in the city that develops the most.

The United States accounted for most of the production of skyscrapers for the peaks of 1982 and 1988. By the next peak, in 1999-2000, United States' production accounted for only 13% of the total. By then, production of supertalls in developing countries had started. The United States never experienced the extreme oscillations of developments other countries exhibited. The standard deviation for projects' construction is 3.5, compared to China's 25. The reasons the response to the business cycles is not as extreme in the United States lies in the fact that the government does not support or stimulate development of supertalls nearly as much as other countries' governments do. The separation between the public and private sector prevents the government from being able to influence the supply side to a considerable extent (World Bank Group, 2017e). The next peak in United States' construction was reached in 2015, with 18 projects started, most of which were located in New York, further increasing the polarization of projects. The factors that have influenced the development of supertalls in North America are: large availability of capital to invest; heavy involvement in global trade and the resulting demand for high-end real estate; relatively recent urbanization process; cultural acceptance of typology; small governmental interference with construction development.

South America and Caribbean

Supertalls in this region are located in the governmental capitals of the different countries, with just few exceptions in Mexico and Colombia. Urban primacy of the largest cities in South America is very high, making the populations disproportionately large compared to the other settlements. This phenomena is here reflected by the fact that only these prime cities are the only ones with enough demand and capital to construct skyscrapers. In this region can be observed a tendency to build residential skyscrapers. Vertical construction, employed specifically for residential use, has been employed for a long time in South America to create density. This is a response to the growing pressure of overpopulation in many of the capitals of the region. Construction of supertalls in the region has begun only in the early 2000s, with the advent of globalization. More projects have been built in the Caribbean area over South America, with Panama City being the location with the most projects in the whole region. The city has large amounts of capital to invest from its industries, banking and commerce, as it is located in one of the most important nodes of commerce in the world, the Panama Canal. Most projects are either residential or mixed, indicating that they do not provide space for the functioning of the economy. The growth of the city's touristic industry correspond with the rise of these buildings, which serve as an attraction for people and investments. The factors that have influenced the modest development of supertalls in South and Central America are: relatively low levels of GDP; lacking full integration in global trade; recent urbanization process; high urbanization rates; cultural acceptance for this typology.

Figure 4.19: projects location and functions in South Asia region

South Asia

South Asia is the region that has developed the least amount of projects. India is the biggest constructor of skyscrapers in the region, with 28 projects started. Most projects are located in Mumbai, India's most populous city. Development of projects in the region did not start until the early 2000s, with the advent of globalization. All projects except one are residential, indicating supertall construction is employed to respond to a growing demand for residential real estate. Because of its potential for urbanization and its forecasted future economic growth, India might witness a strong growth in construction of skyscrapers in the next years, similar to that of China. This development will depend on the future availability of capital, influenced by productivity and attraction of international investments, and from the government's interference on the process.

Global cities

To consult the complete list of global cities and the number of projects built in each location, please consult **Appendix 2, figure 2.1**.

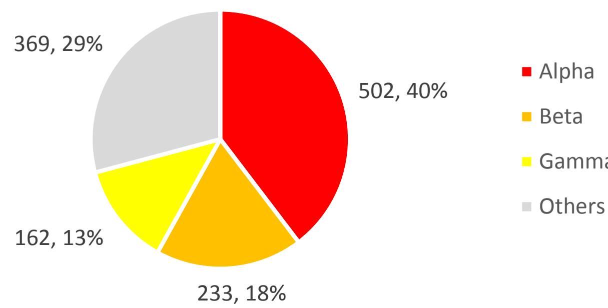


Figure 4.20: distribution of projects started between 2000 and 2016 among global cities and standard cities.

Between 2000 and 2016, 1266 projects have been started globally. Most of the projects have been constructed in the global cities classified by the GaWC during the same period. As it can be seen in the chart above, 71% percent of the projects started in this time period were located in global cities. It is interesting to note that, the higher the classification of cities, the more projects are located there: Alpha cities alone account for 40% of projects. Beta cities host 18% of the projects, while Gamma cities host 13%. Prominence as a node in the global network, tends to boost the verticality of a city: 74% of Alpha cities host supertall skyscrapers. These findings align with existing theory, confirming that the higher the level of a global city, the more growth and development it captures (Sassen, 2005). Projects located in non-global cities are mostly built in developing countries, especially in the East Asia and Pacific. Regardless of its deep involvement in global trade, the region's cities have not reached yet the status of global cities in many cases, as it is not simply the expression of trade, but a measure of integration. Of the 369 projects constructed in non-global cities, 259 were located in China. Regardless of its impressive economic growth and GDP levels, China is still considered a developing country because of its low income per capita (World Bank Group, 2017c). As developing countries' cities will become more integrated in the global network, more and more projects will be located there proportionately as the defining phenomenon of global cities is globalization, which also fuels skyscrapers' construction.

Distributions within countries

The analysis of the distribution of projects within countries led to the discovery of specific patterns. The graphs representing each country's distribution are visible in **Appendix 2, figures 2.2**. Singapore was excluded from this analysis as all the projects are located within the city-state. According to the findings of Berry (1961), there are no relationships between type of city size distribution and either relative economic development or the degree of urbanization of countries. It appears that there is a scale from primate to lognormal distributions which is somehow tied to the number and complexity of forces affecting the urban structure of countries, such that when few strong forces obtain primacy results, and when many forces act in many ways with none predominant a lognormal city size distribution is found (Berry, 1961). Furthermore, it was noted that countries which have until recently been politically and/or economically dependent on some outside country tend to have primate cities, which are the national capitals, cultural and economic centers, often the chief port, and the focus of national consciousness and feeling.

Findings from analysis resulted in the definition of three main models. The first two are defined by previous theories: rank-size rule, which is a lognormal distribution and primate city, in which a city captures a disproportionately high percentage of the population. The third model, named Saturated, describes a distribution in which multiple cities are overly populated to have a lognormal distribution.

RANK-SIZE RULE	PRIMATE CITY	SATURATED
Australia	Canada	China
Philippines	Indonesia	Saudi Arabia
	Japan	South Korea
	Malaysia	
	UAE	
	United States	

Table 4.21: categorization of countries by typology of projects distribution.

Australia and Philippines exhibit rank-size rule distributions. Canada, Indonesia, Japan, Malaysia, UAE and USA exhibit primate city distributions. China, Saudi Arabia and South Korea exhibit saturated distributions. The findings here reported align with those of Berry (1961), as distributions do not have any clear relationship with either economic development or degree of urbanization of countries. There are no clear differences between countries and their characteristics in the three different categories. Although these distributions models were conceived to describe population sizes, it seems skyscrapers distributions tend to follow similar patterns. The reason is that the rank-size distribution is the concretization of forces acting on urban settlements when they are integrated in the same economic system (Gabaix, 1999). These patterns are the product of multiple urban forces in action, making it difficult to recognize major influences. Zipf's law applies also to organism's growth, suggesting that the distribution it forms is a natural phenomenon justified by the goodness to fit into a given space (Brown, Enquist, & West, 2001).

4.3. **Height competition**

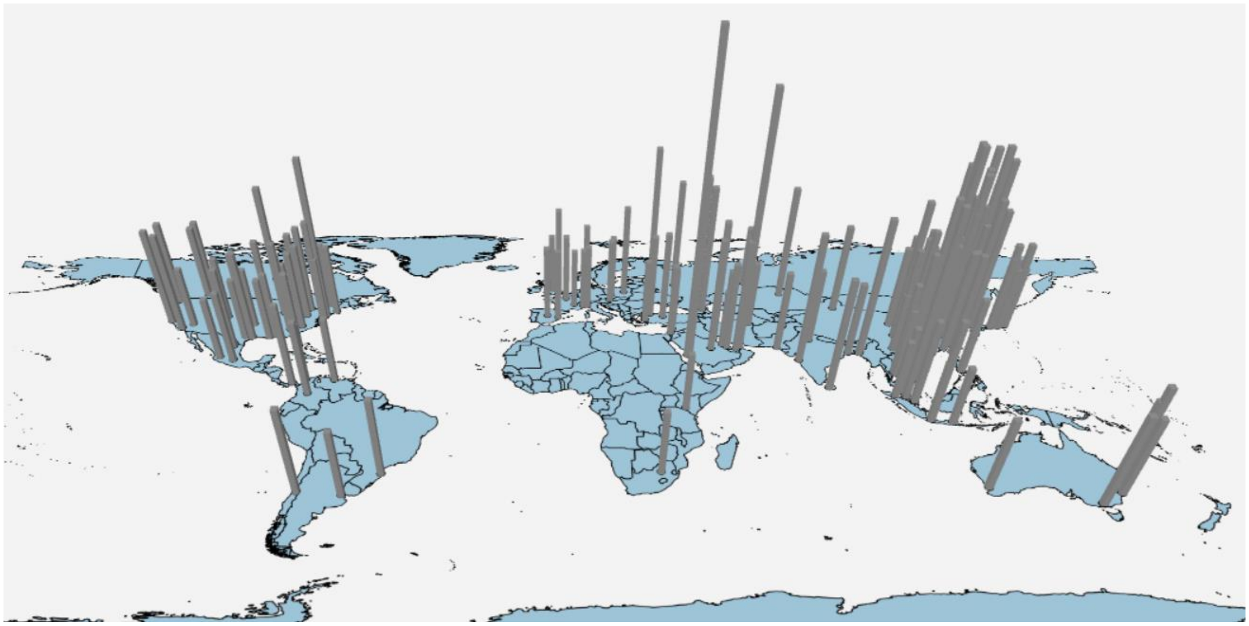


Figure 4.22: projects distribution and height on a world map.

The average height for the global skyscraper portfolio is 251 meters. Average height of projects does not vary widely worldwide. Furthermore, there has been no upward trend in average heights over the last century (Barr, 2010). The reason is that as taller projects are completed through time, many shorter ones are started, as technologies become more established and cheaper. The large output volume brings the average height to a stable level. Middle East and North Africa is the region with the highest average at 251 meters. North America follows with 250 meters of average height. East Asia and Pacific averages 249 meters in height. Europe has an average of 242 meters. Latin America and Caribbean average 234 meters. South Asia has the smallest average at 228 meters.

Although average height seems to be homogeneous throughout regions, regional and country patterns can be observed regarding projects' location and their height. These two are interconnected factors. As it can be seen in **Figure 4.22**, different regions experience development reaching certain height with different types of clusters. Dense clusters of projects do not necessarily spawn taller buildings. In North America projects of similar height are well distributed throughout its network of cities. Projects tend to be taller closer to the coasts and shorter in the middle of the continent. Higher ranked global cities, such as New York and Chicago reach considerable taller heights compared to the average. In South America and Caribbean region, few relatively short projects are located in countries capitals, such as Bogota, Buenos Aires, Mexico City and Panama City. A similar pattern can be noted in Europe, where most projects are located in few cities. Projects in the Middle East have the greatest variance in height. They tend to be polarized in few locations, mostly governmental and commercial capitals for the region, reaching remarkable heights. Projects in South Asia are relatively short and polarized in the region's most populous areas. East Asia and Pacific region has the densest distribution and the largest expansion of projects.

Projects closer to coasts tend to be taller. Projects located in China are the ones that reach the tallest heights.

The grouping of projects into specific height categories revealed that 66% of the world supply is between 200 and 250 meters tall. As height grows, the number of projects built decreases exponentially. Through the measurement of the ratio of floors fit in specific height categories, it was found that taller buildings tend to be built with relatively less floors than short buildings, making them less efficient in allocating space into height.

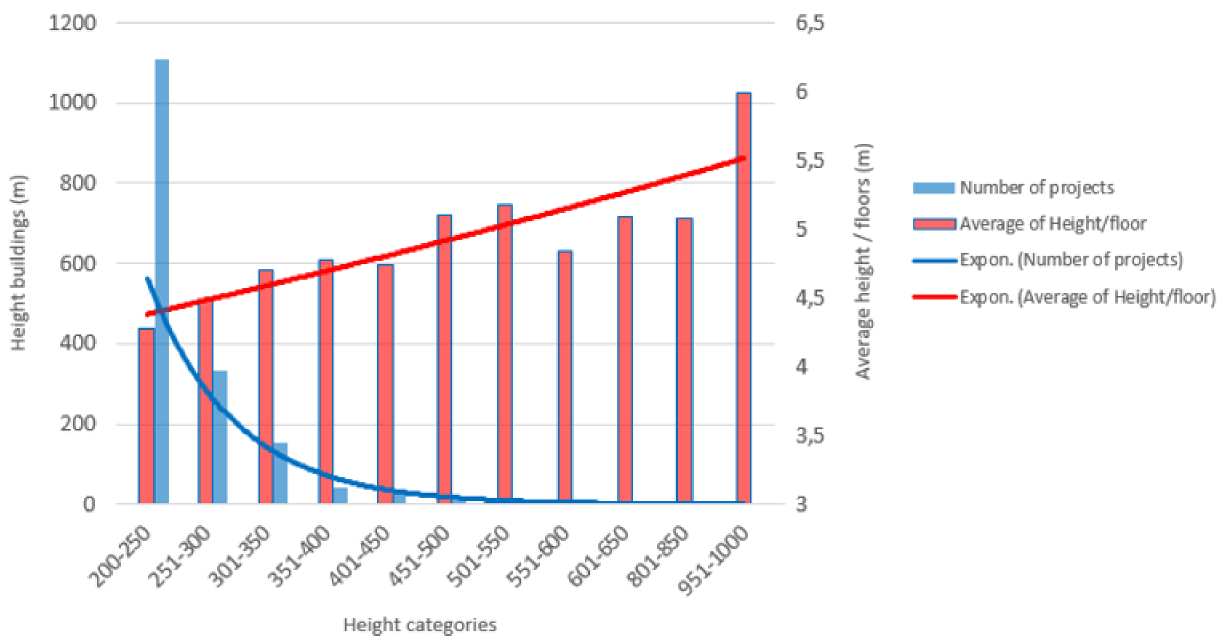


Figure 4.23: number of projects and average height-floor ratio for 11 categories of height distribution (by 50 m).

The average height of floors for the first five categories of height is 4.6m, while it is 5.2m for the buildings in the highest five categories. For the whole world, the average ratio of height and floors is 4.4 meters. This means Vanity Height accounts for an average increase of 12% in the ratio of height-number of floors between buildings lower than 450 meters and those taller than 500 meters. Between the lowest category (200 to 250 meters) and the highest (951 to 1000 meters) there is an increase of 29% in the ratio. These findings are in line with those of the Ctbuh (2013). Although their research was project-based and not height-based, their findings for a sample of 72 buildings pointed to an average Vanity Height between 10% and 30%. The main result was finding that Vanity Height changes depending on location. These results are to be interpreted as the measurement of how many floors were fit into height, not as the actual height of buildings' floors. The actual height of floors does not change as much between buildings, instead in projects that present high height/floors ratios, a significant proportion of building height is occupied by aesthetical components, such as spires and antennas. Going back to the findings, the lowest category of height, 200 to 250 meters, fits proportionately one third more floors in the same height than the tallest category.

To expand the results of previous research, the investigation was expanded into a location-based query. The amount of Vanity Height varies between regions and countries, as it can be observed in the table in **Appendix 3, figure 3.1**. South Asia and Latin America & the Caribbean have the lowest height/floors ratio at 3.9 m. North America presents a ratio of 4.2. East Asia & Pacific has a ratio of 4.4 meters. Middle East & North Africa and Europe & Central Asia have the highest ratios at 4.5 meters. These findings indicate that there definitely is an inclination in some regions to construct buildings that sacrifice functionality for iconicity. Within regions, differences in the ratio increase as well. The region that has the most deviation between its countries' averages is Middle East & North Africa, where Iran has an average height-floor ratio of 6.6 meters and Israel has an average of 4.0 meters. The country with the lowest ratio in the world is Brazil, with an average of 3.6 meters. Moving to single building level, Al Faisaliah Center located in Riyadh is the project with the highest floors-height ratio in the world: 8.9 meters. The structure fits only 30 floors in 266 meters of height. Aurora, located in Brisbane, is the building with the lowest ratio in the world: 3 meters. The building fits 69 floors in 207 meters of height. Project Aurora proportionately has three times the number of floors that Al Faisaliah Center has in the same space.

Projects names

The analysis of projects' names highlighted differences and similarities between developers and owners worldwide in branding their supertall products. Names tend to highlight specific aspects of buildings, and depending on location, different words tend to be adopted more commonly.

By far, the most common word present in projects' names worldwide is 'tower', indicating projects' main physical characteristic: height. The word appears in 738 projects' names out of 1694 total. The two countries in which the word is used the most are China (304 projects) and the United Arab Emirates (69 projects). Another common word used is 'center' or 'centre', employed in the name of 184 projects, emphasizing the centrality and importance of buildings. Chinese projects tend to bear the name of the activity the building supports, as well as the processes linked to it. Common words are: 'trade', employed by 16 projects; 'financial' used for 43 projects; 'world', used for 26 projects; 'capital' used for 7 projects'. In the United States, projects tend to bear the name of their address, making it easy to locate them. Up to 60 projects in this country carry the name of their street. In the region of Middle East more projects than anywhere else carry personal people names (usually the name of the owner or a governing figure): 31. The naming of projects highlights the different goals developers have through branding: in the East they want to communicate projects' functionality, in the West they want to communicate projects' location and in the Middle East they want to communicate who the owner of the building is.

4.4. Technology cycles

Correlations

		Composite	Concrete	Steel	World GDP %	World GDP Level	Global Investments
Composite	Pearson Correlation	1	,813**	,549**	-,185	,856**	,763**
	Sig. (2-tailed)		,000	,002	,279	,000	,000
	N	37	31	29	36	36	34
Concrete	Pearson Correlation	,813**	1	,334	-,012	,897**	,958**
	Sig. (2-tailed)	,000		,071	,945	,000	,000
	N	31	37	30	36	36	36
Steel	Pearson Correlation	,549**	,334	1	-,141	,393*	,256
	Sig. (2-tailed)	,002	,071		,385	,011	,137
	N	29	30	42	40	41	35

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

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

Table 4.24: correlations between materials employment in new construction and economic development at global scale.

Composite employment in new construction has a strong correlation with global GDP level and a medium correlation with foreign investments. Concrete employment has a strong correlation with both global GDP level and global investments Steel employment shows only a weak correlation with global GDP level. None of the three show any correlation with global GDP growth. There are correlations between materials employment themselves (to see full results consult **Appendix 4, figure 4.1**). While concrete and steel employment are not correlated with each other, they both are correlated with composite (steel has a low correlation while concrete has a high one). The reason is the fact that composite structures are made of both steel and concrete (the former in smaller percentage than the latter, hence explaining the difference in the strength of the correlations).

