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THE FORMATION OF URBAN SPATIAL STRUCTURES: *Markets vs. Design*

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ABSTRACT

As cities develop there grows a trade-off between land consumption and commuting efficiency: the larger the area of land consumed per household and per worker, the longer the commuting distance between firms and households and the larger the commuting time and cost. This paper explores how markets and design can each contribute to the creation of an urban spatial structure that provides an optimum trade-off for all firms and households.

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INTRODUCTION

> "Every step and every movement of the multitude, even in what are termed enlightened ages, are made with equal blindness to the future; and nations stumble upon establishments, which are indeed the result of human action, but not the execution of any human design."
>
> Adam Ferguson (1782)

Households need land for shelter. Firms need land for workspace. Yet, for a given population, the larger the area of land consumed per household and per worker, the longer the commuting distance between firms and households will be. It appears, therefore, that there is a trade-off between land consumption and commuting distance.

But commuting distance is only a proxy for commuting travel time and travel cost, which are the real constraints limiting the efficiency of a labor market's concentration. Different transport technologies imply different commuting speeds and commuting costs and therefore make distance an imperfect proxy for labor market efficiency. The real trade-off, therefore, is between land consumption and commuting travel time and cost by different means of transport.

How will the optimum trade-off be achieved between the land consumed and the commuting speed and cost such that the welfare of both firms and households is simultaneously maximized? Is it possible to identify an urban spatial structure that would optimize the trade-off between land consumption and commuting speed for all firms and households?

What is the best way to reach equilibrium between land consumption and commuting distance as population size and household incomes grow and transport technology changes? Economists tend to favor markets, while urban planners tend to favor design.[1]

1 I differentiate "urban planning" from "design": planning involved many tasks, many of them being projections, for instance, demographic and traffic projections or projection of future demand for water or energy. Design is a more specific part of urban planning which involve imposing physical limits on the built environment. Design involves producing the plans of individual buildings but also drawing zoning plans, limiting the height of buildings, separating land use, establishing urban growth boundaries, etc. The recent advocacy of Transit Oriented Development (TOD) among "smart growth" planners is a typical "design" approach to planning. I will discuss TOD in more details in chapter 6.

In the title of this paper, I have set markets against design. How do markets and design contribute to the development of cities? Are markets or is design more likely to shape a city in such a way that an equilibrium is achieved between land consumption and commuting speed? Should planners substitute their own designs for market forces in order to obtain a better spatial outcome or, to the contrary, should planners rely more on markets to guide urban developments?

If the efficiency of spatial urban structures rests on a trade-off between land consumption and commuting speed and cost, what indicators should planners develop to monitor progress in urban structure efficiency?

1. THE ROLE OF MARKETS AND DESIGN IN SHAPING CITIES IN MARKET ECONOMIES

In market economies, the combined effect of market forces and deliberate government design generate urban spatial structures. In the last two command economies left in the world, Cuba and North Korea, design is officially the only factor shaping cities. Let us see how markets and design contribute to the shape of most of the cities in the world.

1.1 MARKETS AS URBAN SHAPE CREATOR

> "The basic economic system should evolve on the decisive role of markets in resource allocation."
>
> Third Plenary Session of the 18th Central Committee of the Communist Party of China, on November 11th, 2013.

Markets create a blind mechanism that produces and constantly modifies urban shapes, in the same way as evolution creates a blind mechanism that produces and modifies living organisms.

Markets shape cities through land prices. High demand for specific locations creates the large differences in land prices observed within cities. Land prices, in turn, shape cities by creating high concentration of floor space – tall buildings – where land prices are high and low concentrations – small buildings –where land prices are low. Very high demand for floor space in a limited area explains the concentration of skyscrapers in central business districts (CBD); similarly, low land prices and high incomes explain the spread of low-density suburbs. Very low household incomes explain the high residential density in slums even in areas where land prices are relatively low. The changing balance between supply and demand, the variations in firms' and households' incomes and the cost of transport can explain the extreme variety of building shapes and their spatial distribution within a metropolitan area. Urban shapes produced by markets illustrate perfectly what Adam Ferguson, the eighteenth century Scottish enlightenment philosopher, called "the result of human action, but not the execution of any human design."

MARKETS AND THE PRICE OF URBAN TRANSPORT

Markets generate different land prices for each location within a city. In most cities, the price of land is usually the highest in the central part because workers and consumers can travel to it in the shortest time and at the least cost. The price of transport – measured in time consumed and money spent – have traditionally been one of the main "shapers" of urban form. Large industrial cities of the 19th century, where walking or riding a horse carriage were the most common commuting modes of transport, required very high densities because when the size of the labor market increased the area accessible within one hour remained about constant. The high cost of transport in either time or money restricted the extent of the built-up area. Consequently, the size of the labor market could grow only by accommodating more people and jobs within the area accessible in less than one hour, resulting in very high population and job densities. The absence of mechanized transport limited the size of a city's built-up area. A city's labor market could keep growing, but only if a large proportion of the population accepted to consume ever less land every year. The high density of the Dickensian slums was the consequence.

At the end of the 19th century, the introduction of various mechanized forms of urban transport allowed higher speeds at lower costs. The first underground rail urban transport was built in London in 1862; it was soon imitated in many large cities of Europe and the US. The introduction of mechanized transport had two main effects on the shape of cities. First, it increased the area accessible within an hour, and therefore increased the size of the labor market even while allowing population densities to decrease. Second, it dramatically increased the accessibility of the city center where the mechanized transport lines converged, increasing the price of land in the central area while decreasing it in the suburbs. The new, emerging transport technology made the concept of Ebenezer Howard's "garden cities" not so utopian after all. Rapid rail transport made large areas of rural land suddenly accessible from the old city centers. The increase in land supply lowered the price of suburban land to the point of making an individual house affordable to the former inner-city slum dweller.

In the mid-1930s, the mass production of cars at a price affordable to the middle class further increased the radius of cities by giving rapid access to areas not yet served by the suburban rail networks. This spatial expansion, made possible by the introduction of a new transport technology, allowed a rapid growth in the size of the labor market while further differentiating the price of land between the center city and the distant suburbs and allowing for an increase in the land consumption of suburban dwellers and firms.

THE RATIO BETWEEN LAND AND FLOOR SPACE IN DIFFERENT LOCATIONS

The spatial expansion of cities requires land, but the final product of urbanization is floor space, not land. Because land is an indispensable input for the building of floor space, a high demand for floor space in a specific location increases the price of land at this location.

In areas where the price of land is high, developers can decrease the area of land they use to produce a given area of floor space by building taller buildings. As a result, the quantity of land required to build a unit of floor space varies greatly within cities and across cities reflecting the large variations in the spatial distribution of land prices set by the market.

For instance, the Shanghai World Financial Center (SWFC), a spectacular office tower built in Pudong, Shanghai's new financial district, has 101 floors with a total area of 377,000 square meters. This office tower has been built on a lot measuring 27,800 square meters. The ratio of floor to land (also called the floor area ratio or FAR) is therefore about 13.5. In other words, to build the SWFC tower, the developer used only one square meter of land to build 13.5 square meters of floor space. By contrast, in Huaxinzhou, a suburb of Shanghai located 24 kilometers from the SWFC, a developer building single family houses used as much as 1,350 square meters of land to build 300 square meters of floor space; this corresponds to a floor area ratio of 0.22. In Shanghai, therefore, building one square meter of floor space in Huaxinzhou occupies about 61 times more land than in Pudong! The large differences in land consumption to produce one meter of floor space in two different locations reflects the large differences in the price of land set by the land market. In the New York metropolitan area, we see a similar scenario. Compare the floor area ratios of Midtown Manhattan (New York's CBD) with those of Glen Rock, a suburb 26 km from Midtown. As in Shanghai, we see that building one square meter of floor space in the suburban location used about 60 times more land than in the CBD.

The decision to build tall buildings or short ones is therefore not a design choice left to a planner, an architect or a developer. It is a financial decision based on the price of land, reflecting the demand for floor space in a particular location. Tall buildings are more expensive to build per unit of floor space than shorter buildings, but the potential higher sale price by unit of floor space due to high demand compensates for the higher construction cost. The higher FAR values lower the cost of land per unit of floor space sold.

A high or low FAR is therefore not a design parameter. The FAR is the rate of substitution of capital for land; it is purely an economic decision depending on the price of land in relation to the price of construction. If the price of land is much lower than the price of construction, there is not much reason to construct buildings higher than 2 or 3 floors. For instance, in Glen Rock, the New York suburb mentioned above, the cost of land is about $450/m2, and the construction cost of a typical, wooden frame home is about $1,600/m2. Therefore, there is not much incentive to substitute capital for land, and as a result, the floor area ratio of most houses is low, around 0.25. By contrast, in New York's Midtown area, the price of land is around $25,000/m2, and the construction cost of a prime office building is around $5,000/m2, only 20% of the price of land. The high cost of land in Midtown significantly increases the incentive to substitute capital for land and thus explains why the floor area ratio of office buildings is around 15. Like in Pudong, the existence of tall buildings in Midtown New York does not reflect a design choice but an economic necessity imposed by markets and reflecting high consumers' demand for this location.

Some urban planners may disagree with me and argue that the existence of tall buildings is mainly the result of a design decision imposed by zoning plans, which fix maximum FAR values through regulation. Here is why they may hold this mistaken notion.

In most cities, planners strictly regulate FAR values because they assume that tall buildings impose large negative externalities to the surrounding neighborhood. Tall buildings indeed cast long shadows and may create congestion in adjacent streets because of the large number of people that are likely to live or work in them. In many cities, because of FAR regulations, the height of buildings is constrained at much lower levels than market demand would suggest. In areas where maximum regulatory FARs are much lower than demand for floor space suggests, most buildings are likely to make full use of the limited floor area ratio permitted by regulations. Eventually, the city's planners may decide to increase the value of the regulatory FAR over the one currently allowed. Developers will then make use of the entire, newly permitted FAR value and will, therefore, build taller buildings. The timing correlation between the increase in regulatory FAR and the construction of taller buildings gives an illusion of causality between regulations and tall buildings. Consequently, some planners think that fixing a FAR regulatory value is a design decision and that new buildings will automatically use the entire FAR value set by regulations.

While this may be true in areas where demand for floor space was previously constrained by regulations, increasing the regulatory FAR value where no demand for taller buildings exists would have no effect on the height of future buildings. In Glen Rock, the New York suburban area mentioned above, the FAR value used in most buildings varies from 0.2 to 0.3 while the maximum permitted FAR is around 0.4. There is not much demand now for the floor space allowed by the current FAR regulations. If planners were to authorize a FAR value of, say, 5, no tall buildings would be constructed following the zoning change.

MARKETS REACT TO EXOGENOUS FACTORS THAT PLANNERS CANNOT ANTICIPATE

Changing exogenous forces are constantly modifying the market's equilibrium, and as a result, urban shapes and land uses created by the market constantly evolve, as well. These exogenous forces are becoming more numerous and their effects more volatile because of globalization. For instance, some 30 years ago, the skills, salary level and availability of clerical workers in India had no impact on the demand for clerical workers in European and American cities. Today, information technology allows clerical workers from India to compete with those from Europe. This outside competition may affect the demand for European clerical workers, and consequently, the demand for and location of office buildings in European cities might change. The change in technology and the availability and salary level of Indian workers are contributing exogenous forces that may affect European cities' land use. The reverse is also true; globally-generated exogenous factors have an impact on land use in Indian cities. For example, the recent multiplication of call centers, a type of land use unknown only a few years ago, is a direct consequence of the availability of new technology and of the higher salaries of European and American clerical workers as compared to their Indian counterparts.

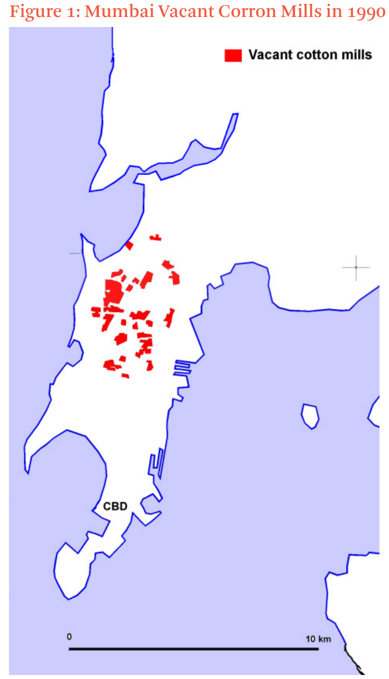
Markets react quickly to worldwide changes. Falling demand for some activities translates into lower rents for the buildings where these activities are taking place, triggering demand for a rapid land use change. Land use changes caused by markets often occur well before urban planners could possibly be aware of the responsible change in demand.

Within cities, markets create new types of land use and make others obsolete. Marx's observation in his Communist Manifesto that markets produced "everlasting uncertainty and agitation" and that as a result "all that is solid melts into air" is still true today and could refer to the changes taking place in the most dynamic cities of emerging economies. Schumpeter, giving a more optimistic version of Marx's original insight, called this process "creative destruction." Markets, thus, recycle obsolete land use quasi-automatically through rising and falling prices. This constant land recycling is usually very positive for the long-term welfare of the urban population. In the short term, changes in land use and in the spatial concentration of employment are disorienting and alarming for workers and firms alike. Responding to the disruptions caused by land use changes, local governments are often tempted to intervene in order to slow down the rate of change and to prevent the recycling of obsolete land use. However, the long-range effects of maintaining obsolete land use through regulations are disastrous for future employment levels and for the general welfare of urban dwellers. Preventing the transformation of obsolete land use also prevents new jobs from being created in its place. Regulations can prevent land use changes but cannot prevent jobs from disappearing from the obsolete areas. A city's labor market then shrinks when the government maintains land under a use for which there is no more demand. Freezing obsolete land use does not prevent Schumpeterian destruction, but it prevents the creation associated with it. "All that is solid melts into air," but the destruction is not followed by any new creation.

LAND USE CHANGE: MUMBAI'S COTTON MILLS

The story of Mumbai's cotton mills best illustrates the tragic consequences of freezing obsolete land uses in the hope of preserving jobs. Indian entrepreneurs built Mumbai's first cotton mills in the middle of the nineteenth century in what was then an industrial suburb of Mumbai. In 1861, the American civil war contributed to a large price increase for Indian cotton cloth (an external shock already occurring much before the spread of globalization). Consequently, the mills multiplied to employ, at their peak in the 1930s, more than 350,000 workers; they occupied an area of 280 hectares, not including worker housing. However, later, competition from other Asian countries and from more modern mills built in smaller Indian cities made the higher price of cotton fabric made in Mumbai increasingly uncompetitive on the world market. Because of outside competition, some mills had to close.