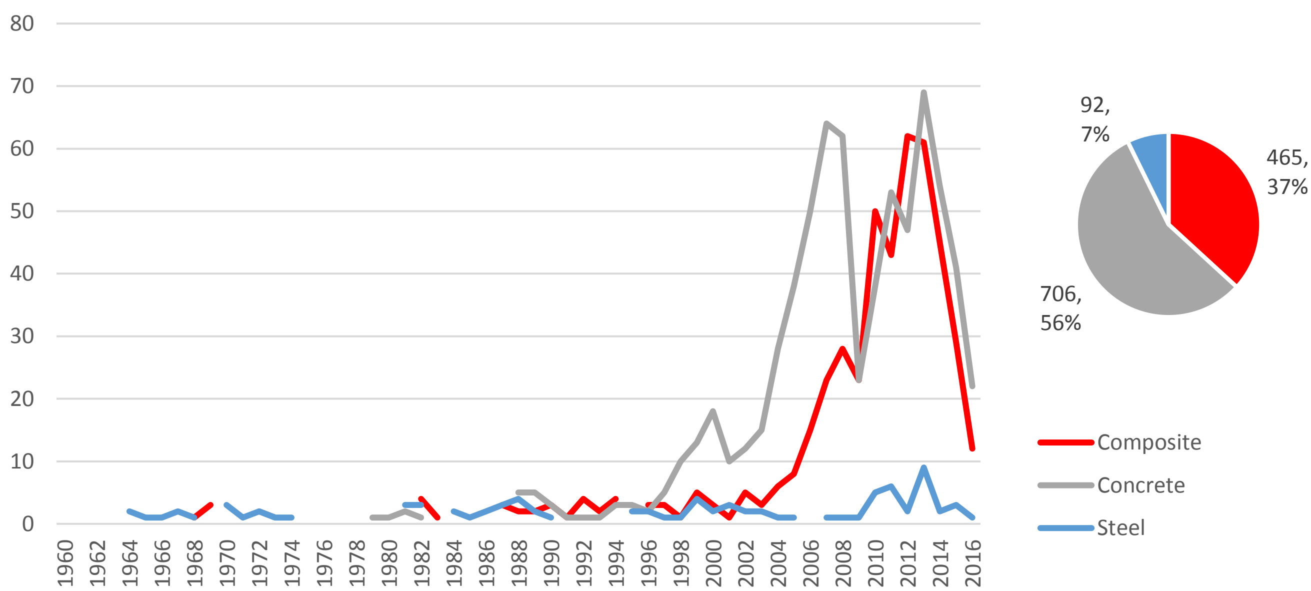


Figure 4.25: number of projects started per structural material between 1960 and 2016.

As it can be seen in **figure 4.25**, the two peaks of 1982 and 1988 are visible, although no specific patterns can be discerned for the single materials because of the small number of projects constructed cumulatively. The first strong deviation can be observed in concrete employment and its reaction to the dot-com crisis between 1997 and 2001, with an exponential growth in employment until 2000, when production started dropping by almost 50%. The employment of concrete and composite structures reacted differently to the 2008 financial crisis. Concrete use grew exponentially before the crisis and reached unprecedented levels with a peak in 2007 with 64 projects started employing it. In the following two years the number of projects started dropped by 65%, to 23. Composite started being intensely employed six years after concrete, in 2003. Its employment took a much lower impact from the financial downturn, an 18% reduction to 23 projects in 2009. Composite became the most employed material in 2011 for the first time. Between 2014 and 2016, employment of both concrete and composite has dramatically reduced, respectively by 60% and 84%. Throughout the analyzed timeframe, concrete is the material whose employment has the highest standard deviation at 21.9. Composite employment has a standard deviation of 17.9. Steel has the lowest deviation at 1.6.

As it is visible in **figure 4.25**, the employment of materials follows a specific cyclicality pattern, with materials reacting differently to exogenous dynamics. Steel is the structural material that has been employed for the longest timeframe for supertall buildings. Although concrete has appeared as a construction material much earlier in history than steel, high-performance applications of it, allowing tall construction, have evolved after the advent of steel structures. In fact, steel structures are the technological system that led to the construction of the first skyscrapers. The unprecedented speed of construction allowed by steel, as well as its strength, drove vertical construction in New York and Chicago at the end of the 19^{th} century. Concrete development has advanced dramatically in its application and characteristics only after the 1950s, with the main advancement made in the 1970s, with the introduction of superplasticizing admixtures.

Many advancements in concrete technology have occurred as a result of two driving forces: the speed of construction and durability of concrete (Metha, 1999). Because of the improving mechanical characteristics of concrete, as well as its availability worldwide, it has been employed in a growing trend in supertalls' structures, both on its own, or coupled with steel elements in composite form. High-performance concrete (HPC) has become vital for the construction of skyscrapers from a structural and economical point of view. Concrete systems have twice the dampening effect compared to steel due to increased mass, and their supply is less dependent on international dynamics. Cost of the two materials are also a factor in the choice of selection; not because of their unitary cost, but rather for the changes of pricing that the two experience. As it can be observed in **Images 4.26** and **4.27**, while concrete has experienced a steady growth in price in the past 26 years, steel followed a much more volatile trend. For supertall buildings, structure cost can be as high as 30% to 35% of total construction cost (Dasui, Jianlong, & Lianjin, 2012). Sudden changes in material cost could disrupt projects' feasibility, making steel the more risky choice. The change in cost of application and improvements in employment are the two strongest drivers in inducing a long-term upsurge of development (Perez, 2002). Arguably, most super-tall buildings in the future will be made of HPC, with a steel or composite spire at the top (Moncef, 2013).

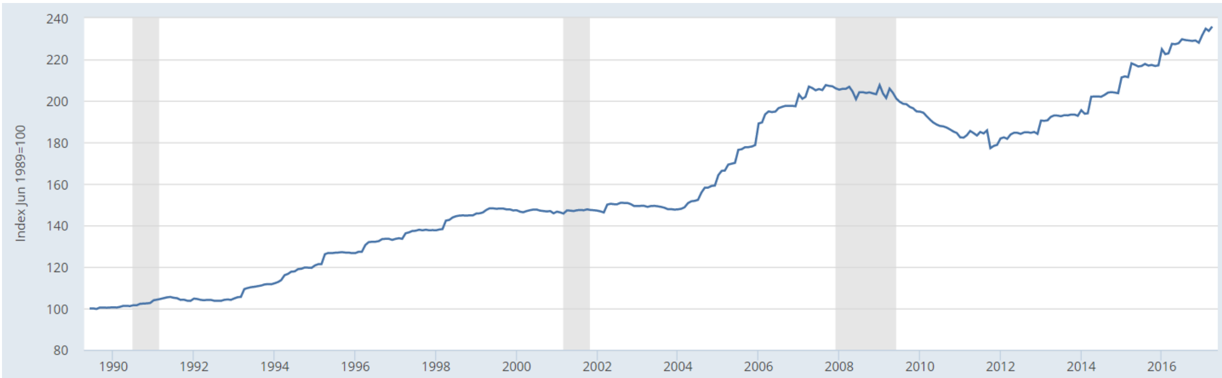


Figure 4.26: changes in global price of concrete between 1990 and 2016. Source: Fred Economic Data.

Figure 4.27: changes in global price of steel between 1990 and 2016. Source: Fred Economic Data.

4.5. Construction costs

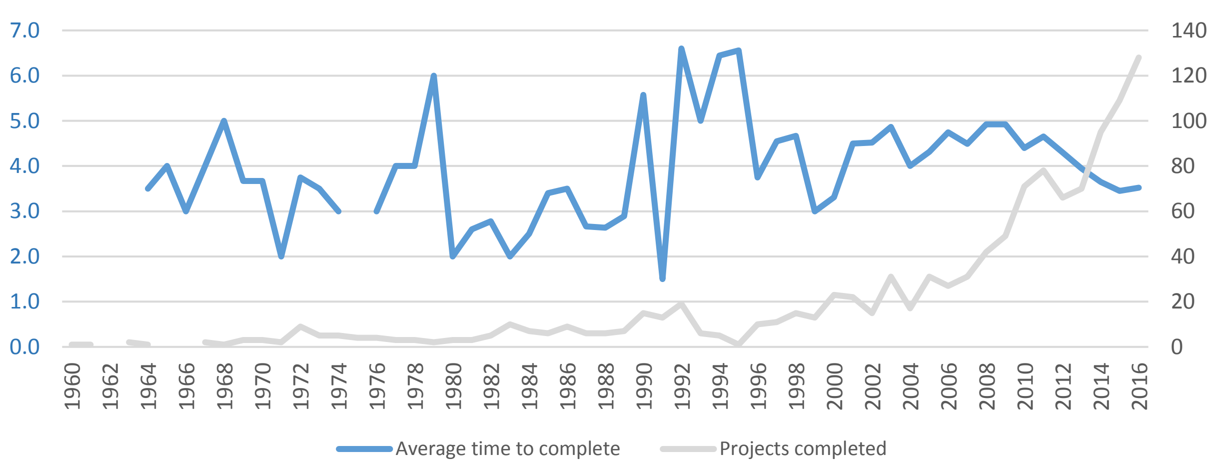


Figure 4.28: average time to complete projects and projects completed between 1960 and 2016.

The average time it takes to complete projects has swung between 1.5 and 6.5 years between 1960 and 2016. It is not directly affected by the cyclicality of the economic cycles, nor responds to it. Instead there are strong deviations in length of construction between the different regions and countries analyzed, as it can be observed in **Appendix 5, figure 5.2**. Developing countries and regions have longer average time of construction, with South Asia having the longest construction periods at 5.5 years, while developed regions and countries have lower averages, with North America leading with 3.2 years. According to data collected from Turner and Townsend, visible in **Table 4.29** below, there are large differences in the cost of construction of skyscrapers between different countries, with the most developed ones paying the highest fees. This finding suggests that the time to complete projects is more dependent on local supply factors, such as cost, than global economic cycles.

Average construction costs per country (2009-2013)		
	Office	Residential
Australia	2919	2163
Canada	2837	1652
China	1424	651
Germany	2391	1064
India	683	718
Japan	3441	3217
Malaysia	1322	605
Russia	1914	1853
Singapore	2164	2065
South Korea	1537	1266
UAE	1948	2065
USA	2509	2076

Table 4.29: average construction costs for high-rise office and residential between 2009 and 2013. Values expressed in current American dollar values. Source: Turner and Townsend.

Starting in the early 2000s, the time to complete projects have stabilized in a frame between 3 to 5 years. Before then, time of completion was more volatile, ranging from 1.5 to 6.5 years. The stabilization of length of construction time coincides with the introduction of concrete as a main structural material. There is a net difference it takes to construct buildings depending on the structural material: composite takes on average the longest, 4.3 years; concrete takes on average 4.2; steel takes on average only 3.3 years. Since concrete and composite structures have become the structures of choice in the past 10 years, the average time to complete reflects this standardization of employment. This fact further highlights that, despite the faster delivery offered by steel, it has become the least preferred material, because of its physical properties and associated costs.

Statistical correlation analysis of cost data produced results with low statistical significance. Analysis has revealed that the timeframe of the data regarding construction costs is too short to carry out correlations. Full results can be seen in **Appendix 5, figures 5.1**. As it can be seen in the tables, the number of observations for each country are too low in value, making results of low significance.

4.6. **Summary of findings**

Global construction of skyscrapers has a high correlation with both global GDP level and investments. No correlation was found with GDP growth. The changes in global average height do not have any correlation with economic indicators. Regions have different levels of correlation between construction and economy and regional and global scale. The more skyscrapers regions develop, the closer the relationship between construction and economic indicators. With the exception of the Middle East, no region has correlations with GDP growth at neither scale.

Countries show very different correlations between amount of construction and economic development. Unlike regions, countries that develop more do not necessarily exhibit a stronger correlation between construction and economic performance. Countries tend to have the same strength of correlation between national and global GDP level. This means that national and global GDP levels exert influences of similar strength on this typology. Skyscrapers' do not get developed more intensely during periods of high inflation. Countries that have the strongest correlations between construction and economic performance are developing countries with middle incomes. As the construction sector in these countries account for a large share of economic output, construction activity is more closely correlated with national and international economic cycles.

The distribution of projects worldwide presents polarizations in specific regions and cities. Governmental, financial and commercial capitals of the world are mostly targeted for development. Functions too tend to be distributed unevenly depending on location. Western countries tend to develop mostly skyscrapers employed as offices in global business. In Eastern countries more diversification is present, with ample employment of high-rise for residential and mixed uses. Between 2000 and 2016, 1266 projects have been started globally. 71% percent of the projects started in this time period were located in global cities. The higher the classification of cities, the more projects are located there: Alpha cities account for 40% of projects. Beta cities host 18% of the projects, while Gamma cities host 13%. Prominence as a node in the global network, tends to boost the verticality of a city: 74% of Alpha cities host supertall skyscrapers. Of the 369 projects constructed in non-global cities, 259 (20% of total global output) were located in China. The analysis of the distribution of projects within countries led to the discovery of specific patterns. Australia and Philippines exhibit rank-size rule distributions. Canada, Indonesia, Japan, Malaysia, UAE and USA exhibit primate city distributions. China, Saudi Arabia and South Korea exhibit saturated distributions.

Construction of residential skyscrapers has a medium correlation with world GDP level and a strong one with global investments. Hotel function has a medium correlation with global investments. Office function has a strong correlation with both global GDP level and investments. Mixed has the strongest correlation with both global GDP level and investments of all functions. Functions go through similar cycles, yet their response to exogenous causes are of different magnitudes. Office has the highest volatility of all functions with a standard deviation of 15.4. Residential function has the second highest standard deviation at 14.3. Mixed has a standard deviation of 11.9. Hotel has the lowest standard deviation at 1.5.

The average height for the global skyscraper portfolio is 251 meters. Average height of projects does not vary widely worldwide. Regions and countries that develop more buildings do not build taller projects. As projects get taller, the less efficient they become in fitting floors in their height. Vanity Height accounts for an average increase of 12% in the ratio of height-number of floors between buildings lower than 450 meters and those taller than 500 meters. Between the lowest category (200 to 250 meters) and the highest (951 to 1000 meters) there is an increase of 29% in the ratio. The amount of Vanity Height varies widely between regions and countries. South Asia and Latin America & the Caribbean have the lowest height/floors ratio at 3.9 m. North America presents a ratio of 4.2. East Asia & Pacific has a ratio of 4.4 meters. Middle East & North Africa and Europe & Central Asia have the highest ratios at 4.5 meters.

The analysis of projects' names highlighted the different goals developers have through branding: in Eastern countries they want to communicate projects' functionality, in the West they want to communicate projects' location and in the Middle East they want to communicate who the owner of the building is.

Structural materials have different correlations with economic cycles. Composite employment in new construction has a strong correlation with global GDP level and a medium correlation with foreign investments. Concrete employment has a strong correlation with both global GDP level and global investments Steel employment shows only a weak correlation with global GDP level. None of the three show any correlation with global GDP growth. Materials offer the possibility to build at different speeds, with steel having the fastest average time of completion of 3.3 years, against concrete and composite taking 4.2 and 4.3 years. Yet steel, because of its volatile cost, has become the least preferred material for skyscrapers structures. The average time to complete projects is also highly influenced by local factors. Costs seem to negatively influence length of construction periods: the lower the cost of construction in a location, the longer the construction periods. Since the introduction of concrete as main structural material in the early 2000s, completion times of projects have stabilized in their year-on-year changes.

CHAPTER 5 – Conclusions

5. Conclusion

5.1. Discussion

This research analyzes the relationship between skyscrapers construction and the business cycle. The analysis focused on specific development factors of projects in the background of economic performance at different scales. The observation of the cyclicality of these factors led to answering the research questions.

Global, regional and country specific economic dynamics are correlated to skyscrapers construction with similar intensity, indicating that this typology is influenced by different levels of the economy similarly. The reason is that this typology's demand and supply are influenced by both macro and micro developments. While global factors stimulate the demand for this typology, national factors dictate the capacity to supply. The influence on demand is created at global level because globalization is the driving force for the exponential growth of supertall construction since the beginning of the 90s. The conditions and concepts of economics are not fixed – and with any property development there are many factors in play – but tall building developments are increasingly tied to global and regional economics and politics, which continue to exhibit sustained uncertainty (Parker & Wood, 2013). Globalization had three major consequences that increased the demand for skyscrapers worldwide. The first consequence of globalization was the opening of new markets with the opportunity to enlarge existing supply chains, with a consequent specialization of different locations. The opening of new centers of production caused a redistribution of capital worldwide. Cities and countries that did not possess capital before, became engines of production, with growing demand for space. Global trade increased the need for business clusters where interaction could take place. These clusters are agglomerations of specialization where proximity is key. The needed density was achieved through the vertical development of construction. The second consequence is that globalization increased the importance of localization. In an interconnected and fast-moving world, uniqueness and distinction are very important. The image of a place or business, as a mean of attraction, has become more and more important in the global competition. In an attempt to win this competition, cities and developers push human and financial capacity to the limit. As the skyline is one of the main features of the city, modelling it with impressive icons has become a common strategy to increase status. The third consequence is that globalization increased the standardization and homogenization of real estate construction and consequent taste worldwide. Since cities compete and interact globally, they have to diversify their built environment following world standards. While design in the past used to be dictated by cultural habits, now it is shaped by global uses. The skyscraper, a symbol of success of the early 20th century in the United States, has been borrowed in its symbolism by the global collective consciousness, as an expression of uniqueness and importance. Places that never developed this typology before started conforming to the new world standard of expression of grandeur: building tall.

Although there are differences in how countries cyclical developments react to endogenous and exogenous forces, there are common factors that influence supertall's supply, most of which happen at national level. The first factor is the national level of GDP. It signals if a country has enough capital to construct supertall. Even if part of the supply team is international, such as developers, contractors or architects coming from developed nations, the construction of buildings taller than 200 meters requires a certain degree of development of the construction industry, both from financial and expertise perspectives. If a nation is not developed enough, producing a high GDP, it can't support the construction of supertalls. The size of economies does not influence production as much as their relative earnings. Foreign investments too influence construction, as they expand the capacity of the economy. The second factor is the level of urbanization and density in the country. The growing importance of global cities drives a movement of populations worldwide towards these nodes of growth and prosperity. The growth from demand of people moving from rural areas increases land values and puts pressure on city limits. The larger the rural population before the urbanization process a country goes through, the stronger the pressure on cities to grow. Developing countries experience the phenomena with more intensity because of their opportunity to grow and consume compared to developed nations. This leads to vertical development being contemplated as a solution. The third factor is government and cultural acceptance. The flexibility of regulation depends on the level of support or restraint government bodies want to exercise on tall construction. Because of the attraction skyscrapers exercise both for tourism and business, this typology is included in governmental strategies of different scales. Changes in city-scale building regulation as well as national changes in foreign investment policies can intensely influence skyscrapers development. Regulations imposed on tall buildings are often linked to the cultural perspective nations collectively have on the built environment. Developed nations with large amounts of historic real estate, such as Europe, tend to restrain from supertall constructions and constraints their development to financial districts. Developed nations with relatively low amounts of historic real estate, such as North America, Australia, South Korea and Japan accept well tall buildings. Developing countries tend to accept supertall buildings regardless of the heritage of the national real estate, because of the strong growing demand for real estate they experience.

Different countries exhibit different cyclicalities, yet there is a global tendency to increase construction towards the peak of economic cycles. This highlights the tight relationship between skyscrapers construction and global financial markets. The peaks of construction coincide with changes in the global economic cycle: 1982, 1986, 1999-2000, 2008 and 2013. Global financial booms fuel new construction, followed by restrained production during periods of busts. While projects' construction is correlated with economic performance, their height is independent from it. Developing countries with middle-income economies experience stronger correlation between construction of skyscrapers and economic development because of the share the construction industry occupies within their respective economies. As countries become fully developed, the construction industry shrinks in size and becomes less financially driven.

Economic cycles influence the construction of skyscrapers through their different components. GDP level is the economic indicator that influences construction the most on multiple scales of observation. This correlation exists as developers are triggered to build tall depending on the amount of overall capital capacity. Foreign direct investments is the second economic indicator that influences construction the most, by influencing the overall capital capacity of countries and regions. There is a close relationship between global FDI cycles and construction cycles of different countries, regardless of the direction of investments. Large international capital movements in general are highly correlated with skyscrapers' construction. The cyclicality of FDI is the one that matches skyscrapers' construction the most out of all the economic indicators. Interest rates influence construction only in specific countries that experienced high rates in the past or whose developers rely on debt to construct. Countries where developers react to changes in interest rates are also those in which development is correlated the most with both national and global economic changes. This means interest rates could be an important element in aligning economic and development cycles. Interest rates influence financing costs hence increasing or decreasing the cost of construction. Annual GDP growth does not influence construction of skyscrapers at neither scale, as developers are not triggered to build by yearly changes in the economic growth. When present, the correlation between construction and economy extends to multiple economic indicators. This is because all economic indicators are interrelated as the complete tables of results show in the **Appendix 1**. The cumulative changes of all the indicators is the expression of the economic cycle.

The different cyclicality regions and countries exhibit in their development patterns are given by endogenous causes that influence their supply. Government intervention in manipulating economic performance through changes in interest rates and incentives can lead to extreme surges in construction. As government and regulation are the greatest restraint in the production of supertalls, they are also the factors that can boost its construction the most. North and South America exhibit development as a market response. The Middle East employs development as a government strategy. East Asia and Pacific shows differences between its countries, mostly driven by the market and supported by governments. South Asia’s development is starting to build up volume and government intervention will become clear in few years. The names given to projects highlight the different goals developers have through branding: in the East they want to communicate projects’ functionality, in the West they want to communicate projects’ location and in the Middle East they want to communicate who the owner of the building is.

Depending on region and buildings’ function, projects tend to be clustered in different locations. In East Asia and Pacific projects are located in financial centers, governmental centers and second tier cities too. Cities with the highest concentrations of projects have the greatest diversity in functions. In Europe, projects are mostly supertall offices clustered in financial centers. North America presents a similar pattern, with only the largest cities offering more diversity in functionality. Middle East presents many residential and hospitality-related skyscrapers clustered in its touristic centers. South Asia has residential skyscrapers clustered in its most populous cities. Although the driving force for skyscrapers construction seems to be common worldwide, their use is influenced by cultural interpretations that vary from region to region. Most skyscrapers today are still office function, as these buildings were originally conceived for responding to growing land prices in business districts. The cyclicality in construction of office is closely tied to changes in global trade, as they serve actors involved in the latter. Globalization expanded the places where skyscrapers are developed and as the underlying strategies in the employment for skyscrapers mutate from place to place, so have their functions. Residential function, built only after 1995, has high volatility, because of the speculative nature its cycles of development follow. The exponential growth of value in housing caused by the 2009 bubble, stimulated developers worldwide to build high-return residential projects over lower yield functions. This exposed the residential function to speculation over other functions. Mixed function follows cycles that are between those of office and residential (since it often contains both functions). For this reason, multi-function projects can achieve higher feasibility and resilience than single function ones: by offering different types of space, demanded by industries influenced by different dynamics, the portfolio of space supplied is more diversified, hence less exposed to unsystematic risk. The trend to develop mixed function skyscrapers more intensely in the last decade coincides with the shift in perception of development in urban areas by planners and the public, with a propensity towards multi-functionality. The latter has grown to be viewed as a tool to achieve higher density, reduce dependence on transportation and achieve higher livability (Muñoz, 2010). Single function hotel skyscrapers have been completed mainly after 2000. These buildings are usually completely owned or leased by a single hotel chain. The typical owners are luxury international corporations such as Four Seasons, Ritz Carlton and Hilton, who possess the financial means to commission such constructions. The major factor driving tall hotels development is the increase in demand created by tourism and air travel, both of which are fueled by globalization. The importance of image brought about by global competitiveness is reflected in this function through the provision of spectacular hotel rooms.

The global distribution of projects aligns with several existing urban theories. Skyscrapers are the result of global and local interaction of specific locations. The multiple new readings of globalization illuminate the global and local pressures upon the city and its particular forms of spatial organization and various architectures (Khan, 2014). For this reason, projects are polarized in the cities integrated in the global network the most. Based on the assumptions of Sassen (2005) and the GaWC (GaWC, 1999), because of globalization, the economy of global cities and their competition go beyond the national level. This concept is confirmed in this research, with the observation of projects being built mostly in global cities, regardless of the national economies encompassing them. In fact, projects development is more aligned with regional and global economic output. The demand for super tall real estate is inherently fueled by global trade. Diversification of tall real estate functions is dependent on the economic base and relevance as global node of the city where it is located. The distribution of projects within countries aligns with findings of Berry (1961). According to theory, as most countries exhibit primate city distributions of projects, there are few urban forces influencing skyscrapers location. This is probably the result of the fact that few cities within countries enjoy the sufficient international integration and local level of supply to allow skyscrapers' erection. As a consequence of these relatively simple limitations, projects are all clustered in one prime city.

The taller projects get, the less efficient they become at fitting floors within their height. Extreme heights are reached without a net increase in usable floors, meaning the extra height does not have a functional purpose, rather an image one. To some degree, going beyond certain heights automatically creates less efficiency in the building, as the structure grows exponentially in volume. At the same time, the most extreme heights are reached in locations where space is not a constraint, such as in Middle East, where overpopulation and urbanization are not pressing issues. Because of the established technology and expertise available to reach and surpass 200 meters, development starting from the mid-90s has encompassed the employment of tall buildings for business-related activities, and has adapted the successful symbolism of height to other uses. They are not only constructed based on an economical foundation, but are also influenced by the status and ego of developers, investors and the city (Helsley & Strange, 2008). Height is therefore considered a strategic component, which can be indirectly capitalized and can be inferred to as a function of economic aspects, land use regulations and the desire for status (Barr, 2012). This unquantifiable value is the reason height does not have correlations with any economic indicator, as the decision of how tall to build is affected by non-economic factors.

By around 1890, the problem of engineering height was essentially solved in the sense that very tall buildings were now technologically feasible. Since then, skyscraper height decisions have been primarily due to economics and status (Barr, 2015). Height depends on development's underlying strategies and cultural taste of local populations. Europe and Middle East are the regions with the highest amount of Vanity Height while South America the one with the least. Regional levels of construction do not influence Vanity Height, instead culture does. Countries accustomed to tall have low vanity height: since tall is normal, it is not a critical selling point as in low-built places. As South America is a vertically developed country, height is seen as a response to a need for space. In Middle East height is a marketable asset in the attraction of tourists and business, part of a national strategy. In Europe, the scarcity of skyscrapers and cultural taste require for supertalls being developed to be aesthetically pleasing. As spires and elements embellish the looks, they create Vanity Height.

The choice of material has shifted from steel to concrete. What was one of the main traits of these buildings, a steel frame, is barely employed anymore as a structure. Although steel allows for faster construction, it has become the least preferred structural material. This choice is dictated by two factors: the volatile cost of steel compared to concrete and the continued technological improvements of concrete as a construction material. To developers, a stable cost of structural material is more important than a quick construction process. The average time to deliver skyscrapers is highly influenced by local factors. Economic cycles at different scales do not seem to have an influence on the construction length in time. Instead national construction costs seem to have a strong influence. Developing nations, experiencing lower construction costs, have longer construction periods. Developed nations, with high construction costs have the shortest construction periods.

5.2. Limitations

The nature of the data collected imposes some limits on the research. The availability and timeframe covered by all the indicators is different, so analysis had to be adapted to the existing information. Furthermore, some data is missing from the databases, for different reasons: regarding projects, data is missing because of non-disclosure or because of the difficulty in retrieving it; economic data can be missing for some countries because of unique governance and economic systems (such as lack of a central bank or separation from global financial markets); cost data can be missing because of difference in scope of the different reports produced by Turner & Townsend through the years. While between 2009 and 2013 the research carried out by T&T was country based, since 2014 it has been city based. Because of the short timeframe of both series, correlations with other indicators yielded low significance. The same reasoning applies to the data provided by the GaWC, which has a relatively short timeframe too. In this case though, the series are not employed in correlations but used to track the number of projects started by city. A prerequisite for projects to be included in the database was to have a date of completion and height data. While the date of completion is present for all projects, the starting date is present for 87% of the projects. In most of the analysis the starting date of projects was employed to reflect developers' intentions. It must be considered that 13% of projects went unaccounted for in these types of analysis. Structural material data is present for 88% of the projects, while function data is present for 98%.

5.3. Recommendations

This research provides an in-depth analysis of the development of skyscrapers, based on the global portfolio comprising 1694 buildings. In order to carry out analysis, a specific database was created in different formats, so that it can be employed by different computer software. The database containing all the coded data and its instructions is available online for public use to stimulate research and ease the lengthy process of data mining for future researchers. As explained in the methodology chapter, data contained in the database comes from different sources, yet for this research it has been organized in a single collective unit, making comparison between different developments easy and immediate. The choice to include every project ever built taller than 200 meters was made to create a global narrative of the evolution of this typology. This choice has allowed statistical analysis producing generalizations, through the study of the specific frameworks of different realities worldwide. Specific areas have been studied because of their high level of development, not because of their intrinsic physical and governmental characteristics. Instead of studying different regulatory backgrounds and see how developers respond to them, this research has focused on analyzing what has been done, without taking in consideration the legal implications. The reason is that such an approach, given the scope of this research, would have required an extremely lengthy process of collecting and analyzing regulations from many different governmental bodies. Furthermore, as it has been eviscerated through the literature research, while regulations are a binding limit to tall developments, the latter can be modified or adapted to allow development that aligns with the strategy of boosting the image of a municipality, region or country. In the future it would be of interest to track changes in regulation in specific areas that develop tall intensely, to understand the specific limitations or support governments give to vertical development of urban settlements and for what reasons.

Following the narrative laid by the book STARCHITECTURE, the proliferation of signature designs around the world is resulting in an increasing homogenization of the supply of high-profile real estate worldwide (Nastasi & Ponzini, 2011). Skyscrapers, because of the importance and difficulty of their design, follow the same trend, with only few firms around the world being capable of designing and constructing them. In this respect, it would be interesting in the future to track the supply side of these projects (developers, contractors and architects) to see their movement around the globe and analyze their products and strategies. As supply chains and expertise become more homogeneous worldwide, it becomes of great importance to study their implications on the built environment and its diversity.

In future research focused on global portfolios and their relationship with economic performance, it is suggested to abandon the traditional measurement of national economies, and instead measure economic performance at city scale. Because of their increasing relevance as nodes in the global network, as confirmed again in this research, cities' development is set to become more and more detached from the national frameworks they are inserted in. Because of this trend, cities need to be compared and analyzed among themselves, encompassing their national background. In this respect, more research must be carried out on which indicators are most effective at measuring cities' performance, as well as how to measure them. From a scientific and social research perspective, the city needs to become the scale of reference on which analysis has to be carried out.

New methods of measurement of integration for cities need to be brought forward. The method conceptualized by the GaWC proved once again effective, yet it misses the opportunity to integrate in its measurement the level of urbanization of cities, as well as their volume of trade. These shortcomings have been highlighted in the research, through the discovery that enormous Chinese cities, with very large populations and with high levels of productions have escaped classification. The reason is that these cities don't align with the somewhat restrictive definition of global city given by the GaWC.

Construction and its cost probably have a strong correlation, especially for this typology because of its high cost of construction. Although the tests carried out in this research on the topic carried too low significance to be considered, given by the short timeframe of the cost data, three countries (Canada, Malaysia, USA) showed a strong correlation (results can be found in **Appendix 5, figures 5.1**) These early findings seem to confirm the hypothesized relationship. To draw reliable conclusions more data has to be collected regarding cost. If the collection of data by Turner & Townsend continues in the future, analysis with higher significance will become possible.

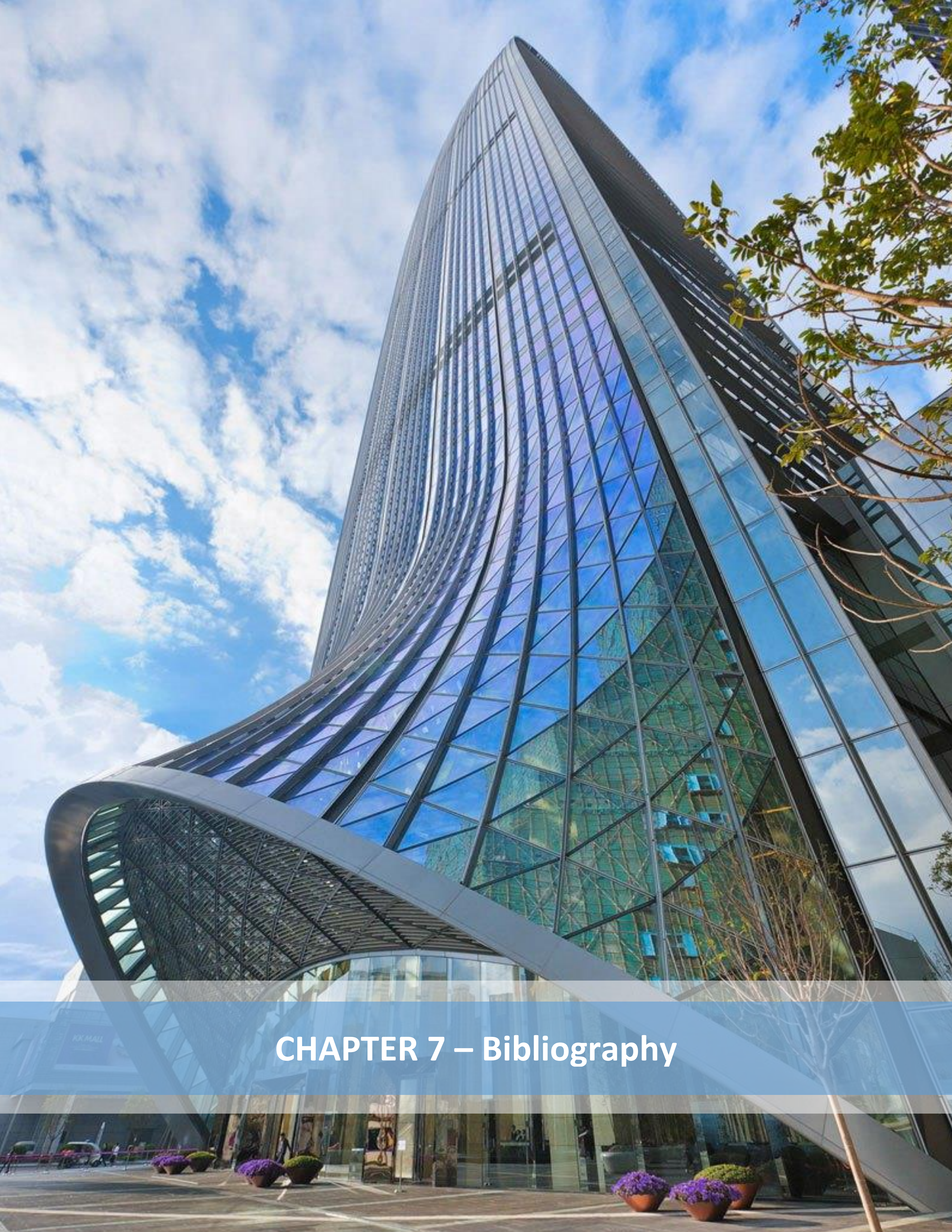
6. Reflection

This document is the result of a research process lasted 11 months. The topic of the research was selected because of the interest of the researcher for complex projects and their relationship with economic developments. Throughout the research the attempt was to measure this relationship, as well as learning its causes. For this reason, a preliminary research on tall buildings in general and their history was carried out. Later in the research, the knowledge acquired in this phase became very valuable in explaining the trends observed. Trying to explore the ever-growing dynamics of integration of both economic and real estate development worldwide, the research was carried out at global scale. In order to comprehend the singularities in the global output, single countries' developments had to be studied as well. This approach proved key in understanding the phenomenon in its totality, although it proved difficult. Generalizations are difficult to be drawn when the table of results contains many different, and sometimes contradicting results. Only through the study of the different countries' economic, governmental and cultural backgrounds differences in output could be explained.

The analytical process was carried out through different processes and tools. It was a mix of mathematical, visual and spatial analysis. The mathematical analysis was carried out mostly through the employment of computer software. The goal was to produce exact statistical results that could be trusted. The results from this type of analysis span from global to national scale, allowing generalizations as well as specificities to be formulated. This analysis was made possible thanks to the knowledge acquired during specific courses taken during the master at TU Delft: Applied Statistics and Financial Management. The visual analysis was carried out by observing graphs representing changes in different trends. This method was valuable to recognize cyclicality in trends. To explain the observed changes, knowledge acquired through different attended courses was employed: Real Estate Valuation and Management & Finance. The last method, spatial analysis, has been carried out with the aid of computer software. Observing the location of projects on a world map with geographical and infrastructural references helped guiding the analysis towards points of attention and allowed quick comparison between different areas of the world. This analysis was made possible thanks to knowledge acquired during an internship at Politecnico di Milano. The choice to employ three complementary analytical methods to carry out analysis comes from a personal choice to employ different academic methods and knowledge acquired so far. This choice also allowed to explore development from many different perspectives: mathematical, economic and spatial.

There have been some missed opportunities during the research, mainly linked to the restriction given by time. It would have been interesting to track buildings' sizes, possibly both the gross floor area and the lettable floor area. This data would have allowed to carry out analysis on buildings' effectiveness not only based on their height, but also on internal space. Because of their peculiar designs, and the resulting internal layout, skyscrapers of different heights can have very different floor plates. Analysis of this kind can reveal the efficiency of different designs and functions, and its findings could contribute to the creation of more effective buildings. Furthermore, tracking the amount of space supplied to markets and its absorption is a useful exercise to control the development cycle and check for any market distortions that can lead to crisis. This data was not collected because it proved too difficult to retrieve for each building and the collection would have been time consuming. Cost analysis too feels like a missed opportunity. It proved difficult to find reliable construction costs related to the studied building typology for a long timeframe. Different indicators could have been employed, such as cost of basic products of construction (concrete laying, specialized labor etc), to measure changes in construction related to changes in the cost of these products.

From a professional perspective, the findings of this research can be employed to inform various actors, within industries that both demand and supply skyscrapers, about global trends. These can be used in strategy making, in the decision to target specific markets because of their potential growth. This research highlighted the impact governmental policy and cultural acceptance can exert on production of specific real estate typology. The cyclicality in development of a specific typology changes depending on the economic, governmental and cultural characteristics of an environment and how cross-scale dynamics influence construction. Real estate development, because of its cost and its necessity, is highly correlated to the economy. Since the latter moves in cycles, so does development. Learning which economic drivers influence construction the most taught me how to read and interpret construction trends. The knowledge acquired and the tools employed can be in the future applied in the research of other typologies.



CHAPTER 7 – Bibliography

7. Bibliography

Al-Kodmany, K. (2015). Tall buildings and elevators: A Review of Recent Technological Advances *Buildings, 5*(3), 1070-1104.

Al-Rasheed, F. (2011). *The Implications of the Financial Crisis on the Housing Finance in Developing Countries*. Paper presented at the 2011 World Economic Forum, Geneva, Switzerland.

Ali, M. (2008). The Role of Tall Buildings in Sustainable Cities. *WIT Transactions on Ecology and the Environment, 117*, 345-354.

Ali, M., & Al-Kodmany, K. (2012). Tall Buildings and Urban Habitat of the 21st Century: A Global Perspective. *Buildings*(2), 384-423.

Antwi, A., & Henneberry, J. (1995). Developers, non-linearity and asymmetry in the development cycle. *Journal of Property Research, 12*(3), 217-239.

Aranya, R. (2008). Location theory in reverse? Location for global production in the IT industry of Bangalore. *Environment and Planning, 40*(2), 446-463.

Balsa, C., Lopes, J., & Nunes, A. (2011). The long-run relationship between the construction sector and the national economy in Cape Verde. *International Journal of Strategic Property Management, 15*(1), 48-59.

Barr, J. (2010). Skyscrapers and the skyline: Manhattan. *Real Estate Economics, 38*, 567-597.

Barr, J. (2012). Skyscrapers Height. *The Journal of Real Estate Finance and Economics, 45*(3), 723-753.