Figure 1: Mumbai Vacant Corron Mills in 1990



After World War II, more mills started closing. The productivity of the mills kept decreasing, in part, because as Mumbai developed, their locations in the middle of a dense and congested metropolis made them too expensive to operate. Another contributing factor was the obsolete factory layout and technology. A workers' strike lasting more than a year in 1982 gave the coup de grace to Mumbai's cotton mills. The story of the growth and decay of a textile industry is not unique to Mumbai; many European industrial cities, like Manchester and Ghent, went through the same cycles, produced by the same external forces.

However in Mumbai, as the mills were closing, Mumbai's municipality and workers' unions, in the hope of preserving the high taxes and the well-paying industrial jobs produced by the mills, prevented mills' owners from selling the potentially expensive land on which the now deserted mills had been built. Later, when it became clear that the mills would never open again, the local government imposed such draconian conditions on the redevelopment of the land that it became frozen in court cases. As a consequence, over the course of more than 40 years, an increasing number of mills stood empty in the middle of Mumbai, obliging the city to expand its infrastructure further north while by-passing the 280 hectares of already well serviced area occupied by the empty mills. When, in 2009, some of the land formerly occupied by the mills was finally auctioned, the price reached more than US $2,200 per square meter!

The failure to realize that urban activities are transient and subject to uncontrollable, external market forces led the municipality and the workers to try, through regulations, to maintain obsolete activities and land use. They assumed that the problem of the failing mills was local and could be solved through bargaining between local stakeholders. In doing so, they prevented new jobs from being created on the very valuable land occupied by the vacant mills. The misunderstanding caused enormous hardship to the workers and to the city economy. It prevented new jobs from being created to replace the ones that had been lost. It forced an extension of the city's infrastructure into new more distant areas while already well-serviced land stood empty.

LAND USE CHANGE: HARTFORD, CONNECTICUT

The case of US city Hartford, Connecticut, referred to as the "insurance capital of the world" in the 1950's, dramatically illustrates how a change in technology can impact local land use and the prosperity of a city that is heavily reliant on one industry. Hartford reached its peak population in 1950 when insurance companies required a high concentration of clerical workers working in close proximity to each other and to management. The digital revolution of the eighties and nineties removed the necessity of such a heavy concentration. Consequently, many insurance companies decentralized their operations and moved out of Hartford. By 2010, Hartford's population had decreased 30% from its 1950 peak, and about 32% of the remaining population was living below the poverty line. Hartford's decline was not due to a slump in the insurance sector but to a technology change that in turn had an impact on location requirements. Of course, land use planners had no way to anticipate the changes affecting the insurance companies. However, if they had tried to diversify the type of activities authorized by land use regulations they may have attracted other industries or services that would have reduced the chances of long-term unemployment for insurance industry workers.

LAND USE CHANGE: HONG KONG

Changes in employment locations and land requirements are not limited to changes within a particular sector of a city's economy, as was the case with the Hartford example. The disappearance of some economic sectors and the emergence of new ones may also cause changes in employment location. These rapid changes in economic trends require equally rapid changes in land use if the urban labor market is to keep functioning through the transition, and avoid the costly mistakes made with Mumbai's mills.

By the early 1960s, Hong Kong's textile manufacturing industry was the most successful in Asia. In 1980, the percentage of Hong Kong workers still employed in the manufacturing industry represented 46% of total employment, and the manufacturing sector represented 24% of the nominal Gross Domestic Product (GDP). By 2010, manufacturing had fallen to 1.8 % of GDP, and employment in manufacturing had been reduced to 3.4% of total employment.

This drastic change in the share of the manufacturing sector over 20 years required an equally drastic change in land use and in job location. Manufacturing jobs in Hong Kong were largely replaced by new jobs in the service sector. But the location and land requirements of the service sector are completely different from those of the manufacturing sector. The replacement of manufacturing employment by service employment could not be done simply by replacing factories with office buildings but by completely reallocating land use and by modifying urban transport to adapt to a new spatial pattern of job concentration.

These changes in Hong Kong's economy were not the result of deliberate plans made by Hong Kong planners but were imposed from the outside by geopolitical changes, such as the opening of mainland China's economy. The spectacular achievements of Hong Kong urban planners in managing land use changes were not that they had made plans in advance to change land use but that once these economic changes imposed by the world's economy had become clear they reacted rapidly to adjust the city land use and infrastructure to the new economy. Contrary to their counterparts in Mumbai, for instance, they didn't try to freeze in place obsolete land use to maintain manufacturing jobs, but quickly allowed land use changes to occur. Hong Kong's Municipality was also ready and able to invest in the new transport infrastructure that supported these land use changes and allowed workers to adapt quickly to the new spatial distribution of jobs.

THE ROLE OF MARKETS IN HISTORICAL PRESERVATION

Historical preservation is one of the few exceptions for which urban managers might want to prevent the mechanical land recycling caused by market forces. Historical heritage buildings are fossil buildings produced by ancient market forces. Preserving the highest quality buildings of the past has many economic and cultural justifications. Conserving historical buildings against market forces seems to contradict the lessons gained from the case studies that I have just discussed. There are important differences, however. The objective of historical preservation is to preserve high quality buildings rather than a specific type of land use. Indeed, the best way to preserve historical buildings is to allow a new type of utilization that will be compatible with conservation while also providing the new users with a location that is compatible with their businesses' activities. There are many successful examples of well-preserved historical buildings sheltering successful modern activities: the historical center of Bologna, whose medieval and renaissance buildings became the prestigious headquarters for banks and retail enterprises; SoHo-Cast Iron Historic District in New York, where the textile sweatshops and printing shops were replaced by artist lofts and high end retail; China-town, next to Singapore's financial district, where traditional restaurants were gradually upgraded to adapt to a business clientele and where small manufacturing workshops were changed into offices for small consultant firms. In all these examples, the conservation of existing historical buildings involved a significant change in the use of the floor space inside the buildings. The higher rents charged for the new land use covered the higher maintenance costs required by historical buildings and insured their preservation.

1.2 DESIGN COMPLEMENTS MARKETS IN SHAPING CITIES

Design, as opposed to the blindness of markets, implies the existence of a rational designer, a human control behind the process directing the creation of designed objects. A designer creates objects that meet explicit objectives and functions.[2] In contrast with shapes created by markets, shapes created by design are permanent and are incapable of spontaneous evolution until they are destroyed or modified by a new iteration of rational design. Modifying designed shapes requires the deliberate intervention of a rational designer.

We have seen that market mechanisms were effective in increasing the urban land supply, in transforming land use, and in setting the quantity of land and floor space consumed and the height of buildings. Markets are shaping cities through land price variations in space and time. Markets are therefore only effective when land and building transactions are taking place at regular intervals. In the absence of real estate transactions, markets cease to be an effective tool for allocating land and floor space. The land occupied by streets and public open space, what economists call public goods, is never subject to market transactions. Consequently, design is the only way to allocate land to streets and to public open space.

2 Designs created by artists do not need any rational justification but are by definition idiosyncratic. I am using here the other definition of design given by Webster dictionary: "to create, plan, or calculate for serving a predetermined end".

WHY ROAD NETWORKS AND PUBLIC OPEN SPACES ARE NOT PROVIDED THROUGH MARKET MECHANISMS

Why can't street networks be built by the private sector, and therefore, be subject to market forces? There are two reasons for this apparent impossibility. First, major roads need to be aligned and to follow a pre-established path often dictated by topography or by the geometry of a road network. Therefore, there is no possible competition between multiple sellers and multiple buyers to acquire the land required for roads' rights of ways; the government must intervene to acquire land through eminent domain, not through a free market transaction. Second, once a road network has been built, it is impractical to allocate and to recover its cost from beneficiaries since not only roads users but also landowners benefit from better accessibility and, therefore, increased land values.