Barr, J. (2013). Skyscrapers and skylines: New York and Chicago, 1885–2007. *Journal of Regional Science, 53*, 369–391.

Barr, J. (2015). The Economics of Manhattan Skyscrapers. *CTBUH journal*(4).

Barr, J., Mizrach, B., & Mundra, K. (2014). Skyscraper Height and the Business Cycle: Separating Myth from Reality. *Applied Economics, 47*(2), 148-160.

Barras, R. (1994). Property and the Economic Cycle: Building Cycles Revisited. *Journal of Property Research, 11*, 183-197.

Barrionuevo, A. (2012, September 18). Rising Tower Emerges as a Billionaires' Haven. *The New York Times*.

Beaverstock, J. V., Smith, R. G., & Taylor, P. J. (1999). A Roster of World Cities. *Cities, 16*(6).

Berry, B. (1961). City Size Distributions and Economic Development. *Economic Development and Cultural Change, 9*(No. 4), 573-588.

Bloomfield, C. (2011). Empire State Building Achieves LEED Gold. *USGBC*.

Bon, R. (1992). The future of international construction: Secular patterns of growth and decline. *Habitat International, 16*(3), 119.

Brown, J., Enquist, B., & West, G. (2001). A general model for ontogenetic growth. *Nature, 413*, 628-631.

Bryman, A. (2012). *Social Research Methods*: Oxford University Press.

Buerk, R. (2011, 24 September 2011). Japan earthquake: Tokyo loses skyscraper passion. *BBC news*.

Čamprag, N. (2015). Frankfurt and Rotterdam: Skylines as Embodiment of a Gobal Cty. *CTBUH journal, 1*, 26-32.

Clark, W., & Kingston, J. (1930). The Skyscraper; a Study in the Economic Height of Modern Office Buildings. *American Institute of Steel Construction*.

Clayton, J., Eichholtz, P., Geltner, D., & Miller, N. (2007). *Commercial Real Estate Analysis and Investments*.

Condit, C. (1968). *American Building: Materials and Techniques from the Beginning of the Colonial Settlements to the Present*. Chicago, US and London, UK: University of Chicago Press.

Crosthwaite, D. (2000). The global construction market: a cross-sectional analysis. . *Construction Management and Economics, 18*(5), 619-627.

Ctbuh. (2013). Vanity Height: the empty space in today's tallest. *CTBUH journal*.

Dasui, W., Jianlong, Z., & Lianjin, B. (2012). Economic Analysis of Structural Systems for Supertall Buildings. *CTBUH journal*.

David, L., & Halbert, L. (2010). Constructing "World-Class" Cities: Hubs of Globalization and High Finance. *Cities : Stearing towards sustainability*.

Davies, R. (2016, August 27). Londoners back limit on skyscrapers as fears for capital's skyline grow. *The Guardian*.

Davis, A. (2012). *The Next Generation of Ultra High-Rise Buildings*. Paper presented at the CTBUH 2012 9th World Congress, Shanghai.

deJong, P. (2016). *Cost approach in development perspective*. Retrieved from Delft:

Dlamini, S. (2012). *Relationship of construction sector to economic growth* University of Reading UK

Dolkart, A. (2003). THE BIRTH OF THE SKYSCRAPER. *The Architecture and Development of New York City*. Retrieved from

Field, A. (2009). *Discovering Statistics Using SPSS*. London: SAGE Publications Ltd.

Gabaix, X. (1999). Zipf's Law for Cities: An Explanation. *The Quarterly Journal of Economics, 114*(3), 739-767.

Garza, N., & Lizieri, C. (2016). Skyscrapers and the economy in Latin America. *Journal of Property Research*.

GaWC. (1999). Research Bulletin 5 *Loughborough University publications*.

Gray, L. E., & Merril, E. (2012). *A paradigm shift in the 21st century skyscraper*. Paper presented at the 9th World Congress on Asia Ascending: Age of the Sustainable Skyscraper City, Shanghai.

Grover, R. (2013). Property cycles, Department of Real Estate & Construction. *Department of Real Estate & Construction*.

Harvey, D. (2005). *A Brief History of Neoliberalism*. Oxford: Oxford University Press.

Helsley, R., & Strange, W. (2008). A game-theoretic analysis of skyscrapers. *Journal of Urban Economics, 64*, 49–64.

Holloway, J. (2012). World's tallest building to be built in only 90 days. *Gizmag*.

Hoyt, H. (1933). *One Hundred Years of Land Values in Chicago: The Relationship of the Growth of Chicago to the Rise in Its Land Values, 1830-1933.* Chicago: University of Chicago Press.

IPD. (1999). *The UK Property Cycle –A History from 1921 to 1997: An Analysis of Property Cycles in the United Kingdom from 1921 to 1997*. London: Royal Institution of Chartered Surveyors.

Jefferson, M. (1939). The Law of the Primate City. *Geographical Review*.

Kalita, N., Maclean, M., & Watts, S. (2007). The Economics of Supertall Towers. *CTBUH publications*.

Khan, H. (2014). A New Paradigm: Glocal Urbanism and Architecture of Rapidly Developing Countries. *International Journal of Islamic Architecture, 3*(1), 5-34.

Kontokosta, C. (2013). Tall Buildings and Urban Expansion: Tracing the Evolution of Zoning in the United States. *Leadership and Management in Engineering, 13*(3).

Law, J. (2009). *A Dictionary of Business and Management* Oxford University Press.

Lawrence, A. (1999). *The Skyscraper Index: Faulty Towers* Retrieved from

Leong, C. (2013). Special economic zones and growth in China and India: an empirical investigation. *International Economics and Economic Policy, 10*(4), 549-567.

Lo, F. C., & Yeung, Y. M. (1998). *Globalization and the World of Large Cities* Tokyo: United Nations University Press.

Löffler, G. (2013). Tower building and stock market returns *Journal of Financial Research, 36*(3), 413-434.

Lutz, M. (2015). High-rise Residential Buildings. *Drees and Sommer Advanced Building Technologies GmbH, 84*(S1), 67-77.

Madhani, P. M. (2010). Rebalancing Fixed and Variable Pay in a Sales Organization: A Business Cycle Perspective. *Compensation & Benefits Review, 42*(3).

Mansharamani, V. (2011). Skyscrapers are a Great Bubble Indicator. *Forbes*.

McGough, T., & Tsolacos, S. (1995). Property cycles in the UK: an empirical investigation of the stylised facts. *Journal of Property Finance, 6*(4), 45-62.

Metha, P. (1999). Advancements in Concrete Technology. *Concrete International*.

Moncef, L. (2013). Only Tall Things Cast Shadows: Opportunities, Challenges and Research Needs of Self-Consolidating Concrete in Super-Tall Buildings *Construction and Building Materials, 48*, 80-90.

Mueller, G. (1993). Refining Economic Diversification Strategies for Real Estate Portfolios. *The journal of real estate research*.

Muñoz, D. (2010). *Capturing Value Increase in Urban Redevelopment: a study of how the economic value increase in urban redevelopment can be used to finance the necessary public infrastructure and other facilities*. Malaga: Sidestone Press.

Nastasi, M., & Ponzini, D. (2011). *STARCHITECTURE: Scenes, Actors and Spectacles in Contemporary Cities*. Turin: Allemandi.

Needham, J. (2008). *Science and civilisation in China* (Vol. 5). Cambridge, UK: Cambridge University Press.

Oldfield, P. (2009). Tall Buildings in the Global Recession 2008, 2020 and Beyond. *CTBUH journal*(1).

Pain, K. (2015). Global networks, cities and economic performance: Observations from an analysis of cities in Europe and the USA. *Urban Studies, 53*(6), 1137-1161.

Parker, D., & Wood, A. (2013). *The Tall Buildings Reference Book* Routledge.

Pashley, R. (2000). *HSC Geography*: Pascal Press.

Perez, C. (2002). *Technological Revolutions and Financial Capital. The Dynamics of Bubbles and Golden Ages*. Cambridge, UK: Edward Elgar Publishing.

Roberts, J. (2015). Global Cities Skyscrapers Report 2015. *Global cities*.

Sassen, S. (2005). The Global City: Introducing a Concept. *Brown Journal of World Affairs, XI*(2), 27-43.

Scheublin, F. (2008). *Tall Buildings in the Netherlands: Contraints to innovation*. Paper presented at the CTBUH 2008 8th World Congress, Dubai.

Schumpeter, J. (1954). *History of Economic Analysis*. London: George Allen & Unwin.

Seah, H. E., & Sklair, L. (2012). Capital Cost Drivers in Tall Buildings. *City, 10*(1).

Sullivan, M. (1988). Tall Buildings on Cheap Land: Building Heights and lntrabuilding Travel Costs. *Journal of Urban Economics, 29*, 310-328.

Thornton, M. (2005). Skyscrapers and Business Cycle. *The quarterly journal of austrian economics, 8*(1), 51-74.

Tiwari, P., & White, M. (2014). *Real Estate Finance in the New Economy*: John Wiley & Sons.

United Nations (Producer). (2015, 5/17/2017). World population projected to reach 9.7 billion by 2050.

Volckens, H. (2011). *Global Challenges Require Global Answers*. Paper presented at the 2011 World Economic Forum, Geneva, Switzerland.

World Bank Group. (2017a). Country lending summary - China. *Countries Overview.*

World Bank Group. (2017b). Country overview - Canada.

World Bank Group. (2017c). Country overview - China.

World Bank Group. (2017d). Country overview - Japan.

World Bank Group. (2017e). Country overview - United States

World Bank Group. (2017f). World Bank Country and Lending Groups.

APPENDIX 1: Economic cycles

Figure 1.1: Change of GDP level by country between 1960 and 2015.

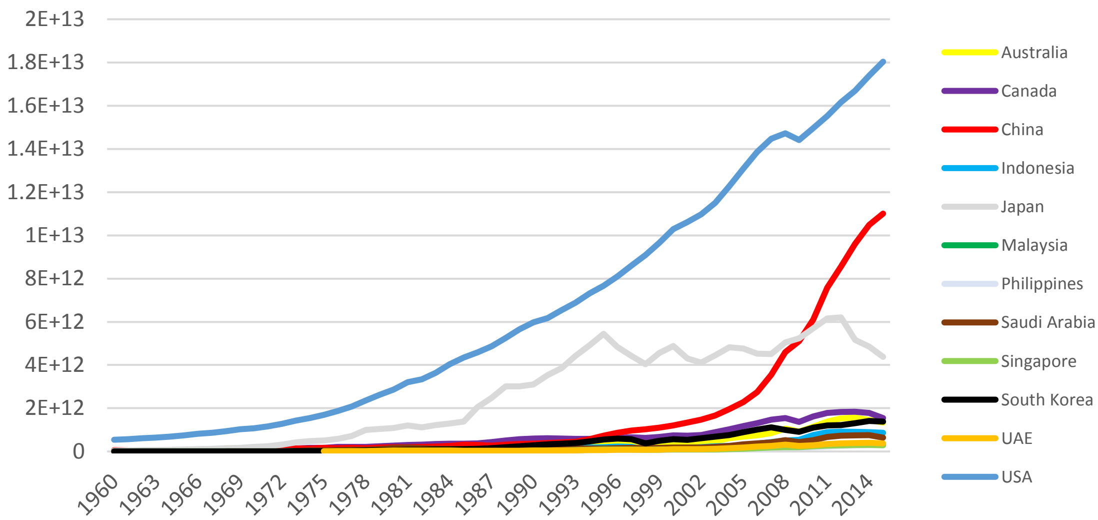


Figure 1.2: change of FDI by country between 1960 and 2015.

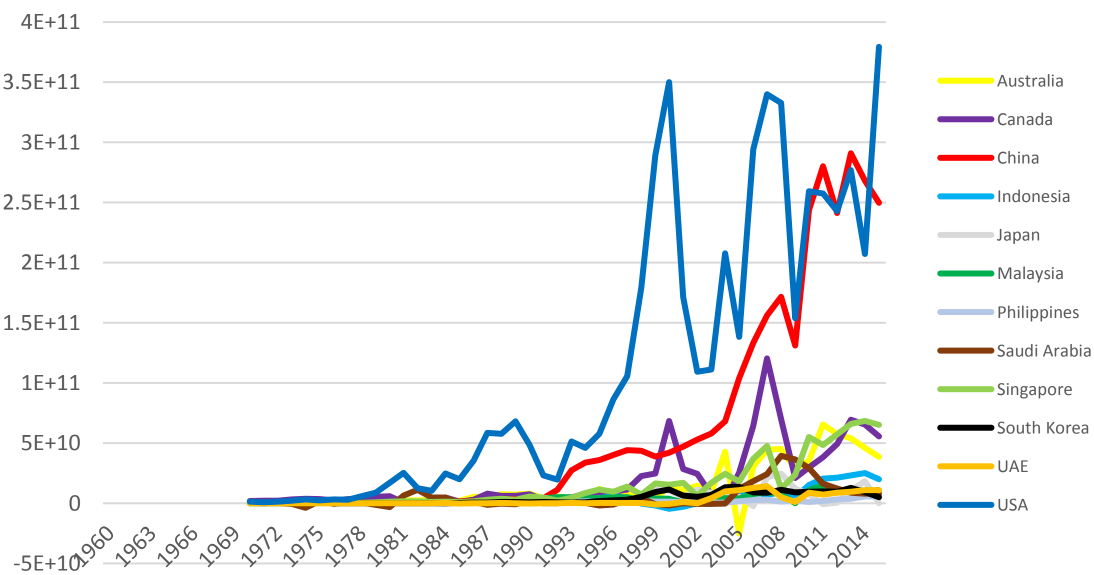


Figure 1.3: change of global GDP growth between 1961 and 2015

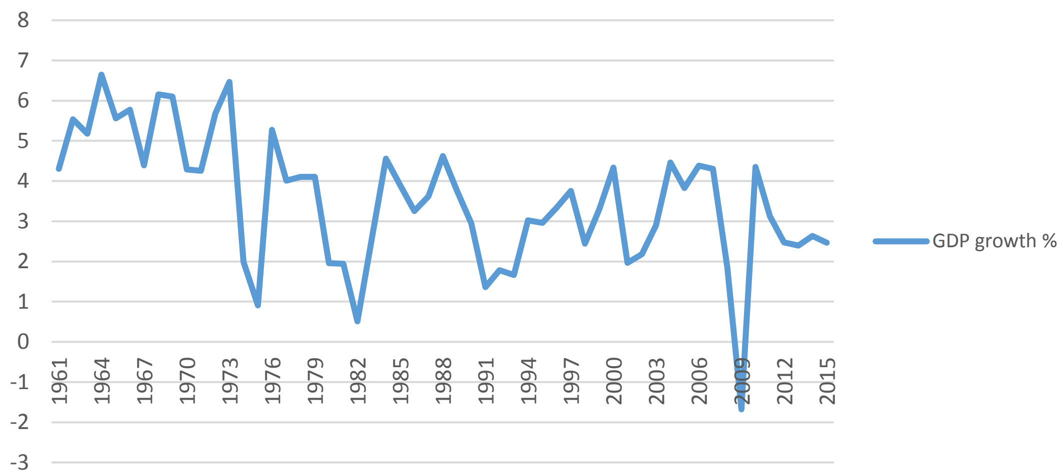


Figure 1.4: change of GDP growth of 12 selected countries between 1961 and 2015

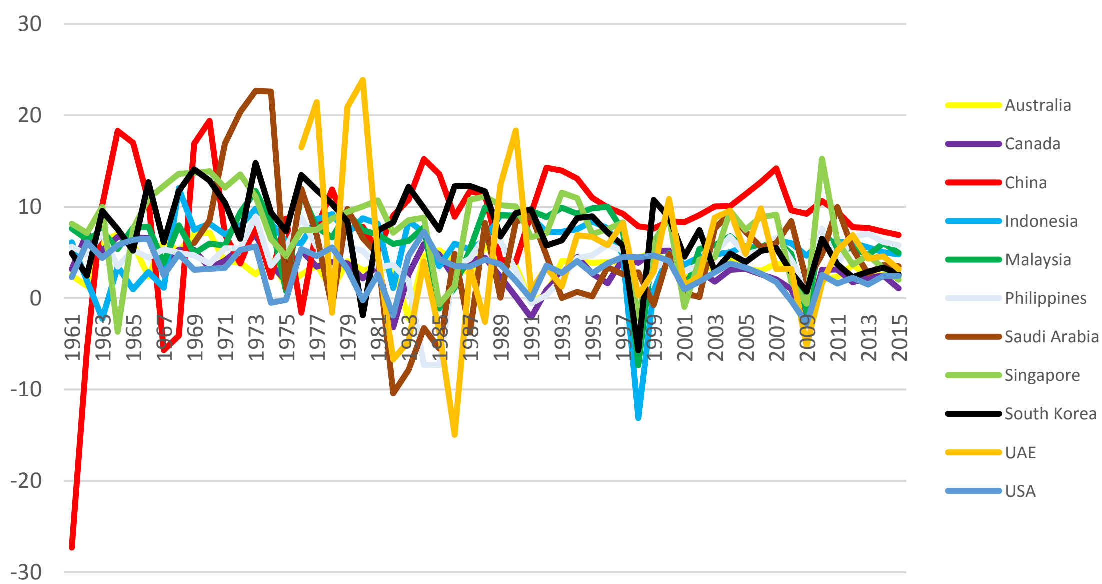


Figure 1.5: Global scale correlations of construction with global economic cycle

Correlations

		Started	Completed	Avg Height	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,908**	-,006	-,231	,921**	,911**
	Sig. (2-tailed)		,000	,964	,103	,000	,000
	N	52	50	52	51	52	45
Completed	Pearson Correlation	,908**	1	,086	-,280*	,898**	,802**
	Sig. (2-tailed)	,000		,551	,044	,000	,000
	N	50	53	50	52	53	46
Avg Height	Pearson Correlation	-,006	,086	1	-,118	,016	-,042
	Sig. (2-tailed)	,964	,551		,409	,913	,783
	N	52	50	52	51	52	45
World GDP %	Pearson Correlation	-,231	-,280*	-,118	1	-,417**	-,082
	Sig. (2-tailed)	,103	,044	,409		,002	,587
	N	51	52	51	55	55	46
World GDP Level	Pearson Correlation	,921**	,898**	,016	-,417**	1	,916**
	Sig. (2-tailed)	,000	,000	,913	,002		,000
	N	52	53	52	55	56	46
Global Investments	Pearson Correlation	,911**	,802**	-,042	-,082	,916**	1
	Sig. (2-tailed)	,000	,000	,783	,587	,000	
	N	45	46	45	46	46	46

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

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

Figure 1.6: Correlations of functions with global economic cycle

Correlations

		Residential	Hotel	Office	Mixed	World GDP %	World GDP Level	Global Investments
Residential	Pearson Correlation	1	,283	,641**	,750**	,227	,791**	,837**
	Sig. (2-tailed)		,288	,001	,000	,309	,000	,000
	N	23	16	23	23	22	22	22
Hotel	Pearson Correlation	,283	1	,418	,322	,110	,435	,628**
	Sig. (2-tailed)	,288		,060	,155	,645	,055	,003
	N	16	21	21	21	20	20	20
Office	Pearson Correlation	,641**	,418	1	,921**	-,268	,867**	,805**
	Sig. (2-tailed)	,001	,060		,000	,065	,000	,000
	N	23	21	50	50	48	49	43
Mixed	Pearson Correlation	,750**	,322	,921**	1	-,235	,908**	,896**
	Sig. (2-tailed)	,000	,155	,000		,096	,000	,000
	N	23	21	50	53	51	52	45
World GDP %	Pearson Correlation	,227	,110	-,268	-,235	1	-,417**	-,082
	Sig. (2-tailed)	,309	,645	,065	,096		,002	,587
	N	22	20	48	51	55	55	46
World GDP Level	Pearson Correlation	,791**	,435	,867**	,908**	-,417**	1	,916**
	Sig. (2-tailed)	,000	,055	,000	,000	,002		,000
	N	22	20	49	52	55	56	46
Global Investments	Pearson Correlation	,837**	,628**	,805**	,896**	-,082	,916**	1
	Sig. (2-tailed)	,000	,003	,000	,000	,587	,000	
	N	22	20	43	45	46	46	46

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

Figure 1.7: East Asia and Pacific correlations with regional and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,801**	,069	-,039	,927**	,964**	-,182	,905**	,837**
	Sig. (2-tailed)		,000	,685	,818	,000	,000	,282	,000	,000
	N	37	28	37	37	37	37	37	37	37
Completed	Pearson Correlation	,801**	1	,110	-,066	,901**	,891**	-,104	,856**	,671**
	Sig. (2-tailed)	,000		,577	,730	,000	,000	,584	,000	,000
	N	28	30	28	30	30	30	30	30	30
Avg Height	Pearson Correlation	,069	,110	1	-,237	,209	,103	-,358*	,192	,029
	Sig. (2-tailed)	,685	,577		,158	,215	,544	,030	,254	,865
	N	37	28	37	37	37	37	37	37	37
GDP %	Pearson Correlation	-,039	-,066	-,237	1	-,306*	-,003	,762**	-,327*	,015
	Sig. (2-tailed)	,818	,730	,158		,023	,986	,000	,015	,923
	N	37	30	37	55	55	46	55	55	46
GDP Level	Pearson Correlation	,927**	,901**	,209	-,306*	1	,967**	-,398**	,990**	,877**
	Sig. (2-tailed)	,000	,000	,215	,023		,000	,003	,000	,000
	N	37	30	37	55	56	46	55	56	46
FDI	Pearson Correlation	,964**	,891**	,103	-,003	,967**	1	-,139	,956**	,915**
	Sig. (2-tailed)	,000	,000	,544	,986	,000		,356	,000	,000
	N	37	30	37	46	46	46	46	46	46
World GDP %	Pearson Correlation	-,182	-,104	-,358*	,762**	-,398**	-,139	1	-,417**	-,082
	Sig. (2-tailed)	,282	,584	,030	,000	,003	,356		,002	,587
	N	37	30	37	55	55	46	55	55	46
World GDP Level	Pearson Correlation	,905**	,856**	,192	-,327*	,990**	,956**	-,417**	1	,916**
	Sig. (2-tailed)	,000	,000	,254	,015	,000	,000	,002		,000
	N	37	30	37	55	56	46	55	56	46
Global Investments	Pearson Correlation	,837**	,671**	,029	,015	,877**	,915**	-,082	,916**	1
	Sig. (2-tailed)	,000	,000	,865	,923	,000	,000	,587	,000	
	N	37	30	37	46	46	46	46	46	46

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

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

Figure 1.8: Europe and Central Asia correlations with regional and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,289	,464*	-,107	,759**	,618**	-,123	,744**	,721**
	Sig. (2-tailed)		,363	,034	,655	,000	,004	,594	,000	,000
	N	21	12	21	20	21	20	21	21	20
Completed	Pearson Correlation	,289	1	,024	-,205	,576*	,298	-,245	,650**	,553*
	Sig. (2-tailed)	,363		,942	,446	,020	,262	,360	,006	,026
	N	12	16	12	16	16	16	16	16	16
Avg Height	Pearson Correlation	,464*	,024	1	-,250	,353	,254	-,283	,342	,238
	Sig. (2-tailed)	,034	,942		,288	,116	,280	,214	,129	,312
	N	21	12	21	20	21	20	21	21	20
GDP %	Pearson Correlation	-,107	-,205	-,250	1	-,326*	-,040	,914**	-,321*	-,119
	Sig. (2-tailed)	,655	,446	,288		,029	,795	,000	,032	,435
	N	20	16	20	45	45	45	45	45	45
GDP Level	Pearson Correlation	,759**	,576*	,353	-,326*	1	,833**	-,433**	,991**	,921**
	Sig. (2-tailed)	,000	,020	,116	,029		,000	,001	,000	,000
	N	21	16	21	45	56	46	55	56	46
FDI	Pearson Correlation	,618**	,298	,254	-,040	,833**	1	-,026	,799**	,960**
	Sig. (2-tailed)	,004	,262	,280	,795	,000		,865	,000	,000
	N	20	16	20	45	46	46	46	46	46
World GDP %	Pearson Correlation	-,123	-,245	-,283	,914**	-,433**	-,026	1	-,417**	-,082
	Sig. (2-tailed)	,594	,360	,214	,000	,001	,865		,002	,587
	N	21	16	21	45	55	46	55	55	46
World GDP Level	Pearson Correlation	,744**	,650**	,342	-,321*	,991**	,799**	-,417**	1	,916**
	Sig. (2-tailed)	,000	,006	,129	,032	,000	,000	,002		,000
	N	21	16	21	45	56	46	55	56	46
Global Investments	Pearson Correlation	,721**	,553*	,238	-,119	,921**	,960**	-,082	,916**	1
	Sig. (2-tailed)	,000	,026	,312	,435	,000	,000	,587	,000	
	N	20	16	20	45	46	46	46	46	46

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

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

Figure 1.9: Latin America and Caribbean correlations with regional and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,186	,276	,007	,486	,584*	-,267	,542*	,739**
	Sig. (2-tailed)		,690	,340	,980	,092	,028	,355	,045	,003
	N	14	7	14	14	13	14	14	14	14
Completed	Pearson Correlation	,186	1	-,339	,105	,429	,429	-,149	,388	,456
	Sig. (2-tailed)	,690		,457	,787	,250	,249	,701	,302	,218
	N	7	9	7	9	9	9	9	9	9
Avg Height	Pearson Correlation	,276	-,339	1	-,125	,033	,154	,011	,342	,567*
	Sig. (2-tailed)	,340	,457		,670	,916	,598	,971	,232	,034
	N	14	7	14	14	13	14	14	14	14
GDP %	Pearson Correlation	,007	,105	-,125	1	,124	-,147	,628**	-,334*	-,082
	Sig. (2-tailed)	,980	,787	,670		,486	,329	,000	,013	,589
	N	14	9	14	55	34	46	55	55	46
GDP Level	Pearson Correlation	,486	,429	,033	,124	1	,984**	-,126	,985**	,875**
	Sig. (2-tailed)	,092	,250	,916	,486		,000	,479	,000	,000
	N	13	9	13	34	34	34	34	34	34
FDI	Pearson Correlation	,584*	,429	,154	-,147	,984**	1	-,165	,951**	,909**
	Sig. (2-tailed)	,028	,249	,598	,329	,000		,273	,000	,000
	N	14	9	14	46	34	46	46	46	46
World GDP %	Pearson Correlation	-,267	-,149	,011	,628**	-,126	-,165	1	-,417**	-,082
	Sig. (2-tailed)	,355	,701	,971	,000	,479	,273		,002	,587
	N	14	9	14	55	34	46	55	55	46
World GDP Level	Pearson Correlation	,542*	,388	,342	-,334*	,985**	,951**	-,417**	1	,916**
	Sig. (2-tailed)	,045	,302	,232	,013	,000	,000	,002		,000
	N	14	9	14	55	34	46	55	56	46
Global Investments	Pearson Correlation	,739**	,456	,567*	-,082	,875**	,909**	-,082	,916**	1
	Sig. (2-tailed)	,003	,218	,034	,589	,000	,000	,587	,000	
	N	14	9	14	46	34	46	46	46	46

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

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

Figure 1.10: Middle East and North Africa correlations with regional and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,128	-,143	,562**	,274	,795**	,253	,341	,618**
	Sig. (2-tailed)		,636	,548	,010	,243	,000	,282	,141	,004
	N	20	16	20	20	20	20	20	20	20
Completed	Pearson Correlation	,128	1	-,181	,072	,836**	,478	,072	,819**	,673**
	Sig. (2-tailed)	,636		,503	,791	,000	,061	,792	,000	,004
	N	16	16	16	16	16	16	16	16	16
Avg Height	Pearson Correlation	-,143	-,181	1	-,313	-,251	-,238	-,089	-,257	-,366
	Sig. (2-tailed)	,548	,503		,179	,286	,311	,709	,275	,113
	N	20	16	20	20	20	20	20	20	20
GDP %	Pearson Correlation	,562**	,072	-,313	1	-,157	,024	,458**	-,169	-,004
	Sig. (2-tailed)	,010	,791	,179		,291	,875	,001	,256	,980
	N	20	16	20	47	47	46	47	47	46
GDP Level	Pearson Correlation	,274	,836**	-,251	-,157	1	,793**	-,282	,973**	,902**
	Sig. (2-tailed)	,243	,000	,286	,291		,000	,052	,000	,000
	N	20	16	20	47	48	46	48	48	46
FDI	Pearson Correlation	,795**	,478	-,238	,024	,793**	1	-,114	,798**	,913**
	Sig. (2-tailed)	,000	,061	,311	,875	,000		,449	,000	,000
	N	20	16	20	46	46	46	46	46	46
World GDP %	Pearson Correlation	,253	,072	-,089	,458**	-,282	-,114	1	-,417**	-,082
	Sig. (2-tailed)	,282	,792	,709	,001	,052	,449		,002	,587
	N	20	16	20	47	48	46	55	55	46
World GDP Level	Pearson Correlation	,341	,819**	-,257	-,169	,973**	,798**	-,417**	1	,916**
	Sig. (2-tailed)	,141	,000	,275	,256	,000	,000	,002		,000
	N	20	16	20	47	48	46	55	56	46
Global Investments	Pearson Correlation	,618**	,673**	-,366	-,004	,902**	,913**	-,082	,916**	1
	Sig. (2-tailed)	,004	,004	,113	,980	,000	,000	,587	,000	
	N	20	16	20	46	46	46	46	46	46

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

Figure 1.11: North America correlations with regional and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,128	-,143	,562**	,274	,795**	,253	,341	,618**
	Sig. (2-tailed)		,636	,548	,010	,243	,000	,282	,141	,004
	N	20	16	20	20	20	20	20	20	20
Completed	Pearson Correlation	,128	1	-,181	,072	,836**	,478	,072	,819**	,673**
	Sig. (2-tailed)	,636		,503	,791	,000	,061	,792	,000	,004
	N	16	16	16	16	16	16	16	16	16
Avg Height	Pearson Correlation	-,143	-,181	1	-,313	-,251	-,238	-,089	-,257	-,366
	Sig. (2-tailed)	,548	,503		,179	,286	,311	,709	,275	,113
	N	20	16	20	20	20	20	20	20	20
GDP %	Pearson Correlation	,562**	,072	-,313	1	-,157	,024	,458**	-,169	-,004
	Sig. (2-tailed)	,010	,791	,179		,291	,875	,001	,256	,980
	N	20	16	20	47	47	46	47	47	46
GDP Level	Pearson Correlation	,274	,836**	-,251	-,157	1	,793**	-,282	,973**	,902**
	Sig. (2-tailed)	,243	,000	,286	,291		,000	,052	,000	,000
	N	20	16	20	47	48	46	48	48	46
FDI	Pearson Correlation	,795**	,478	-,238	,024	,793**	1	-,114	,798**	,913**
	Sig. (2-tailed)	,000	,061	,311	,875	,000		,449	,000	,000
	N	20	16	20	46	46	46	46	46	46
World GDP %	Pearson Correlation	,253	,072	-,089	,458**	-,282	-,114	1	-,417**	-,082
	Sig. (2-tailed)	,282	,792	,709	,001	,052	,449		,002	,587
	N	20	16	20	47	48	46	55	55	46
World GDP Level	Pearson Correlation	,341	,819**	-,257	-,169	,973**	,798**	-,417**	1	,916**
	Sig. (2-tailed)	,141	,000	,275	,256	,000	,000	,002		,000
	N	20	16	20	47	48	46	55	56	46
Global Investments	Pearson Correlation	,618**	,673**	-,366	-,004	,902**	,913**	-,082	,916**	1
	Sig. (2-tailed)	,004	,004	,113	,980	,000	,000	,587	,000	
	N	20	16	20	46	46	46	46	46	46

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

Figure 1.12: South Asia correlations with regional and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	-1,000**	,150	,041	,513	,034	,128	,529	,261
	Sig. (2-tailed)		.	,700	,918	,158	,931	,742	,143	,498
	N	9	2	9	9	9	9	9	9	9
Completed	Pearson Correlation	-1,000**	1	-1,000**	1,000**	-1,000**	-1,000**	1,000**	-1,000**	-1,000**
	Sig. (2-tailed)	.		.	.	.	.	.	.	.
	N	2	2	2	2	2	2	2	2	2
Avg Height	Pearson Correlation	,150	-1,000**	1	-,328	,266	,042	,487	,246	,507
	Sig. (2-tailed)	,700	.		,389	,489	,914	,184	,523	,163
	N	9	2	9	9	9	9	9	9	9
GDP %	Pearson Correlation	,041	1,000**	-,328	1	,407**	,337*	-,206	,447**	,415**
	Sig. (2-tailed)	,918	.	,389		,002	,022	,132	,001	,004
	N	9	2	9	55	55	46	55	55	46
GDP Level	Pearson Correlation	,513	-1,000**	,266	,407**	1	,930**	-,346**	,964**	,885**
	Sig. (2-tailed)	,158	.	,489	,002		,000	,010	,000	,000
	N	9	2	9	55	56	46	55	56	46
FDI	Pearson Correlation	,034	-1,000**	,042	,337*	,930**	1	-,238	,898**	,897**
	Sig. (2-tailed)	,931	.	,914	,022	,000		,112	,000	,000
	N	9	2	9	46	46	46	46	46	46
World GDP %	Pearson Correlation	,128	1,000**	,487	-,206	-,346**	-,238	1	-,417**	-,082
	Sig. (2-tailed)	,742	.	,184	,132	,010	,112		,002	,587
	N	9	2	9	55	55	46	55	55	46
World GDP Level	Pearson Correlation	,529	-1,000**	,246	,447**	,964**	,898**	-,417**	1	,916**
	Sig. (2-tailed)	,143	.	,523	,001	,000	,000	,002		,000
	N	9	2	9	55	56	46	55	56	46
Global Investments	Pearson Correlation	,261	-1,000**	,507	,415**	,885**	,897**	-,082	,916**	1
	Sig. (2-tailed)	,498	.	,163	,004	,000	,000	,587	,000	
	N	9	2	9	46	46	46	46	46	46

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

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

Figure 1.13: Australia correlations with country and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	Deflated GDP	Interest Rate	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	-,178	,279	-,365	,381	,337	-,471	,341	-,325	,449	,514*
	Sig. (2-tailed)		,736	,278	,165	,145	,202	,076	,196	,219	,081	,041
	N	17	6	17	16	16	16	15	16	16	16	16
Completed	Pearson Correlation	-,178	1	-,019	-,637*	,127	,130	-,031	-,295	-,398	,118	,002
	Sig. (2-tailed)	,736		,972	,014	,665	,657	,916	,306	,158	,689	,993
	N	6	15	6	14	14	14	14	14	14	14	14
Avg Height	Pearson Correlation	,279	-,019	1	-,285	-,001	-,030	-,004	-,135	-,382	,048	,071
	Sig. (2-tailed)	,278	,972		,284	,998	,912	,989	,619	,145	,861	,793
	N	17	6	17	16	16	16	15	16	16	16	16
GDP %	Pearson Correlation	-,365	-,637*	-,285	1	-,240	-,264	,069	-,090	,437**	-,245	-,059
	Sig. (2-tailed)	,165	,014	,284		,077	,052	,666	,552	,001	,072	,698
	N	16	14	16	55	55	55	41	46	55	55	46
GDP Level	Pearson Correlation	,381	,127	-,001	-,240	1	,970**	-,635**	,874**	-,372**	,977**	,889**
	Sig. (2-tailed)	,145	,665	,998	,077		,000	,000	,000	,005	,000	,000
	N	16	14	16	55	56	56	41	46	55	56	46
Deflated GDP	Pearson Correlation	,337	,130	-,030	-,264	,970**	1	-,632**	,859**	-,391**	,931**	,863**
	Sig. (2-tailed)	,202	,657	,912	,052	,000		,000	,000	,003	,000	,000
	N	16	14	16	55	56	56	41	46	55	56	46
Interest Rate	Pearson Correlation	-,471	-,031	-,004	,069	-,635**	-,632**	1	-,513**	,104	-,687**	-,642**
	Sig. (2-tailed)	,076	,916	,989	,666	,000	,000		,001	,519	,000	,000
	N	15	14	15	41	41	41	41	41	41	41	41
FDI	Pearson Correlation	,341	-,295	-,135	-,090	,874**	,859**	-,513**	1	-,136	,841**	,815**
	Sig. (2-tailed)	,196	,306	,619	,552	,000	,000	,001		,369	,000	,000
	N	16	14	16	46	46	46	41	46	46	46	46
World GDP %	Pearson Correlation	-,325	-,398	-,382	,437**	-,372**	-,391**	,104	-,136	1	-,417**	-,082
	Sig. (2-tailed)	,219	,158	,145	,001	,005	,003	,519	,369		,002	,587
	N	16	14	16	55	55	55	41	46	55	55	46
World GDP Level	Pearson Correlation	,449	,118	,048	-,245	,977**	,931**	-,687**	,841**	-,417**	1	,916**
	Sig. (2-tailed)	,081	,689	,861	,072	,000	,000	,000	,000	,002		,000
	N	16	14	16	55	56	56	41	46	55	56	46
Global Investments	Pearson Correlation	,514*	,002	,071	-,059	,889**	,863**	-,642**	,815**	-,082	,916**	1
	Sig. (2-tailed)	,041	,993	,793	,698	,000	,000	,000	,000	,587	,000	
	N	16	14	16	46	46	46	41	46	46	46	46

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

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

Figure 1.14: Canada correlations with country and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	Deflated GDP	Interest Rate	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,603	-,134	-,604*	,745**	,716**	-,583*	,759**	-,360	,777**	,745**
	Sig. (2-tailed)		,205	,621	,013	,001	,002	,018	,001	,171	,000	,001
	N	16	6	16	16	16	16	16	15	16	16	15
Completed	Pearson Correlation	,603	1	-,393	-,065	,618*	,612*	-,486	,647*	-,124	,609*	,596*
	Sig. (2-tailed)	,205		,441	,826	,019	,020	,078	,017	,672	,021	,032
	N	6	14	6	14	14	14	14	13	14	14	13
Avg Height	Pearson Correlation	-,134	-,393	1	,587*	-,374	-,353	,058	-,314	,407	-,367	-,390
	Sig. (2-tailed)	,621	,441		,017	,153	,180	,831	,255	,118	,162	,150
	N	16	6	16	16	16	16	16	15	16	16	15
GDP %	Pearson Correlation	-,604*	-,065	,587*	1	-,439**	-,452**	-,071	-,107	,827**	-,434**	-,196
	Sig. (2-tailed)	,013	,826	,017		,001	,001	,606	,478	,000	,001	,193
	N	16	14	16	55	55	55	55	46	55	55	46
GDP Level	Pearson Correlation	,745**	,618*	-,374	-,439**	1	,988**	-,510**	,772**	-,402**	,994**	,930**
	Sig. (2-tailed)	,001	,019	,153	,001		,000	,000	,000	,002	,000	,000
	N	16	14	16	55	56	56	56	46	55	56	46
Deflated GDP	Pearson Correlation	,716**	,612*	-,353	-,452**	,988**	1	-,443**	,775**	-,411**	,974**	,935**
	Sig. (2-tailed)	,002	,020	,180	,001	,000		,001	,000	,002	,000	,000
	N	16	14	16	55	56	56	56	46	55	56	46
Interest Rate	Pearson Correlation	-,583*	-,486	,058	-,071	-,510**	-,443**	1	-,509**	-,093	-,541**	-,664**
	Sig. (2-tailed)	,018	,078	,831	,606	,000	,001		,000	,501	,000	,000
	N	16	14	16	55	56	56	56	46	55	56	46
FDI	Pearson Correlation	,759**	,647*	-,314	-,107	,772**	,775**	-,509**	1	-,017	,760**	,912**
	Sig. (2-tailed)	,001	,017	,255	,478	,000	,000	,000		,911	,000	,000
	N	15	13	15	46	46	46	46	46	46	46	46
World GDP %	Pearson Correlation	-,360	-,124	,407	,827**	-,402**	-,411**	-,093	-,017	1	-,417**	-,082
	Sig. (2-tailed)	,171	,672	,118	,000	,002	,002	,501	,911		,002	,587
	N	16	14	16	55	55	55	55	46	55	55	46
World GDP Level	Pearson Correlation	,777**	,609*	-,367	-,434**	,994**	,974**	-,541**	,760**	-,417**	1	,916**
	Sig. (2-tailed)	,000	,021	,162	,001	,000	,000	,000	,000	,002		,000
	N	16	14	16	55	56	56	56	46	55	56	46
Global Investments	Pearson Correlation	,745**	,596*	-,390	-,196	,930**	,935**	-,664**	,912**	-,082	,916**	1
	Sig. (2-tailed)	,001	,032	,150	,193	,000	,000	,000	,000	,587	,000	
	N	15	13	15	46	46	46	46	46	46	46	46