The same problem occurs with the provision of public open space. On occasion, the private sector can provide and maintain parks and public open spaces, but private provision alone cannot insure supply in adequate quantity to respond to demand. In addition, government is more likely than a private developer to provide public access to privileged topographic areas like sea frontages, lakes, forests, hills and mountains, and only government can provide the possibility of free public access to these exceptional environmental assets. Because the land market price of such assets is likely to be high, it would normally be impractical for the private sector to provide free access. In addition, there is usually a consensus across cultures that such exceptional assets should belong to an entire nation and not be parceled out to private individuals who could bar access to the public.

Consequently, we cannot rely on market mechanisms to supply major roads and public open spaces. The quantity, location, and standards of roads and public open space have to be designed by government. There is no possibility of supply elasticity when demand is high, i.e. the quantity of roads cannot be increased when demand for roads in a specific location becomes very high. Government has to substitute design for markets to insure an adequate supply of all public goods, including roads. An adequate supply of urban roads is particularly important as roads provide the indispensable mobility that allows labor markets to function and cities to exist.

Eventually, governments have to use the power of eminent domain to purchase land for road alignment in order to link together local, privately built road segments. While the government may well compensate landowners for their land at an equivalent market price, the acquisition of the land is not a market operation. There is only one buyer: the government, and the seller of the land has no choice but to sell, whether or not he is willing to do so. Therefore, the provision of major roads, cutting across many properties, cannot be driven by markets but must be designed by government.

Increasingly, governments are using contracts with private firms to build major, discrete lengths of road or rail infrastructure. These build-operate-transfer (BOT) or build-operate-own-transfer (BOOT) contracts, however, do not in any way remove the primary responsibility from the government for initiating the design, deciding on the specifications and imposing the contractual arrangement. In BOT or BOOT arrangements, the government is always the initiator. Therefore, regardless of a BOT contract, the outcome is the same: a major road is always the product of government design not of market mechanism, even when a private contractor builds it, maintains it, and collects tolls from its users.

When goods are provided through markets, a high demand for goods will automatically trigger a supply response; eventually, the production quantities and the prices will reach a supply and demand equilibrium. By contrast, when goods like roads or parks are provided by a government's design, high demand creates congestion but it does not increase the supply of additional roads or parks.

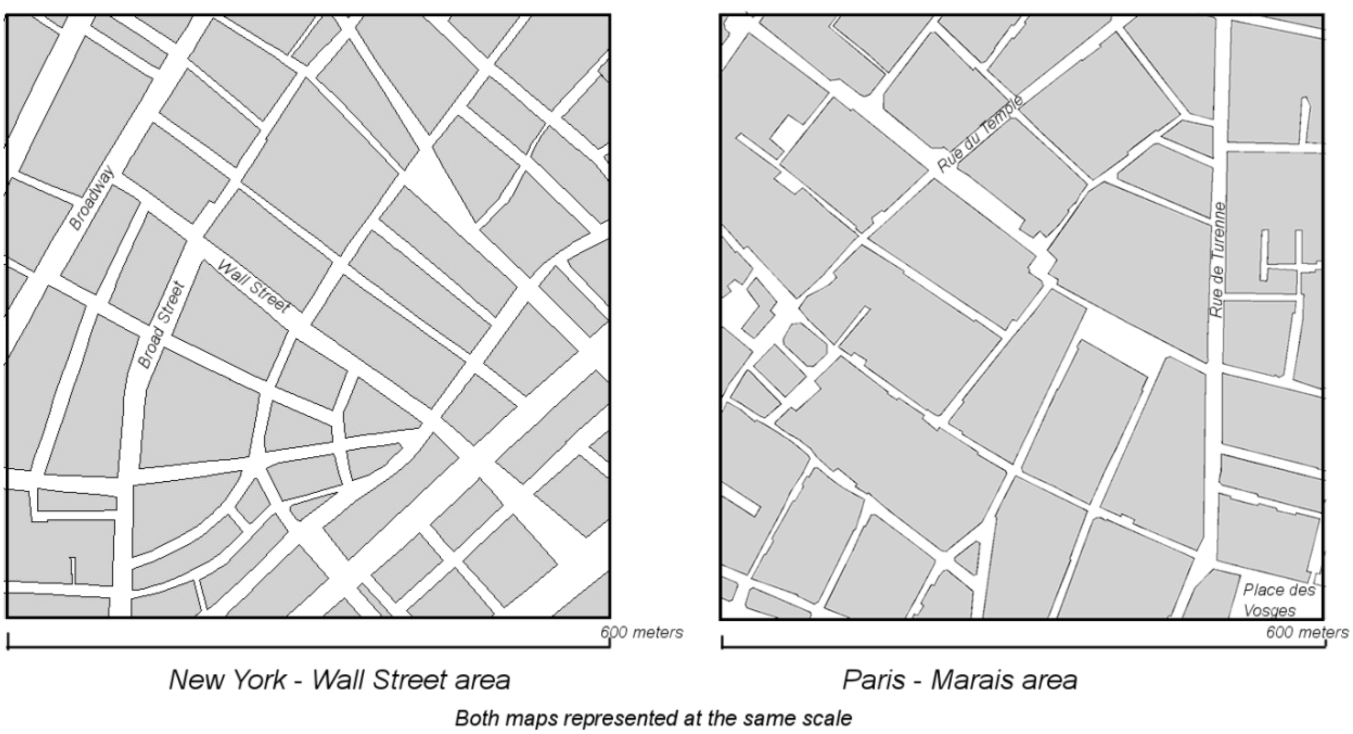
URBAN ROAD NETWORKS MADE OF PRIVATELY DEVELOPED ACCESS ROADS CONSTITUTE POOR METROPOLITAN ROAD NETWORKS

So far, a city has yet to find a way to entirely rely on the private sector to design, finance, and operate a metropolitan network of roads without any government intervention.

It is important to distinguish the provision of local access roads from a road network serving an entire metropolitan area. Private developers routinely provide roads within or at the edges of their property lines. Eventually, ownership of these access roads is typically transferred to a local authority and, later, integrated into the public domain to form a network of interconnected streets. An aggregation of originally privately developed roads constitutes the core of many cities; the two maps shown in Figure 2 illustrate this process well. The street networks in the Wall Street area in the historical core of New York and in the Marais neighborhood of Paris have many similarities. The street networks followed original property lines with some internal subdivision created by the original developers. They each constitute a non-hierarchical network, which is sufficient for providing access to properties but inadequate for allowing mobility across a large metropolitan area. The aggregation of privately built access roads does not constitute a metropolitan network that would allow the labor market to function efficiently.

The New York and Paris neighborhood maps also demonstrate how resilient street networks are once they have been designed. The Wall Street area's street pattern dates from the 17th century and the Marais street pattern, from the 13th century. The buildings within the blocks have been demolished and rebuilt many times since the road network was designed. However, the rights of way, setting a limit between public good and private good, have barely changed since they were created several centuries ago.

Figure 2: Street Patterns in New York (Wall Street Area) and in Paris (Marais)



To build an effective, citywide circulation network, a city needs to connect these privately-built, local roads with a government-designed network of major roads, linking various neighborhoods and allowing travel speeds consistent with the efficient functioning of the labor market.