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

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

Figure 1.15: China correlations with country and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	Deflated GDP	Interest Rate	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,520**	,064	-,246	,892**	,894**	-,465*	,937**	,003	,892**	,772**
	Sig. (2-tailed)		,009	,735	,199	,000	,000	,011	,000	,987	,000	,000
	N	30	24	30	29	29	29	29	29	29	29	29
Completed	Pearson Correlation	,520**	1	,340	-,231	,884**	,878**	-,515**	,765**	-,018	,783**	,570**
	Sig. (2-tailed)	,009		,104	,266	,000	,000	,008	,000	,931	,000	,003
	N	24	26	24	25	25	25	25	24	25	25	25
Avg Height	Pearson Correlation	,064	,340	1	,054	,132	,115	,268	,103	,094	,096	,008
	Sig. (2-tailed)	,735	,104		,779	,496	,552	,160	,594	,628	,622	,967
	N	30	24	30	29	29	29	29	29	29	29	29
GDP %	Pearson Correlation	-,246	-,231	,054	1	,052	,086	,236	-,197	-,058	,173	,098
	Sig. (2-tailed)	,199	,266	,779		,705	,530	,166	,265	,673	,208	,518
	N	29	25	29	55	55	55	36	34	55	55	46
GDP Level	Pearson Correlation	,892**	,884**	,132	,052	1	,994**	-,469**	,961**	-,295*	,897**	,811**
	Sig. (2-tailed)	,000	,000	,496	,705		,000	,004	,000	,029	,000	,000
	N	29	25	29	55	56	56	36	34	55	56	46
Deflated GDP	Pearson Correlation	,894**	,878**	,115	,086	,994**	1	-,501**	,966**	-,341*	,926**	,836**
	Sig. (2-tailed)	,000	,000	,552	,530	,000		,002	,000	,011	,000	,000
	N	29	25	29	55	56	56	36	34	55	56	46
Interest Rate	Pearson Correlation	-,465*	-,515**	,268	,236	-,469**	-,501**	1	-,532**	,148	-,436**	-,502**
	Sig. (2-tailed)	,011	,008	,160	,166	,004	,002		,001	,387	,008	,002
	N	29	25	29	36	36	36	36	34	36	36	36
FDI	Pearson Correlation	,937**	,765**	,103	-,197	,961**	,966**	-,532**	1	-,057	,970**	,871**
	Sig. (2-tailed)	,000	,000	,594	,265	,000	,000	,001		,749	,000	,000
	N	29	24	29	34	34	34	34	34	34	34	34
World GDP %	Pearson Correlation	,003	-,018	,094	-,058	-,295*	-,341*	,148	-,057	1	-,417**	-,082
	Sig. (2-tailed)	,987	,931	,628	,673	,029	,011	,387	,749		,002	,587
	N	29	25	29	55	55	55	36	34	55	55	46
World GDP Level	Pearson Correlation	,892**	,783**	,096	,173	,897**	,926**	-,436**	,970**	-,417**	1	,916**
	Sig. (2-tailed)	,000	,000	,622	,208	,000	,000	,008	,000	,002		,000
	N	29	25	29	55	56	56	36	34	55	56	46
Global Investments	Pearson Correlation	,772**	,570**	,008	,098	,811**	,836**	-,502**	,871**	-,082	,916**	1
	Sig. (2-tailed)	,000	,003	,967	,518	,000	,000	,002	,000	,587	,000	
	N	29	25	29	46	46	46	36	34	46	46	46

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

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

Figure 1.16: Indonesia correlations with country and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	Deflated GDP	Interest Rate	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	-,096	,199	,018	,883**	,857**	-,765*	,905**	,101	,846**	-,284
	Sig. (2-tailed)		,838	,582	,964	,002	,003	,016	,001	,797	,004	,459
	N	10	7	10	9	9	9	9	9	9	9	9
Completed	Pearson Correlation	-,096	1	,490	-,492	,509	-,215	-,416	,405	-,312	,505	,372
	Sig. (2-tailed)	,838		,264	,178	,162	,578	,265	,279	,413	,166	,324
	N	7	10	7	9	9	9	9	9	9	9	9
Avg Height	Pearson Correlation	,199	,490	1	-,625	,577	,172	-,360	,595	-,107	,608	-,395
	Sig. (2-tailed)	,582	,264		,072	,104	,658	,341	,091	,785	,082	,293
	N	10	7	10	9	9	9	9	9	9	9	9
GDP %	Pearson Correlation	,018	-,492	-,625	1	-,095	,429**	-,428*	,105	,039	-,062	-,198
	Sig. (2-tailed)	,964	,178	,072		,514	,001	,018	,550	,780	,654	,187
	N	9	9	9	55	49	55	30	35	55	55	46
GDP Level	Pearson Correlation	,883**	,509	,577	-,095	1	-,593**	-,775**	,951**	-,267	,946**	,845**
	Sig. (2-tailed)	,002	,162	,104	,514		,000	,000	,000	,064	,000	,000
	N	9	9	9	49	49	49	30	35	49	49	46
Deflated GDP	Pearson Correlation	,857**	-,215	,172	,429**	-,593**	1	,327	-,296	-,045	-,415**	-,741**
	Sig. (2-tailed)	,003	,578	,658	,001	,000		,078	,084	,742	,001	,000
	N	9	9	9	55	49	56	30	35	55	56	46
Interest Rate	Pearson Correlation	-,765*	-,416	-,360	-,428*	-,775**	,327	1	-,697**	-,017	-,790**	-,716**
	Sig. (2-tailed)	,016	,265	,341	,018	,000	,078		,000	,928	,000	,000
	N	9	9	9	30	30	30	30	30	30	30	30
FDI	Pearson Correlation	,905**	,405	,595	,105	,951**	-,296	-,697**	1	-,041	,860**	,686**
	Sig. (2-tailed)	,001	,279	,091	,550	,000	,084	,000		,814	,000	,000
	N	9	9	9	35	35	35	30	35	35	35	35
World GDP %	Pearson Correlation	,101	-,312	-,107	,039	-,267	-,045	-,017	-,041	1	-,417**	-,082
	Sig. (2-tailed)	,797	,413	,785	,780	,064	,742	,928	,814		,002	,587
	N	9	9	9	55	49	55	30	35	55	55	46
World GDP Level	Pearson Correlation	,846**	,505	,608	-,062	,946**	-,415**	-,790**	,860**	-,417**	1	,916**
	Sig. (2-tailed)	,004	,166	,082	,654	,000	,001	,000	,000	,002		,000
	N	9	9	9	55	49	56	30	35	55	56	46
Global Investments	Pearson Correlation	-,284	,372	-,395	-,198	,845**	-,741**	-,716**	,686**	-,082	,916**	1
	Sig. (2-tailed)	,459	,324	,293	,187	,000	,000	,000	,000	,587	,000	
	N	9	9	9	46	46	46	30	35	46	46	46

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

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

Figure 1.17: Japan correlations with country and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	Deflated GDP	Interest Rate	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,224	,213	,215	,285	,261	-,173	-,581*	,173	,123	,150
	Sig. (2-tailed)		,563	,413	,407	,268	,312	,521	,037	,507	,639	,566
	N	17	9	17	17	17	17	16	13	17	17	17
Completed	Pearson Correlation	,224	1	,227	-,062	,081	,058	-,086	,325	,034	,020	,174
	Sig. (2-tailed)	,563		,558	,795	,733	,807	,717	,189	,885	,932	,463
	N	9	21	9	20	20	20	20	18	20	20	20
Avg Height	Pearson Correlation	,213	,227	1	,369	,058	,045	,033	,007	,250	-,066	-,197
	Sig. (2-tailed)	,413	,558		,145	,824	,862	,902	,982	,334	,802	,450
	N	17	9	17	17	17	17	16	13	17	17	17
GDP %	Pearson Correlation	,215	-,062	,369	1	-,680**	-,668**	,587**	-,462**	,740**	-,616**	-,437**
	Sig. (2-tailed)	,407	,795	,145		,000	,000	,000	,003	,000	,000	,002
	N	17	20	17	55	55	55	54	39	55	55	46
GDP Level	Pearson Correlation	,285	,081	,058	-,680**	1	,994**	-,921**	,423**	-,466**	,890**	,727**
	Sig. (2-tailed)	,268	,733	,824	,000		,000	,000	,007	,000	,000	,000
	N	17	20	17	55	56	56	55	39	55	56	46
Deflated GDP	Pearson Correlation	,261	,058	,045	-,668**	,994**	1	-,928**	,440**	-,453**	,928**	,785**
	Sig. (2-tailed)	,312	,807	,862	,000	,000		,000	,005	,001	,000	,000
	N	17	20	17	55	56	56	55	39	55	56	46
Interest Rate	Pearson Correlation	-,173	-,086	,033	,587**	-,921**	-,928**	1	-,572**	,282*	-,896**	-,797**
	Sig. (2-tailed)	,521	,717	,902	,000	,000	,000		,000	,039	,000	,000
	N	16	20	16	54	55	55	55	38	54	55	45
FDI	Pearson Correlation	-,581*	,325	,007	-,462**	,423**	,440**	-,572**	1	-,145	,527**	,604**
	Sig. (2-tailed)	,037	,189	,982	,003	,007	,005	,000		,378	,001	,000
	N	13	18	13	39	39	39	38	39	39	39	39
World GDP %	Pearson Correlation	,173	,034	,250	,740**	-,466**	-,453**	,282*	-,145	1	-,417**	-,082
	Sig. (2-tailed)	,507	,885	,334	,000	,000	,001	,039	,378		,002	,587
	N	17	20	17	55	55	55	54	39	55	55	46
World GDP Level	Pearson Correlation	,123	,020	-,066	-,616**	,890**	,928**	-,896**	,527**	-,417**	1	,916**
	Sig. (2-tailed)	,639	,932	,802	,000	,000	,000	,000	,001	,002		,000
	N	17	20	17	55	56	56	55	39	55	56	46
Global Investments	Pearson Correlation	,150	,174	-,197	-,437**	,727**	,785**	-,797**	,604**	-,082	,916**	1
	Sig. (2-tailed)	,566	,463	,450	,002	,000	,000	,000	,000	,587	,000	
	N	17	20	17	46	46	46	45	39	46	46	46

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

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

Figure 1.18: Malaysia correlations with country and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	Deflated GDP	Interest Rate	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	-,250	,209	,134	,585*	,569*	-,352	,469	-,086	,519	,292
	Sig. (2-tailed)		,588	,455	,649	,028	,034	,239	,091	,771	,057	,311
	N	15	7	15	14	14	14	13	14	14	14	14
Completed	Pearson Correlation	-,250	1	,519	-,645*	-,059	-,080	,499	-,094	-,283	-,003	-,027
	Sig. (2-tailed)	,588		,232	,032	,864	,816	,142	,784	,399	,992	,938
	N	7	12	7	11	11	11	10	11	11	11	11
Avg Height	Pearson Correlation	,209	,519	1	,060	-,242	-,246	,428	-,054	-,125	-,268	-,394
	Sig. (2-tailed)	,455	,232		,838	,404	,397	,145	,855	,670	,354	,163
	N	15	7	15	14	14	14	13	14	14	14	14
GDP %	Pearson Correlation	,134	-,645*	,060	1	-,188	-,151	,121	,022	,357**	-,208	-,217
	Sig. (2-tailed)	,649	,032	,838		,169	,273	,531	,887	,008	,128	,147
	N	14	11	14	55	55	55	29	46	55	55	46
GDP Level	Pearson Correlation	,585*	-,059	-,242	-,188	1	,968**	-,838**	,893**	-,358**	,981**	,897**
	Sig. (2-tailed)	,028	,864	,404	,169		,000	,000	,000	,007	,000	,000
	N	14	11	14	55	56	56	29	46	55	56	46
Deflated GDP	Pearson Correlation	,569*	-,080	-,246	-,151	,968**	1	-,798**	,898**	-,444**	,987**	,873**
	Sig. (2-tailed)	,034	,816	,397	,273	,000		,000	,000	,001	,000	,000
	N	14	11	14	55	56	56	29	46	55	56	46
Interest Rate	Pearson Correlation	-,352	,499	,428	,121	-,838**	-,798**	1	-,596**	,092	-,865**	-,779**
	Sig. (2-tailed)	,239	,142	,145	,531	,000	,000		,001	,635	,000	,000
	N	13	10	13	29	29	29	29	29	29	29	29
FDI	Pearson Correlation	,469	-,094	-,054	,022	,893**	,898**	-,596**	1	-,066	,880**	,829**
	Sig. (2-tailed)	,091	,784	,855	,887	,000	,000	,001		,664	,000	,000
	N	14	11	14	46	46	46	29	46	46	46	46
World GDP %	Pearson Correlation	-,086	-,283	-,125	,357**	-,358**	-,444**	,092	-,066	1	-,417**	-,082
	Sig. (2-tailed)	,771	,399	,670	,008	,007	,001	,635	,664		,002	,587
	N	14	11	14	55	55	55	29	46	55	55	46
World GDP Level	Pearson Correlation	,519	-,003	-,268	-,208	,981**	,987**	-,865**	,880**	-,417**	1	,916**
	Sig. (2-tailed)	,057	,992	,354	,128	,000	,000	,000	,000	,002		,000
	N	14	11	14	55	56	56	29	46	55	56	46
Global Investments	Pearson Correlation	,292	-,027	-,394	-,217	,897**	,873**	-,779**	,829**	-,082	,916**	1
	Sig. (2-tailed)	,311	,938	,163	,147	,000	,000	,000	,000	,587	,000	
	N	14	11	14	46	46	46	29	46	46	46	46

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

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

Figure 1.19: Philippines correlations with country and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	Deflated GDP	Interest Rate	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,375	,001	,509	,613*	,597*	-,590*	,191	-,216	,612*	,183
	Sig. (2-tailed)		,534	,998	,091	,034	,040	,044	,552	,501	,034	,570
	N	13	5	13	12	12	12	12	12	12	12	12
Completed	Pearson Correlation	,375	1	,499	-,182	,468	,439	-,460	,396	-,468	,554	,320
	Sig. (2-tailed)	,534		,392	,614	,173	,204	,181	,258	,173	,097	,368
	N	5	11	5	10	10	10	10	10	10	10	10
Avg Height	Pearson Correlation	,001	,499	1	-,678*	-,163	-,114	,458	-,225	-,607*	-,226	-,445
	Sig. (2-tailed)	,998	,392		,015	,612	,723	,134	,482	,036	,480	,147
	N	13	5	13	12	12	12	12	12	12	12	12
GDP %	Pearson Correlation	,509	-,182	-,678*	1	,156	,251	-,718**	,214	,272*	,115	,242
	Sig. (2-tailed)	,091	,614	,015		,256	,065	,000	,152	,044	,404	,105
	N	12	10	12	55	55	55	40	46	55	55	46
GDP Level	Pearson Correlation	,613*	,468	-,163	,156	1	-,445**	-,708**	,885**	-,380**	,970**	,871**
	Sig. (2-tailed)	,034	,173	,612	,256		,001	,000	,000	,004	,000	,000
	N	12	10	12	55	56	56	40	46	55	56	46
Deflated GDP	Pearson Correlation	,597*	,439	-,114	,251	-,445**	1	,023	-,330*	,328*	-,602**	-,402**
	Sig. (2-tailed)	,040	,204	,723	,065	,001		,887	,025	,015	,000	,006
	N	12	10	12	55	56	56	40	46	55	56	46
Interest Rate	Pearson Correlation	-,590*	-,460	,458	-,718**	-,708**	,023	1	-,621**	,055	-,720**	-,717**
	Sig. (2-tailed)	,044	,181	,134	,000	,000	,887		,000	,736	,000	,000
	N	12	10	12	40	40	40	40	40	40	40	40
FDI	Pearson Correlation	,191	,396	-,225	,214	,885**	-,330*	-,621**	1	-,177	,841**	,760**
	Sig. (2-tailed)	,552	,258	,482	,152	,000	,025	,000		,240	,000	,000
	N	12	10	12	46	46	46	40	46	46	46	46
World GDP %	Pearson Correlation	-,216	-,468	-,607*	,272*	-,380**	,328*	,055	-,177	1	-,417**	-,082
	Sig. (2-tailed)	,501	,173	,036	,044	,004	,015	,736	,240		,002	,587
	N	12	10	12	55	55	55	40	46	55	55	46
World GDP Level	Pearson Correlation	,612*	,554	-,226	,115	,970**	-,602**	-,720**	,841**	-,417**	1	,916**
	Sig. (2-tailed)	,034	,097	,480	,404	,000	,000	,000	,000	,002		,000
	N	12	10	12	55	56	56	40	46	55	56	46
Global Investments	Pearson Correlation	,183	,320	-,445	,242	,871**	-,402**	-,717**	,760**	-,082	,916**	1
	Sig. (2-tailed)	,570	,368	,147	,105	,000	,006	,000	,000	,587	,000	
	N	12	10	12	46	46	46	40	46	46	46	46

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

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

Figure 1.20: Saudi Arabia correlations with country and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	Deflated GDP	Interest Rate	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,800	-,160	,438	,586*	,480	.b	,402	-,018	,561*	,331
	Sig. (2-tailed)		,056	,601	,134	,035	,097	.	,174	,954	,046	,269
	N	13	6	13	13	13	13	0	13	13	13	13
Completed	Pearson Correlation	,800	1	-,268	,020	,386	,284	.b	-,031	-,192	,301	,061
	Sig. (2-tailed)	,056		,608	,963	,345	,496	.	,941	,649	,469	,885
	N	6	9	6	8	8	8	0	8	8	8	8
Avg Height	Pearson Correlation	-,160	-,268	1	-,446	,050	-,017	.b	-,226	-,101	-,019	-,152
	Sig. (2-tailed)	,601	,608		,126	,870	,956	.	,457	,744	,951	,619
	N	13	6	13	13	13	13	0	13	13	13	13
GDP %	Pearson Correlation	,438	,020	-,446	1	-,089	-,151	.b	-,076	,383**	-,106	,002
	Sig. (2-tailed)	,134	,963	,126		,550	,310	.	,614	,008	,477	,988
	N	13	8	13	47	47	47	0	46	47	47	46
GDP Level	Pearson Correlation	,586*	,386	,050	-,089	1	,966**	.b	,642**	-,301*	,953**	,877**
	Sig. (2-tailed)	,035	,345	,870	,550		,000	.	,000	,037	,000	,000
	N	13	8	13	47	48	48	0	46	48	48	46
Deflated GDP	Pearson Correlation	,480	,284	-,017	-,151	,966**	1	.b	,622**	-,397**	,955**	,868**
	Sig. (2-tailed)	,097	,496	,956	,310	,000		.	,000	,005	,000	,000
	N	13	8	13	47	48	48	0	46	48	48	46
Interest Rate	Pearson Correlation	.b	.b	.b	.b	.b	.b	.b	.b	.b	.b	.b
	Sig. (2-tailed)	.	.	.	.	.	.		.	.	.	.
	N	0	0	0	0	0	0	0	0	0	0	0
FDI	Pearson Correlation	,402	-,031	-,226	-,076	,642**	,622**	.b	1	-,299*	,641**	,717**
	Sig. (2-tailed)	,174	,941	,457	,614	,000	,000	.		,044	,000	,000
	N	13	8	13	46	46	46	0	46	46	46	46
World GDP %	Pearson Correlation	-,018	-,192	-,101	,383**	-,301*	-,397**	.b	-,299*	1	-,417**	-,082
	Sig. (2-tailed)	,954	,649	,744	,008	,037	,005	.	,044		,002	,587
	N	13	8	13	47	48	48	0	46	55	55	46
World GDP Level	Pearson Correlation	,561*	,301	-,019	-,106	,953**	,955**	.b	,641**	-,417**	1	,916**
	Sig. (2-tailed)	,046	,469	,951	,477	,000	,000	.	,000	,002		,000
	N	13	8	13	47	48	48	0	46	55	56	46
Global Investments	Pearson Correlation	,331	,061	-,152	,002	,877**	,868**	.b	,717**	-,082	,916**	1
	Sig. (2-tailed)	,269	,885	,619	,988	,000	,000	.	,000	,587	,000	
	N	13	8	13	46	46	46	0	46	46	46	46

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

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

b. Cannot be computed because at least one of the variables is constant.