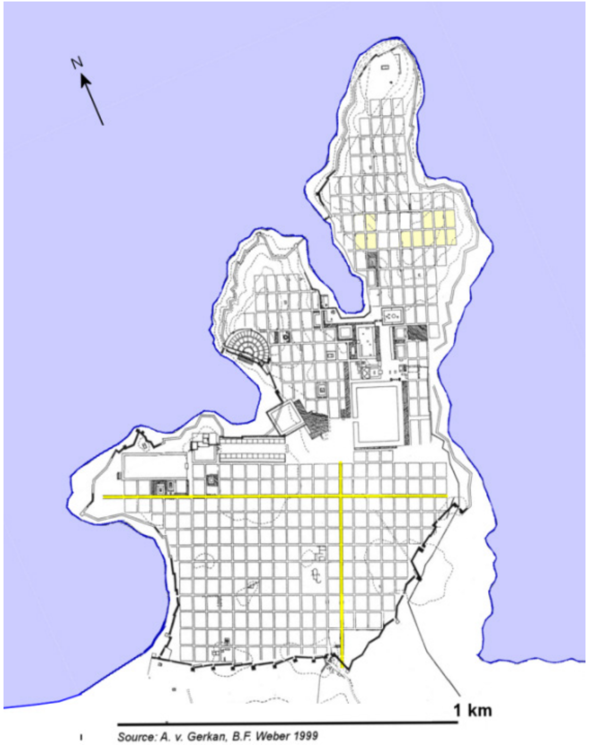
ROAD NETWORK ENTIRELY DESIGNED BY GOVERNMENT

In this paper alone I will not be able to all the various shapes that a metropolitan road network could take nor the impact of network shapes on land values and urban spatial structures; I will only discuss why government intervention is desirable for the design of a street network, in spite of the rigidity and inadaptability to change that is inherent to designed objects.

Early in the history of urbanization, local governments recognized the limitations of creating a street network by simply connecting the residual space left between property lines. In the sixth century BC, the local governments of several Greek trading ports in Asia Minor developed one of the earliest, coherently designed plans separating public and private space in advance of settlements. The plan of Miletus, today in Turkey, shows one of the first known examples[3] in the Mediterranean world of a complete street network designed in advance by a local government. Hippodamus, one of the first known urban planners,

3 Many ancient Cities of China were also planned along a square grid like Chang'an the capital of the Sui and Tang dynasties dating from the 6th century AD.

Figure 3: Plan of Miletus, 6th Century BC



designed the plan of Miletus in the sixth century BC. Incidentally, Miletus was also the birthplace of Thales, the mathematician and philosopher.

The plan designed by Hippodamus established the boundaries between public space and the private lots. In addition to the streets' rights of way, Hippodamus also planned the location of the public buildings and the amenities that contemporary Greeks considered indispensable to the functioning of a city: an agora- where business, justice, and politics were conducted, and an amphitheater- for drama and comedy. Hippodamus selected the site for the theater ahead of time because, contrary to a modern theater, a Greek amphitheater had to be built in a favorable slope in order to improve acoustics, allow for the carving of terraced bleachers and to reduce construction costs.

The plan of Miletus had two advantages. First, it distinguished clearly and in advance the private areas that could be developed by markets from the areas that would remain unsalable, public goods. Second, it provided a coherent, well-connected, citywide street network, which allowed for easy communication among different parts of the city. While Hippodamus identified the locations of public buildings and of the large open space required by the agora, he did not attempt to plan or to control the use of buildings within the private blocks. The excavations of the Miletus site have shown that shops and workshops were built in the areas that anybody familiar with modern land markets could have predicted: along the main axis and near the two ports and the agora.

The design of Washington, D.C.'s street network by L'Enfant in 1792 followed an approach similar to that of Miletus. L'Enfant designed a citywide street pattern, and selected the locations of the principal government buildings, but he abstained to exert any explicit control over the use and development of private lots. Indeed, L'Enfant had no way of knowing that K street would be used mainly for lobbyists' offices or that the political and bureaucratic elite would choose to live mainly in Georgetown, a village located outside the perimeter of his plan. L'Enfant's biographies tell us that he was far from modest, but even so, he did not have the hubris of modern planners, attempting to design and to control the type of use of every private block within a city.

The advance design of an entire city's street network, as done in Miletus and Washington, D.C., is a rather rare occurrence in the history of cities. Most cities start as unplanned villages with a street network formed by the aggregation of residual space between property lines, similar to the patterns shown Figure 2 for Paris and New York. However, when a city's population becomes larger than, say, 100,000 people, this nonhierarchical street pattern hinders the speed of travel between distant locations within the city. Some cities then plan the extension of their street network to avoid the replication ad infinitum of the original village's street pattern. In the 19th century, the New York commissioner's plan provided a better-designed extension of the existing street network, adding the famous Manhattan grid to the original "village" pattern of streets, which still exists today in the area south of Houston Street. In a similar way, the extension plan designed by Ildefons Cerdà for Barcelona was added to the original "Barri Gòtic" network, which also still exists today. The objective of both extensions was simply to design the streets' rights of way in order to preempt developers from defining the street networks from the residual space left between property lines. However, neither design prescribed specific uses or densities for the private plots delimited by the new road network.

Modifying an existing road network, rather than planning a greenfield extension as was done in New York and Barcelona, is very difficult and, consequently, has occurred rarely in the past. The new street network designed by Haussmann in 1865 for Paris is one of the rare examples of extensive modification of an existing street network. Haussmann's design did not aim to provide an extension to the existing street network but to modify the original network itself by opening major streets across the pattern of medieval, narrow lanes that covered most of the city at the time. Haussmann's approach is rare since the necessary use of eminent domain to relocate houses and business makes it very costly and greatly disrupts the social and economic life of the city during its implementation. Haussmann could implement his plan for Paris because he had the strong support of the emperor, Napoleon III. In a democracy, Haussmann's approach would probably never have been possible. In modern times, the muscular and energetic urban management typical in a number of Chinese cities allows a restructuration of the street network that I would characterize as neo-Haussmanian.

L'Enfant, Cerdà and Haussmann designed the new city street layouts of Washington, Barcelona and Paris, but each design was limited to the layout of streets and to the location of a few civic monuments. The design was limited to marking on the ground the line separating public goods – streets and parks – from private goods – private plots. Markets remained the main, decisive factor shaping the land use within the blocks between streets. Long after the new streets were built, markets remained responsible for the constant modification in the location of commercial activities and for the changes in residential and job densities.

Land readjustment, used at time in a number of countries like Japan, South Korea and Germany, is an alternative to eminent domain to acquire streets right of ways. Land readjustment requires a strong government involvement in allocating land among original landowners, in particular to make sure that the design of local streets is consistent with a metropolitan wide network. Land readjustment is currently the most common mode of land development in the largest cities in the State of Gujarat in India. While land readjustment does not involve the use of eminent domain, the resulting street network is the result of design based on norms and urban planners decisions, not of market mechanism.

Because there is no known market mechanism for creating a network of streets that consistently corresponds to changing demands for accessibility and transport, planners play an important role in designing street layouts in advance of urbanization. L'Enfant, Cerdà and Haussmann had no knowledge of the future densities in the areas served by the streets they designed. But their choices of street widths and block lengths, however arbitrary, were beneficial in the absence of a market alternative. The designed networks separated, clearly and in advance, the public non-salable land from the private land and enabled land markets to work more efficiently by removing uncertainty regarding the location of new streets.

For many planners, however, limiting planning to the design of a street layout is not ambitious enough. Although the quantity of land allocated to different urban private uses is more appropriately determined by markets, planners believe they can significantly improve it through design. Their lack of information about future users' requirements does not deter them from extending their design activities from road networks to private blocks, thus substituting themselves for markets.

Some land uses have obvious negative impact on their neighbors, and planners are legitimately called to separate these incompatible uses. But these incompatible uses are few in a modern city and easily identifiable. One would not allow a lead smelter to be built next to a school. Planners have taken the nuisance issue much farther than that and use it to try to systematically control not only what activity can take place on private plots but what height and area of floor space can be built on it. Interestingly enough, planners now are trying to introduce new regulations to allow mixed land use in many residential areas where past regulations were aiming precisely at segregating various uses like commerce and residence. In the same ways, transport oriented development (TOD) aims at increasing FAR around transit stations. If FAR had not be regulated around the stations in the first place they would have long ago reached the level corresponding to demand in these areas. TOD is a good example of the arbitrariness that characterizes modern land use planning.

Fortunately, planners' advance designs for entire cities, including every building in the city, are relatively rare and mainly pertain to new capitals. However, the concept of planner design as a substitute for markets is creeping into most urban regulations, implicitly setting land and floor consumption both through minimum plot and floor area regulations and through maximum floor area ratio. When substituting design for markets, the negative impact on the welfare of inhabitants is not trivial. Planners' detailed designs by regulatory proxy are mostly responsible for the terrible environmental conditions found in the slums of developing countries.

UTOPIA AND DESIGN SUBSTITUTING FOR MARKETS IN DISTRIBUTING LAND AND FLOOR SPACE

I will now give two examples where planners' decisions tried to replace markets in determining the quantity and heights of buildings. In these examples, markets had no influence on the physical outcome. Consumption of both land and floor space was based, in the first case, on an idiosyncratic design and, in the second, on a pseudo-scientific norm. The first example, a design proposed by Le Corbusier in 1925, was an attempt at "redesigning" Paris' center free from the rule of markets. The second example consists of a simple "scientific" housing design norm used in China before the reforms of 1990; those reforms resulted in substituting normative design for markets in all new urban residential areas in China.

DESIGN INSTEAD OF MARKETS: LE CORBUSIER'S PLAN VOISIN FOR PARIS CBD

Figure 4: Le Corbusier's Plan Voisin for Paris

In 1925, the architect-planner Le Corbusier proposed to replace the old, traditional center of Paris with a "correctly" designed new center called "Plan Voisin" (Figure 4). Le Corbusier thought that the primary and overwhelming objective in the building of cities was to give each dwelling an optimum amount of sunlight and immediate access to large parks. Being physiologically similar, he concluded that all humans had the same space and sunlight requirements, hence his repetitive tower design. This project, fortunately never implemented, is typical of the "design" approach to planning. The quantity of floor produced and of land developed and the number and size of apartments are not driven by supply and demand but by what the designer thinks is the "correct" design norm based on perceived "needs." Le Corbusier's doctrine consisted of deliberately ignoring markets and of designing neighborhoods, and even entire cities, based on the norms he selected and on his interpretation of rational human "needs."

Counterintuitively, the "design" approach to urban planning often results in repetitive design while the market approach results in a multiple variety of designs. This apparent paradox is easy to understand. Design is based on rationality, and rationality has the ambition of being universal. Once the correct, rational design is found, it would be irrational to alter it just for the sake of variety. The "Plan Voisin" for Paris, shown on Figure 4, demonstrates this point.

The rational norm argument is useful for designing some manufactured products. For instance, when a rational norm is found for the design of, say, incandescent light bulbs, there is no advantage to endlessly tweaking the norm; repetition of the same design results in a big advantage for all. But incandescent light bulbs have a simple function and a simple objective, about which everyone can agree. Cities, by contrast, are extremely complex objects inhabited by extremely diverse human beings whose preferences and circumstances change over time. Consequently, the design of cities cannot be reduced to a simple objective –be that optimum access to sunlight and parks or some other, worthy objective. Markets are messy and, indeed, are only muddling through toward constantly moving states of equilibrium. However, markets, even when working imperfectly, can easily integrate the complexity of information required to shape cities.

While the "Plan Voisin" was never implemented, Le Corbusier's ideas had an immense influence on city planning during the second half of the twentieth century. His ideas were given international and universal legitimacy through the periodic meetings of the CIAM[4] and the publication of the "Charte d'Athènes," which promoted his design concept of high residential towers implanted in parks in order to optimize access to natural light and green areas. The ideological message was that scientific design should replace markets in allocating land and floor space consumption. This message fit well with intellectuals' attraction to totalitarian ideology, unfortunately, widely shared during most of the twentieth century.

Le Corbusier's influence was felt less through the design of new cities – which were few and include Chandigarh and Brasilia – and more through land use regulations and the design of public housing. Practically all the housing projects built in the Soviet Union and in China before 1980 were based on norms with foundations in Le Corbusier's concepts. In the liberal democracies of Western Europe and Northern America, Le Corbusier's influence was limited to the design of large, government-sponsored public housing projects, for instance Sarcelles in the northern suburbs of Paris and the Pruitt–Igoe housing project in St. Louis, Missouri. The repetitive design of public housing buildings is not due to a lack of architectural skill but to a "design" based on a mythical optimum norm, used as a substitute for markets and pretending to represent universal values.

Through his books and conferences, Le Corbusier clearly expressed his view that the main objective of urban planning and architecture should be to maximize access to sunlight and to parks and open space. But, to my knowledge, he never attempted to optimize his ideas through a mathematical formula. However, his followers in China tried to do just that.

Design Replacing Markets: China Residential Areas 1960-1985

Having rejected market mechanisms, countries guided by Marxist ideology had to find a different way to allocate land to various users. Marxists claimed that rationality and science were the base of their ideology. It was therefore natural that Chinese urban planners tried to find a universal "scientific" rule to allocate land in residential areas in a country as large and diverse as China.

An urban regulation established in China in the fifties specified that at least one room per apartment should be able to receive a minimum of one hour of sunshine on the day of the winter solstice (Dec 21) when the sun is at its lowest in the northern hemisphere.[5] This rule was applied to government and enterprise housing built between 1950 and the mid 1980s. While this rule is no longer applied in China, the housing stock built during the thirty-year, pre-reform period is still largely intact, and it is worth exploring the impact that this "design" rule has had on the spatial structure of Chinese cities.

At first sight, this single design requirement seems innocuous. Nobody would argue against sunlight. For central planners, substituting scientific rationalism for the messy and unpredictable outcome of markets provides a powerful legitimacy. In addition, a uniform norm for the entire country gives the impression of equality under the law. The norm was used as a rule when designing municipal housing estate or for housing built by state enterprises for their workers. The remnants of this housing estate are trading at the low end of the market, and can still be seen in Chinese cities, designated popularly as "danwei housing".

Because the norm had to be used by local government, every household living at the same latitude would consume the same amount of land, and regardless of that latitude, every household would enjoy a minimum of one hour of sunlight every day. The whimsical, idiosyncratic design aspect of Le Corbusier's Plan Voisin disappears and is replaced by a simple mathematical formula: the distance d between buildings is determined by the height of building h multiplied by the tangent of the angle α of the sun on the winter solstice at 11:30 in the morning using solar time.[6] Or:

$$d=h.\tan(\alpha.\pi/180)$$

A regulation expressed through a mathematical formula linked to the movement of the sun appears to have scientific and universal legitimacy. In reality, it is only pseudo-scientific because while the height of the sun at noon on the winter solstice at a given

4 *CIAM (Congres International d'Architecture Moderne, or International Congress of Modern Architecture) was created by a group of notorious architects and artists in 1928 and met regularly until 1959. They were responsible for spreading the ideas of Le Corbusier who was their main guide.*

5 *The regulation was national but specified through local ordinances. In Shanghai it was specified in "Code of urban Residential Areas Planning & Design"(GB50180-93)*

6 *The distance between buildings that would allow every apartment to receive at least one hour of direct sunlight all year is minimized when all buildings face south. As the sun is the highest at noon, the hour of sunlight has to start at 11:30 am and finish at 12:30 pm. The height of the sun at this hour depends on the latitude under which the apartment is located. Solar time has to be used rather than clock time to calculate the angle of the sun, because under official country time zones (for instance UTC+8 used in China for the entire country) the sun doesn't necessary reach its zenith at noon.*

latitude is an indisputable, scientific fact, one hour of sun exposure per day in one room per apartment is not an established scientific necessity.