Figure 1.21: Singapore correlations with country and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	Deflated GDP	Interest Rate	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,116	-,516*	,179	-,049	-,060	,234	,053	,108	-,003	,417
	Sig. (2-tailed)		,784	,049	,523	,861	,833	,402	,850	,702	,992	,122
	N	15	8	15	15	15	15	15	15	15	15	15
Completed	Pearson Correlation	,116	1	,446	,356	,394	,385	-,013	,469	,389	,361	,153
	Sig. (2-tailed)	,784		,268	,232	,183	,193	,967	,106	,189	,225	,618
	N	8	14	8	13	13	13	12	13	13	13	13
Avg Height	Pearson Correlation	-,516*	,446	1	,379	-,634*	-,636*	,226	-,550*	-,123	-,697**	-,864**
	Sig. (2-tailed)	,049	,268		,164	,011	,011	,417	,034	,664	,004	,000
	N	15	8	15	15	15	15	15	15	15	15	15
GDP %	Pearson Correlation	,179	,356	,379	1	-,324*	-,328*	,185	-,215	,414**	-,336*	-,270
	Sig. (2-tailed)	,523	,232	,164		,016	,015	,267	,151	,002	,012	,069
	N	15	13	15	55	55	55	38	46	55	55	46
GDP Level	Pearson Correlation	-,049	,394	-,634*	-,324*	1	,999**	-,569**	,952**	-,355**	,981**	,896**
	Sig. (2-tailed)	,861	,183	,011	,016		,000	,000	,000	,008	,000	,000
	N	15	13	15	55	56	56	38	46	55	56	46
Deflated GDP	Pearson Correlation	-,060	,385	-,636*	-,328*	,999**	1	-,588**	,947**	-,371**	,989**	,899**
	Sig. (2-tailed)	,833	,193	,011	,015	,000		,000	,000	,005	,000	,000
	N	15	13	15	55	56	56	38	46	55	56	46
Interest Rate	Pearson Correlation	,234	-,013	,226	,185	-,569**	-,588**	1	-,494**	-,143	-,634**	-,557**
	Sig. (2-tailed)	,402	,967	,417	,267	,000	,000		,002	,393	,000	,000
	N	15	12	15	38	38	38	38	38	38	38	38
FDI	Pearson Correlation	,053	,469	-,550*	-,215	,952**	,947**	-,494**	1	-,077	,918**	,862**
	Sig. (2-tailed)	,850	,106	,034	,151	,000	,000	,002		,612	,000	,000
	N	15	13	15	46	46	46	38	46	46	46	46
World GDP %	Pearson Correlation	,108	,389	-,123	,414**	-,355**	-,371**	-,143	-,077	1	-,417**	-,082
	Sig. (2-tailed)	,702	,189	,664	,002	,008	,005	,393	,612		,002	,587
	N	15	13	15	55	55	55	38	46	55	55	46
World GDP Level	Pearson Correlation	-,003	,361	-,697**	-,336*	,981**	,989**	-,634**	,918**	-,417**	1	,916**
	Sig. (2-tailed)	,992	,225	,004	,012	,000	,000	,000	,000	,002		,000
	N	15	13	15	55	56	56	38	46	55	56	46
Global Investments	Pearson Correlation	,417	,153	-,864**	-,270	,896**	,899**	-,557**	,862**	-,082	,916**	1
	Sig. (2-tailed)	,122	,618	,000	,069	,000	,000	,000	,000	,587	,000	
	N	15	13	15	46	46	46	38	46	46	46	46

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

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

Figure 1.22: South Korea correlations with country and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	Deflated GDP	Interest Rate	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,360	-,071	-,002	,406	,422	-,236	,200	,380	,346	,570*
	Sig. (2-tailed)		,342	,802	,993	,133	,117	,417	,474	,162	,207	,027
	N	15	9	15	15	15	15	14	15	15	15	15
Completed	Pearson Correlation	,360	1	,436	-,231	,496	,483	-,415	,422	-,034	,539*	,544*
	Sig. (2-tailed)	,342		,241	,428	,071	,081	,141	,133	,909	,047	,044
	N	9	15	9	14	14	14	14	14	14	14	14
Avg Height	Pearson Correlation	-,071	,436	1	-,280	,189	,154	-,153	-,053	-,131	,237	,316
	Sig. (2-tailed)	,802	,241		,312	,500	,584	,601	,850	,641	,396	,252
	N	15	9	15	15	15	15	14	15	15	15	15
GDP %	Pearson Correlation	-,002	-,231	-,280	1	-,524**	-,486**	,044	-,488**	,427**	-,539**	-,520**
	Sig. (2-tailed)	,993	,428	,312		,000	,000	,797	,001	,001	,000	,000
	N	15	14	15	55	55	55	36	40	55	55	46
GDP Level	Pearson Correlation	,406	,496	,189	-,524**	1	,981**	-,802**	,817**	-,354**	,990**	,924**
	Sig. (2-tailed)	,133	,071	,500	,000		,000	,000	,000	,008	,000	,000
	N	15	14	15	55	56	56	36	40	55	56	46
Deflated GDP	Pearson Correlation	,422	,483	,154	-,486**	,981**	1	-,808**	,779**	-,366**	,967**	,894**
	Sig. (2-tailed)	,117	,081	,584	,000	,000		,000	,000	,006	,000	,000
	N	15	14	15	55	56	56	36	40	55	56	46
Interest Rate	Pearson Correlation	-,236	-,415	-,153	,044	-,802**	-,808**	1	-,660**	-,090	-,776**	-,684**
	Sig. (2-tailed)	,417	,141	,601	,797	,000	,000		,000	,601	,000	,000
	N	14	14	14	36	36	36	36	36	36	36	36
FDI	Pearson Correlation	,200	,422	-,053	-,488**	,817**	,779**	-,660**	1	-,009	,817**	,844**
	Sig. (2-tailed)	,474	,133	,850	,001	,000	,000	,000		,956	,000	,000
	N	15	14	15	40	40	40	36	40	40	40	40
World GDP %	Pearson Correlation	,380	-,034	-,131	,427**	-,354**	-,366**	-,090	-,009	1	-,417**	-,082
	Sig. (2-tailed)	,162	,909	,641	,001	,008	,006	,601	,956		,002	,587
	N	15	14	15	55	55	55	36	40	55	55	46
World GDP Level	Pearson Correlation	,346	,539*	,237	-,539**	,990**	,967**	-,776**	,817**	-,417**	1	,916**
	Sig. (2-tailed)	,207	,047	,396	,000	,000	,000	,000	,000	,002		,000
	N	15	14	15	55	56	56	36	40	55	56	46
Global Investments	Pearson Correlation	,570*	,544*	,316	-,520**	,924**	,894**	-,684**	,844**	-,082	,916**	1
	Sig. (2-tailed)	,027	,044	,252	,000	,000	,000	,000	,000	,587	,000	
	N	15	14	15	46	46	46	36	40	46	46	46

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

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

Figure 1.23: United Arab Emirates correlations with country and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	Deflated GDP	Interest Rate	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	,185	,181	-,589*	,332	,337	.b	,119	-,436	,325	,503*
	Sig. (2-tailed)		,510	,519	,016	,209	,202	.	,660	,091	,220	,047
	N	17	15	15	16	16	16	0	16	16	16	16
Completed	Pearson Correlation	,185	1	,139	-,077	,632*	,553*	.b	,420	,175	,662**	,551*
	Sig. (2-tailed)	,510		,650	,784	,011	,032	.	,119	,533	,007	,033
	N	15	16	13	15	15	15	0	15	15	15	15
Avg Height	Pearson Correlation	,181	,139	1	-,157	,028	-,044	.b	,061	-,209	,077	-,150
	Sig. (2-tailed)	,519	,650		,577	,922	,875	.	,829	,455	,786	,593
	N	15	13	16	15	15	15	0	15	15	15	15
GDP %	Pearson Correlation	-,589*	-,077	-,157	1	-,086	-,090	.b	,015	,334*	-,108	-,057
	Sig. (2-tailed)	,016	,784	,577		,598	,579	.	,929	,035	,509	,729
	N	16	15	15	40	40	40	0	40	40	40	40
GDP Level	Pearson Correlation	,332	,632*	,028	-,086	1	,958**	.b	,822**	-,131	,970**	,912**
	Sig. (2-tailed)	,209	,011	,922	,598		,000	.	,000	,413	,000	,000
	N	16	15	15	40	41	41	0	41	41	41	41
Deflated GDP	Pearson Correlation	,337	,553*	-,044	-,090	,958**	1	.b	,789**	-,489**	,970**	,895**
	Sig. (2-tailed)	,202	,032	,875	,579	,000		.	,000	,000	,000	,000
	N	16	15	15	40	41	56	0	46	55	56	46
Interest Rate	Pearson Correlation	.b	.b	.b	.b	.b	.b	.b	.b	.b	.b	.b
	Sig. (2-tailed)	.	.	.	.	.	.		.	.	.	.
	N	0	0	0	0	0	0	0	0	0	0	0
FDI	Pearson Correlation	,119	,420	,061	,015	,822**	,789**	.b	1	,079	,800**	,856**
	Sig. (2-tailed)	,660	,119	,829	,929	,000	,000	.		,603	,000	,000
	N	16	15	15	40	41	46	0	46	46	46	46
World GDP %	Pearson Correlation	-,436	,175	-,209	,334*	-,131	-,489**	.b	,079	1	-,417**	-,082
	Sig. (2-tailed)	,091	,533	,455	,035	,413	,000	.	,603		,002	,587
	N	16	15	15	40	41	55	0	46	55	55	46
World GDP Level	Pearson Correlation	,325	,662**	,077	-,108	,970**	,970**	.b	,800**	-,417**	1	,916**
	Sig. (2-tailed)	,220	,007	,786	,509	,000	,000	.	,000	,002		,000
	N	16	15	15	40	41	56	0	46	55	56	46
Global Investments	Pearson Correlation	,503*	,551*	-,150	-,057	,912**	,895**	.b	,856**	-,082	,916**	1
	Sig. (2-tailed)	,047	,033	,593	,729	,000	,000	.	,000	,587	,000	
	N	16	15	15	40	41	46	0	46	46	46	46

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

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

b. Cannot be computed because at least one of the variables is constant.

Figure 1.24: United States correlations with country and global economic cycles

Correlations

		Started	Completed	Avg Height	GDP %	GDP Level	Deflated GDP	Interest Rate	FDI	World GDP %	World GDP Level	Global Investments
Started	Pearson Correlation	1	-,083	-,036	-,138	,538**	,501**	-,170	,478**	-,139	,544**	,471**
	Sig. (2-tailed)		,601	,814	,372	,000	,000	,264	,002	,367	,000	,003
	N	46	42	46	44	45	45	45	38	44	45	38
Completed	Pearson Correlation	-,083	1	,101	-,053	-,028	,000	,181	-,293	-,183	-,027	-,247
	Sig. (2-tailed)	,601		,526	,724	,851	1,000	,218	,063	,218	,853	,119
	N	42	49	42	47	48	48	48	41	47	48	41
Avg Height	Pearson Correlation	-,036	,101	1	-,012	,160	,131	-,248	,132	,020	,212	,202
	Sig. (2-tailed)	,814	,526		,938	,293	,392	,100	,429	,899	,162	,223
	N	46	42	46	44	45	45	45	38	44	45	38
GDP %	Pearson Correlation	-,138	-,053	-,012	1	-,374**	-,367**	-,078	-,173	,790**	-,390**	-,278
	Sig. (2-tailed)	,372	,724	,938		,005	,006	,572	,251	,000	,003	,061
	N	44	47	44	55	55	55	55	46	55	55	46
GDP Level	Pearson Correlation	,538**	-,028	,160	-,374**	1	,990**	-,366**	,884**	-,427**	,986**	,911**
	Sig. (2-tailed)	,000	,851	,293	,005		,000	,006	,000	,001	,000	,000
	N	45	48	45	55	56	56	56	46	55	56	46
Deflated GDP	Pearson Correlation	,501**	,000	,131	-,367**	,990**	1	-,288*	,887**	-,448**	,960**	,893**
	Sig. (2-tailed)	,000	1,000	,392	,006	,000		,031	,000	,001	,000	,000
	N	45	48	45	55	56	56	56	46	55	56	46
Interest Rate	Pearson Correlation	-,170	,181	-,248	-,078	-,366**	-,288*	1	-,486**	-,154	-,400**	-,546**
	Sig. (2-tailed)	,264	,218	,100	,572	,006	,031		,001	,261	,002	,000
	N	45	48	45	55	56	56	56	46	55	56	46
FDI	Pearson Correlation	,478**	-,293	,132	-,173	,884**	,887**	-,486**	1	-,048	,854**	,928**
	Sig. (2-tailed)	,002	,063	,429	,251	,000	,000	,001		,750	,000	,000
	N	38	41	38	46	46	46	46	46	46	46	46
World GDP %	Pearson Correlation	-,139	-,183	,020	,790**	-,427**	-,448**	-,154	-,048	1	-,417**	-,082
	Sig. (2-tailed)	,367	,218	,899	,000	,001	,001	,261	,750		,002	,587
	N	44	47	44	55	55	55	55	46	55	55	46
World GDP Level	Pearson Correlation	,544**	-,027	,212	-,390**	,986**	,960**	-,400**	,854**	-,417**	1	,916**
	Sig. (2-tailed)	,000	,853	,162	,003	,000	,000	,002	,000	,002		,000
	N	45	48	45	55	56	56	56	46	55	56	46
Global Investments	Pearson Correlation	,471**	-,247	,202	-,278	,911**	,893**	-,546**	,928**	-,082	,916**	1
	Sig. (2-tailed)	,003	,119	,223	,061	,000	,000	,000	,000	,587	,000	
	N	38	41	38	46	46	46	46	46	46	46	46

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

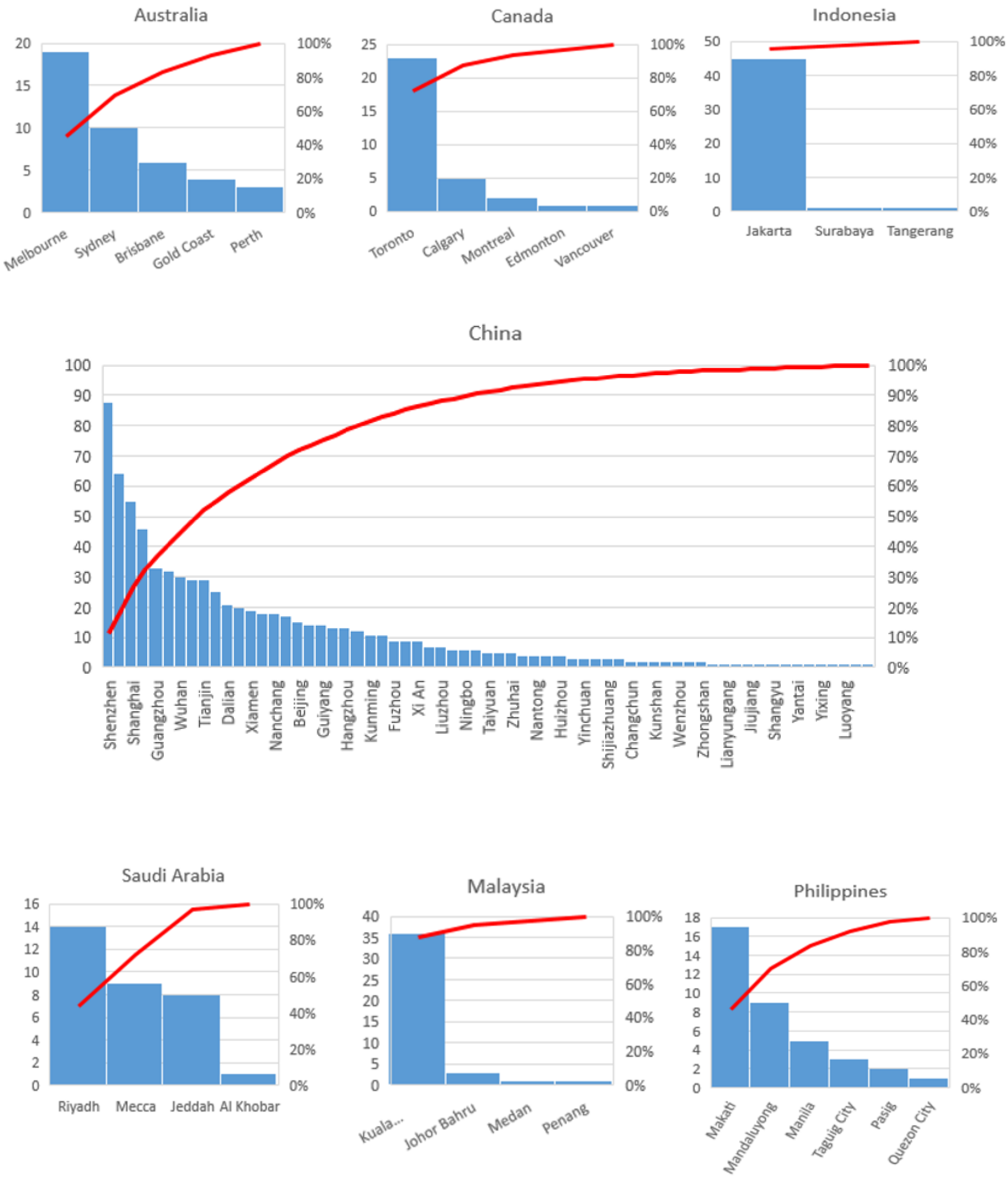
*. Correlation is significant at the 0.05 level (2-tailed).