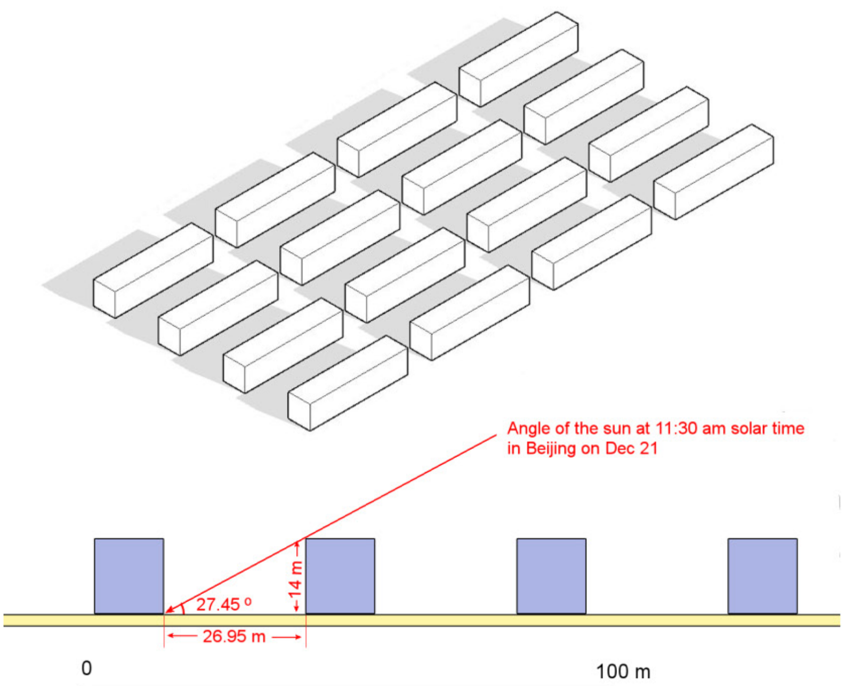
The "one hour of sun" rule sets the distance between apartment blocks for every city in the country and makes this distance dependent on a city's latitude. Figure 5 illustrates the implication of using such a formula for allocating land to housing at the latitude of Beijing. The sun requirement implicitly sets the distance between buildings based on their height. Most housing blocks in China were 5 floors high[7] during the period when this rule was used, the norm therefore inevitably fixed the ratio between floor space and land for every alternative number of floors. The table in Figure 5 shows the distance between five stories buildings as dictated by the norm at Beijing's latitude. That distance, in turn, fixed the population density that could be derived by estimating an average floor space per apartment. The solar norm, therefore, implicitly mandated for Beijing latitude, for instance, a density of 700 people per hectare, assuming a gross floor space of 65 m2 per household and 3.5 persons per household.

results in uniformity. Markets, by contrast, have more chances in resulting in individual design variety as each supplier tries to innovate in an effort to capture a larger share of consumer demand.

The implications on urban form of this alleged rational norm are staggering. First, it implicitly sets the same area of land consumed per area of floor space built for every location within the same latitude, regardless of whether a location is in a large city or a small one, in the center of a city or in a suburb. Second, it implies that more land should be used to produce one unit of floor space at northern latitudes than at southern latitudes. Or, in other words, it suggests that densities should be lower in Beijing and higher in Hainan! If this rule was applied to the United States, it would prescribe that the densities of Chicago and New York should be much lower than those of Houston and Phoenix!

When I was working on housing reform in China in the 80s, this norm was constantly cited as a main constraint by my Chinese counterparts when discussing the possibility of looking for an alternative housing design that would make more efficient use of land. But was this design approach really followed in all housing projects in China?

Figure 5: China Distance Between Buildings Determined by the Angle of the Sun on the Winter Solstice



Calculation of distance between buildings for a minimum 1 hour sun exposure per day
at the latitude of Beijing

Latitude	39.1118 N		
Longitude	117.274 E		
Number of floors	5 floors		
Height between floors	2.8 m		
Height of building	14 m		
Angle of sun at 11:30 am (solar time)	27.45 degrees	on Dec 21	
distance between buildings	**26.95 m**		
Distance between buildings	**=height of building/(TAN(angle of sun*PI()/180))**		

Corresponding land use

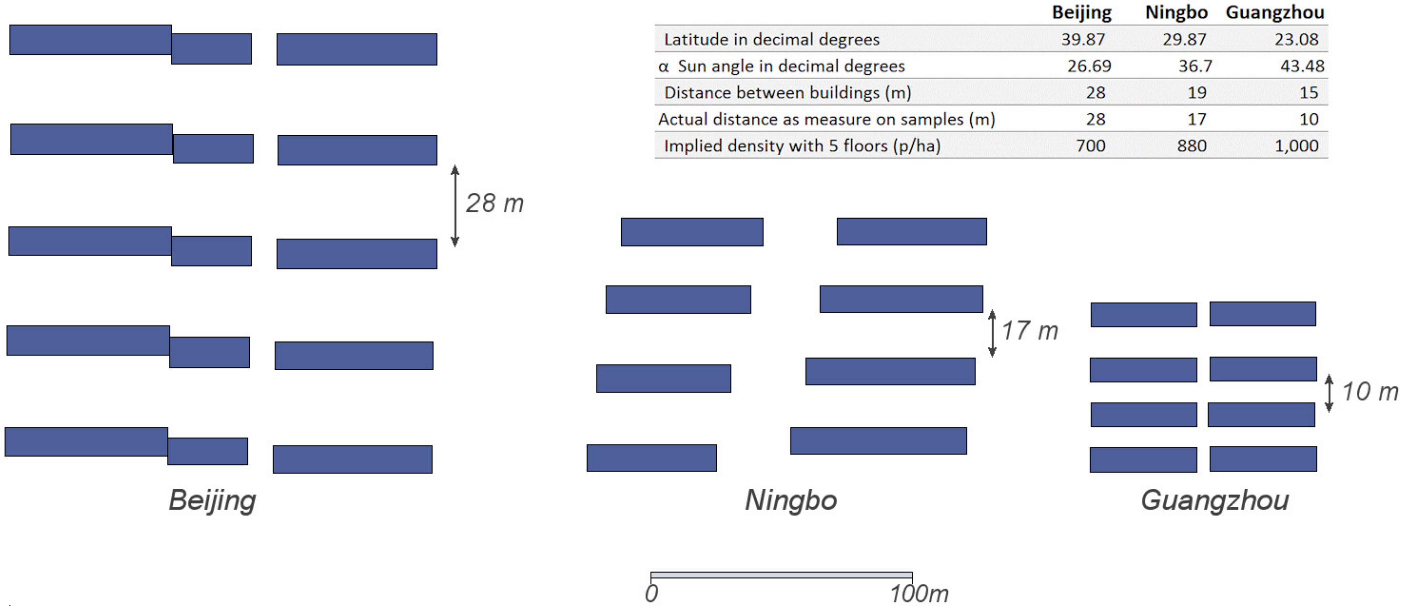
total land area per building	2,996 m2	
number of floors	5	
Building footprint	780 m2	26%
Total floor area	3,900 m2	
gross apartment area per household	65 m2	
people per apartment	3.5	
reidential density	701 p/ha	
Floor area ratio	1.30	

In addition, Figure 5 also shows the predictable repetitive site plan that such a regulation produces. As we have already observed with Le Corbusier's Paris plan, a scientific design norm inevitably

7 Five floors was the maximum number allowed for apartment blocks without requiring an elevator. Given the shortage of power in pre-reform China, practically all apartment blocks built were 5 floors high.