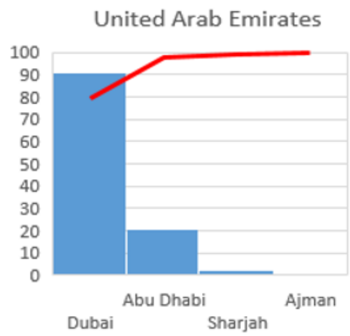
APPENDIX 2: Geographic distribution

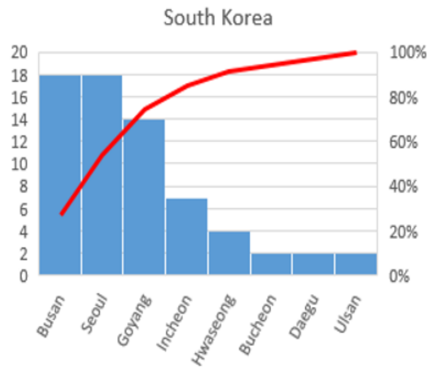
Figure 2.1: global cities ranking and projects started by each city

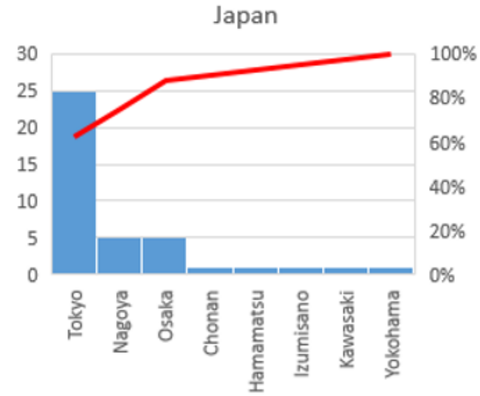
City	Rank	Projects	City	Rank	Projects	City	Rank	Projects
London	Alpha ++	6	Montevideo	Beta		Managua	Gamma +	
New York	Alpha ++	47	Berlin	Beta		Durbaan	Gamma +	
Singapore	Alpha +	23	Abu Dhabi	Beta	21	St. Petersburg	Gamma +	1
Hong Kong	Alpha +	32	Casablanca	Beta		Tegucigalpa	Gamma	
Paris	Alpha +		Montreal	Beta		Phoenix	Gamma	
Beijing	Alpha +	14	Philadelphia	Beta	3	Austin	Gamma	2
Tokyo	Alpha +	11	Shenzhen	Beta	72	Pune	Gamma	
Shanghai	Alpha +	30	Vancouver	Beta	1	Guadalajara	Gamma	
Dubai	Alpha +	86	Sofia	Beta		Tblisi	Gamma	
Sydney	Alpha	5	Perth	Beta	1	Dalian	Gamma	14
Sao Paulo	Alpha		Hanoi	Beta	6	Dar Es Salaam	Gamma	
Milan	Alpha	2	Beirut	Beta	1	Chongqing	Gamma	41
Chicago	Alpha	14	Brisbane	Beta	6	Ankara	Gamma	1
Mexico City	Alpha	4	Bratislava	Beta		Lusaka	Gamma	
Mumbai	Alpha	26	Manama	Beta	7	Ahmedabad	Gamma	
Moscow	Alpha	14	Port Louis	Beta -		Cincinnati	Gamma	1
Frankfurt	Alpha	1	Minneapolis	Beta -		Asuncion	Gamma	
Warsaw	Alpha	1	Chennai	Beta -		Harare	Gamma	
Johannesburg	Alpha		Stuttgart	Beta -		Gothenburg	Gamma	
Madrid	Alpha	4	Santo Domingo	Beta -		Al-Mawsil	Gamma	
Toronto	Alpha	17	Rio De Janeiro	Beta -		Xiamen	Gamma	
Instanbul	Alpha	7	Kuwait City	Beta -	9	Kansas City	Gamma	
Seoul	Alpha	9	Chengdu	Beta -	18	Accra	Gamma	
Kuala Lumpur	Alpha	27	Panama City	Beta -	20	Minsk	Gamma	
Jakarta	Alpha	38	Denver	Beta -		Turin	Gamma	1
Amsterdam	Alpha		Lahore	Beta -		Nanning	Gamma	
Brussels	Alpha		Jeddah	Beta -	8	Tampa	Gamma	
Los Angeles	Alpha	2	Tunis	Beta -		Luanda	Gamma	
Dublin	Alpha -		Quito	Beta -		Abidjan	Gamma	
Melbourne	Alpha -	12	Belgrade	Beta -		Tirana	Gamma	
Washington	Alpha -		Manchester	Beta -	1	Lausanne	Gamma	
New Delhi	Alpha -		Guatemala City	Beta -		Taizhong	Gamma -	
Bangkok	Alpha -	13	Lyon	Beta -		Wuhan	Gamma -	22
Zurich	Alpha -		San Jose	Beta -		Charlotte	Gamma -	1
Vienna	Alpha -	1	Tianjin	Beta -	25	Belfast	Gamma -	
Taipei	Alpha -	3	Calgary	Beta -	4	Baltimore	Gamma -	
San Francisco	Alpha -	2	Amman	Beta -		Leipzig	Gamma -	
Guangzhou	Alpha -	24	San Juan	Beta -		Leeds	Gamma -	
Manila	Alpha -	3	San Salvador	Beta -		Medellin	Gamma -	
Bogota	Alpha -	3	Antwerp	Beta -		Raleigh	Gamma -	
Miami	Alpha -	6	Seattle	Beta -	1	Douala	Gamma -	
Riyadh	Alpha -	12	Zagreb	Beta -		Maputo	Gamma -	
Luxembourg	Alpha -		Calcutta	Beta -		Skopje	Gamma -	
Santiago	Alpha -	1	Tallin	Beta -		Gaborone	Gamma -	
Barcelona	Alpha -		St Louis	Beta -		Bristol	Gamma -	
Tel Aviv	Alpha -	1	Monterrey	Beta -	4	Dakar	Gamma -	
Lisbon	Alpha -		Hyderabad	Beta -		Orlando	Gamma -	
Prague	Beta +		Edinburgh	Beta -		Suzhou	Gamma -	12
Copenhagen	Beta +		San Diego	Beta -		Malmo	Gamma -	
Ho Chi Minh City	Beta +	5	Cologne	Beta -		Changsha	Gamma -	14
Boston	Beta +	1	Rotterdam	Beta -		Strasbourg	Gamma -	
Dusseldorf	Beta +		Islamabad	Beta -		Edmont	Gamma -	1
Athens	Beta +		Dhaka	Beta -		Bilbao	Gamma -	
Munich	Beta +		Guayaquil	Gamma +		Bologna	Gamma -	
Bucharest	Beta +		Cleveland	Gamma +		Columbus	Gamma -	
Atlanta	Beta +	2	Riga	Gamma +		Wellington	Gamma -	
Helsinki	Beta +		Baku	Gamma +	1	Nurnberg	Gamma -	
Budapest	Beta +		Adelaide	Gamma +		Yangon	Gamma -	
Kiev	Beta +		Vilnus	Gamma +		Xi'An	Gamma -	8
Hamburg	Beta +		Birmingham	Gamma +		Wroclaw	Gamma -	
Bangalore	Beta +		Glasgow	Gamma +		Marseille	Gamma -	
Rome	Beta +		Nanchang	Gamma +		Dresden	Gamma -	
Oslo	Beta +		Hamilton	Gamma +		Shenyang	Gamma -	14
Dallas	Beta +		Colombo	Gamma +	3	Algiers	Gamma -	
Cairo	Beta +		Porto	Gamma +		Almaty	Gamma -	
Lima	Beta +		Quingdao	Gamma +	9	Curitba	Gamma -	
Lagos	Beta +		Valencia	Gamma +	1	Hangzhou	Gamma -	11
Auckland	Beta +		Detroit	Gamma +		Indianapolis	Gamma -	
Houston	Beta +	1	Muscat	Gamma +		Krakow	Gamma -	
Caracas	Beta +		Osaka	Gamma +	1	La Paz	Gamma -	
Cape Town	Beta +		Ljubljana	Gamma +		Milwaukee	Gamma -	
Karachi	Beta	1	Kampala	Gamma +		Nagoya	Gamma -	3
Geneva	Beta		Georgetown	Gamma +		Nairobi	Gamma -	

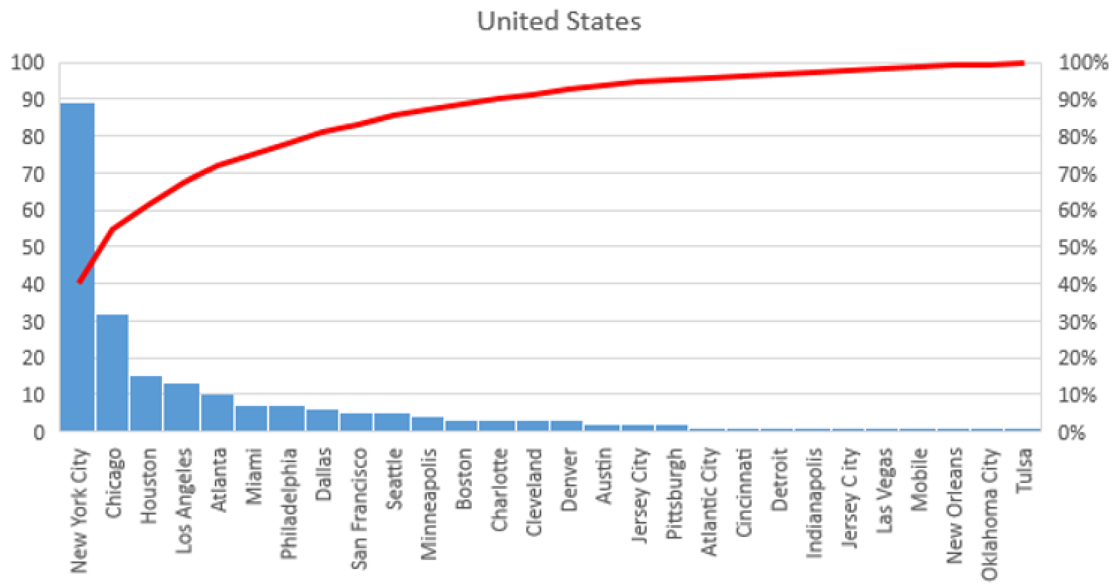
Figures 2.2: distribution of projects within countries




United Arab Emirates
100
90
80
70
60
50
40
30
20
10
0
100%
80%
60%
40%
20%
0%
Dubai
Abu Dhabi
Sharjah
Ajman


South Korea
20
18
16
14
12
10
8
6
4
2
0
100%
80%
60%
40%
20%
0%
Busan
Seoul
Goyang
Incheon
Hwaseong
Bucheon
Daegu
Ulsan


Japan
30
25
20
15
10
5
0
100%
80%
60%
40%
20%
0%
Tokyo
Nagoya
Osaka
Chonan
Hamamatsu
Izumisano
Kawasaki
Yokohama


United States
100
90
80
70
60
50
40
30
20
10
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
New York City
Chicago
Houston
Los Angeles
Atlanta
Miami
Philadelphia
Dallas
San Francisco
Seattle
Minneapolis
Boston
Charlotte
Cleveland
Denver
Austin
Jersey City
Pittsburgh
Atlantic City
Cincinnati
Detroit
Indianapolis
Jersey C ity
Las Vegas
Mobile
New Orleans
Oklahoma City
Tulsa

APPENDIX 3: Height competition

Figure 3.1: average ratio floors-height for regions and countries. Green means the value is lower than world average, red means higher.

Region / country	Ratio	Region / country	Ratio
East Asia & Pacific	**4.4**	**Middle East & North Africa**	**4.5**
Australia	3.8	Bahrain	4.7
China	4.5	Iran	6.6
Indonesia	4.5	Israel	4.0
Japan	4.5	Kuwait	5.0
Macau	3.9	Lebanon	4.4
Malaysia	4.4	Qatar	4.4
North Korea	3.9	Saudi Arabia	5.0
Philippines	3.9	UAE	4.3
Singapore	4.7	**South Asia**	**3.9**
South Korea	3.9	Bangladesh	4.4
Taiwan	5.0	India	3.8
Thailand	4.1	Pakistan	4.4
Vietnam	4.7	Sri Lanka	3.9
Europe & Central Asia	**4.5**	**North America**	**4.2**
Austria	3.9	Canada	3.9
Azerbaijan	5.1	USA	4.3
France	4.3	**Latin America & Caribbean**	**3.9**
Germany	4.0	Argentina	4.4
Italy	5.3	Brazil	3.6
Poland	5.0	Chile	4.8
Russia	4.5	Colombia	4.0
Spain	4.6	Mexico	4.3
Turkey	4.5	Panama	3.8
United Kingdom	4.1	Venezuela	4.0

APPENDIX 4: Technology cycles

Figure 4.1: Correlations of materials with global business cycle

Correlations

		Composite	Concrete	Steel	World GDP %	World GDP Level	Global Investments
Composite	Pearson Correlation	1	,813**	,549**	-,185	,856**	,763**
	Sig. (2-tailed)		,000	,002	,279	,000	,000
	N	37	31	29	36	36	34
Concrete	Pearson Correlation	,813**	1	,334	-,012	,897**	,958**
	Sig. (2-tailed)	,000		,071	,945	,000	,000
	N	31	37	30	36	36	36
Steel	Pearson Correlation	,549**	,334	1	-,141	,393*	,256
	Sig. (2-tailed)	,002	,071		,385	,011	,137
	N	29	30	42	40	41	35
World GDP %	Pearson Correlation	-,185	-,012	-,141	1	-,417**	-,082
	Sig. (2-tailed)	,279	,945	,385		,002	,587
	N	36	36	40	55	55	46
World GDP Level	Pearson Correlation	,856**	,897**	,393*	-,417**	1	,916**
	Sig. (2-tailed)	,000	,000	,011	,002		,000
	N	36	36	41	55	56	46
Global Investments	Pearson Correlation	,763**	,958**	,256	-,082	,916**	1
	Sig. (2-tailed)	,000	,000	,137	,587	,000	
	N	34	36	35	46	46	46

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

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

APPENDIX 5: Construction Costs

Figures 5.1: Cost correlations with construction by country

Correlations

AUSTRALIA		Started	Office Cost	Residential Cost
Started	Pearson Correlation	1	,617	-,316
	Sig. (2-tailed)		,267	,605
	N	17	5	5
Office Cost	Pearson Correlation	,617	1	,291
	Sig. (2-tailed)	,267		,526
	N	5	7	7
Residential Cost	Pearson Correlation	-,316	,291	1
	Sig. (2-tailed)	,605	,526	
	N	5	7	7

Correlations

CANADA		Started	Office Cost	Residential Cost
Started	Pearson Correlation	1	-,959*	-,925
	Sig. (2-tailed)		,041	,075
	N	16	4	4
Office Cost	Pearson Correlation	-,959*	1	,992**
	Sig. (2-tailed)	,041		,001
	N	4	5	5
Residential Cost	Pearson Correlation	-,925	,992**	1
	Sig. (2-tailed)	,075	,001	
	N	4	5	5

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

Correlations

CHINA		Started	Office Cost	Residential Cost
Started	Pearson Correlation	1	,390	,327
	Sig. (2-tailed)		,387	,475
	N	30	7	7
Office Cost	Pearson Correlation	,390	1	,919**
	Sig. (2-tailed)	,387		,003
	N	7	7	7
Residential Cost	Pearson Correlation	,327	,919**	1
	Sig. (2-tailed)	,475	,003	
	N	7	7	7

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

Correlations

JAPAN		Started	Office Cost	Residential Cost
Started	Pearson Correlation	1	.a	.a
	Sig. (2-tailed)		.	.
	N	17	2	2
Office Cost	Pearson Correlation	.a	1	,973
	Sig. (2-tailed)	.		,147
	N	2	3	3
Residential Cost	Pearson Correlation	.a	,973	1
	Sig. (2-tailed)	.	,147	
	N	2	3	3

a. Cannot be computed because at least one of the variables is constant.

Correlations

MALAYSIA		Started	Office Cost	Residential Cost
Started	Pearson Correlation	1	,898*	,866*
	Sig. (2-tailed)		,015	,026
	N	15	6	6
Office Cost	Pearson Correlation	,898*	1	,994**
	Sig. (2-tailed)	,015		,000
	N	6	6	6
Residential Cost	Pearson Correlation	,866*	,994**	1
	Sig. (2-tailed)	,026	,000	
	N	6	6	6

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

Correlations

SINGAPORE		Started	Office Cost	Residential Cost
Started	Pearson Correlation	1	-,100	,093
	Sig. (2-tailed)		,873	,881
	N	15	5	5
Office Cost	Pearson Correlation	-,100	1	,710
	Sig. (2-tailed)	,873		,114
	N	5	6	6
Residential Cost	Pearson Correlation	,093	,710	1
	Sig. (2-tailed)	,881	,114	
	N	5	6	6

Correlations

SOUTH KOREA		Started	Office Cost	Residential Cost
Started	Pearson Correlation	1	,004	-,061
	Sig. (2-tailed)		,996	,939
	N	15	4	4
Office Cost	Pearson Correlation	,004	1	,997**
	Sig. (2-tailed)	,996		,000
	N	4	5	5
Residential Cost	Pearson Correlation	-,061	,997**	1
	Sig. (2-tailed)	,939	,000	
	N	4	5	5

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

Correlations

UAE		Started	Residential Cost	Office Cost
Started	Pearson Correlation	1	-,469	,790
	Sig. (2-tailed)		,349	,061
	N	15	6	6
Residential Cost	Pearson Correlation	-,469	1	,617
	Sig. (2-tailed)	,349		,268
	N	6	6	5
Office Cost	Pearson Correlation	,790	,617	1
	Sig. (2-tailed)	,061	,268	
	N	6	5	6

Correlations

USA		Started	Office Cost	Residential Cost
Started	Pearson Correlation	1	,982**	,902*
	Sig. (2-tailed)		,003	,036
	N	45	5	5
Office Cost	Pearson Correlation	,982**	1	,910*
	Sig. (2-tailed)	,003		,012
	N	5	6	6
Residential Cost	Pearson Correlation	,902*	,910*	1
	Sig. (2-tailed)	,036	,012	
	N	5	6	6

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

Figure 5.2: average time it takes to complete a project in different regions and countries. Green means shorter than global average, red means longer. Global average is 4.1 years.

Region / country	Years	Region / country	Years
East Asia & Pacific	**4.2**	**Middle East & North Africa**	**5.0**
Australia	3.2	Bahrain	6.0
China	4.3	Iran	6.0
Indonesia	3.7	Israel	3.7
Japan	3.8	Kuwait	5.4
Macau	2.0	Lebanon	3.0
Malaysia	4.4	Qatar	4.9
North Korea	1.0	Saudi Arabia	6.2
Philippines	4.8	UAE	4.6
Singapore	3.5	**South Asia**	**5.5**
South Korea	3.6	Bangladesh	5.0
Taiwan	3.4	India	5.5
Thailand	3.6	Pakistan	9.0
Vietnam	4.8	Sri Lanka	5.0
Europe & Central Asia	**4.1**	**North America**	**3.2**
Austria	2.5	Canada	3.8
Azerbaijan	3.0	USA	3.0
France	3.3	**Latin America & Caribbean**	**4.4**
Germany	2.8	Argentina	5.0
Italy	4.0	Brazil	4.3
Poland	3.6	Chile	8.0
Russia	5.5	Colombia	4.8
Spain	4.8	Mexico	4.5
Turkey	3.8	Panama	4.1
United Kingdom	3.0	Venezuela	4.4