Figure 6: Application of the Sun Rule – Footprint of "Danwei Housing" in Beijing, Ningbo and Guangzhou

	Beijing	Ningbo	Guangzhou
Latitude in decimal degrees	39.87	29.87	23.08
α Sun angle in decimal degrees	26.69	36.7	43.48
Distance between buildings (m)	28	19	15
Actual distance as measure on samples (m)	28	17	10
Implied density with 5 floors (p/ha)	700	880	1,000



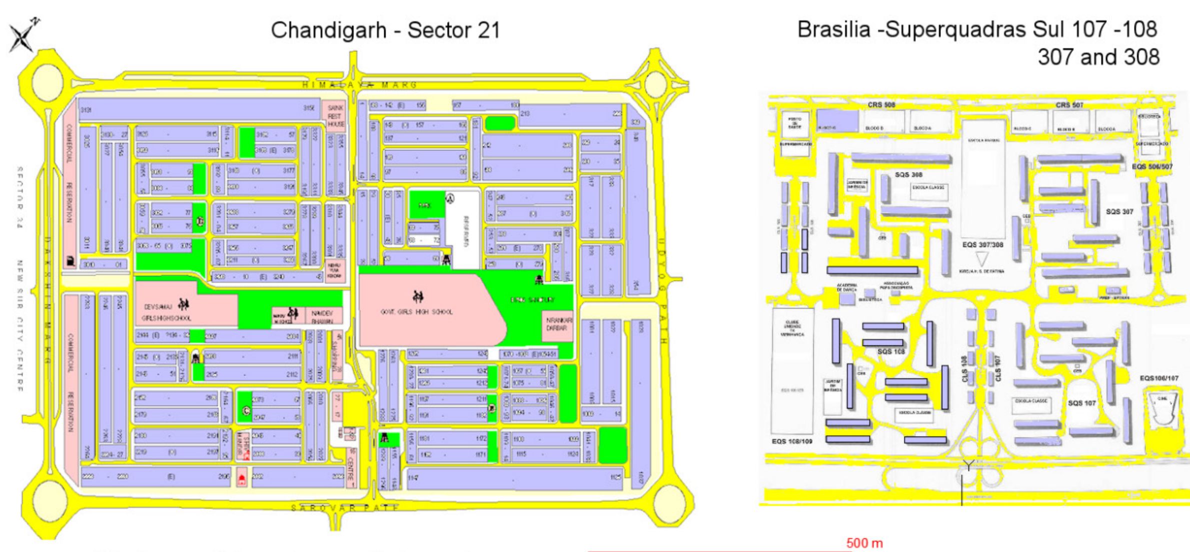
From a limited survey of sample site plans in Chinese cities selected at various latitudes, Beijing (latitude 39.9 o N), Ningbo (latitude 29.9 o N) and Guangzhou (latitude 23.0 o N), it appears that the rule was closely followed, with greater variation toward higher densities in cities further away from Beijing (Figure 6). Indeed, the densities vary with the latitude: higher densities in lower latitudes. The table on Figure 6 shows the variations between the actual building distances and those prescribed by strict application of the one-hour rule.

After the market reforms of the 80s, Chinese municipalities rapidly abandoned the allocation of land through design norms and replaced it with a more pragmatic approach, relying on the market price obtained through auction of land use rights. Post-reform Chinese cities had a strong incentive to abandon the wasteful, normative use of urban land because they derived a large part of their revenue from the market price sale of land use rights to developers. In spite of having been abandoned, the use of this regulatory norm still had an enormous impact on the structure of Chinese cities. That impact is typical of the unintended consequences of many land use regulations.

DESIGN EXTENDED TO THE PRIVATE BLOCKS OF ENTIRE CITIES

Very few cities have been designed in their entirety, including street layouts and buildings, with no provisions made for land use to

Figure 7: The Design of Building Inside a Block in Chandigarh and Brasilia



be modified by market forces at a foreseeable point in future. Illustrating attempts to control everything through design, examples like New Delhi, Brasilia, Canberra or Chandigarh are very different in concept from Miletus, Washington or Haussmann's Paris.

In addition to the street networks, planners imposed detailed regulations specific to each private block. These regulations were so detailed they essentially designed each block's buildings. They specified the use of land, the size of lots, the height of buildings, the area of dwellings, the lot coverage, etc. These planner-designed regulations completely prevented market forces from contributing to the shape of the city.

Figure 7 shows detailed plans of residential areas in Chandigarh and Brasilia; every building -- whether a community facility, an apartment block, or a commercial area, was designed in advance through regulations. Nothing was left to markets: prices were ignored, FAR were set for every single block, and land was allocated to residential and commercial use based on arbitrary design norms.

1.3 THE GROWTH OF PUDONG: MARKETS AND DESIGN

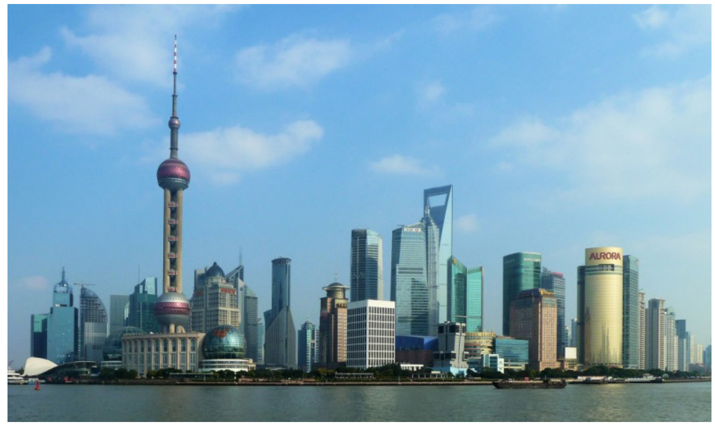
Many of the examples that I have used so far to illustrate the role of markets and design in the development of cities were taken from the past- the oldest, Miletus, in the sixth century BC, the most recent, Chandigarh and Brasilia, dating from 1960. Let us look now at markets and design at work using the example of Pudong, the new financial center of Shanghai, built over the last 25 five years.

At first sight, design seems to be entirely responsible for the stunning skyline of Pudong, as seen from the west bank of the Huangpu River (Figure 8). Architectural firms working for developers have designed the unique shape of each skyscraper. The skyline, formed by the sum of each individual building's design, appears also to be the product of design. Paradoxically, this is not the case.

PUDONG WAS CREATED BY MARKET FORCES

The skyline of Pudong, as seen in the picture of Figure 8, was created by the high demand for floor space in this area, reflecting its high

Figure 8: Shanghai – Pudong New Financial Center



accessibility to Shanghai's labor force. Developers, anticipating a high demand for office space at a price point higher than building costs (including the cost of land), initiated, and financed the building of skyscrapers.

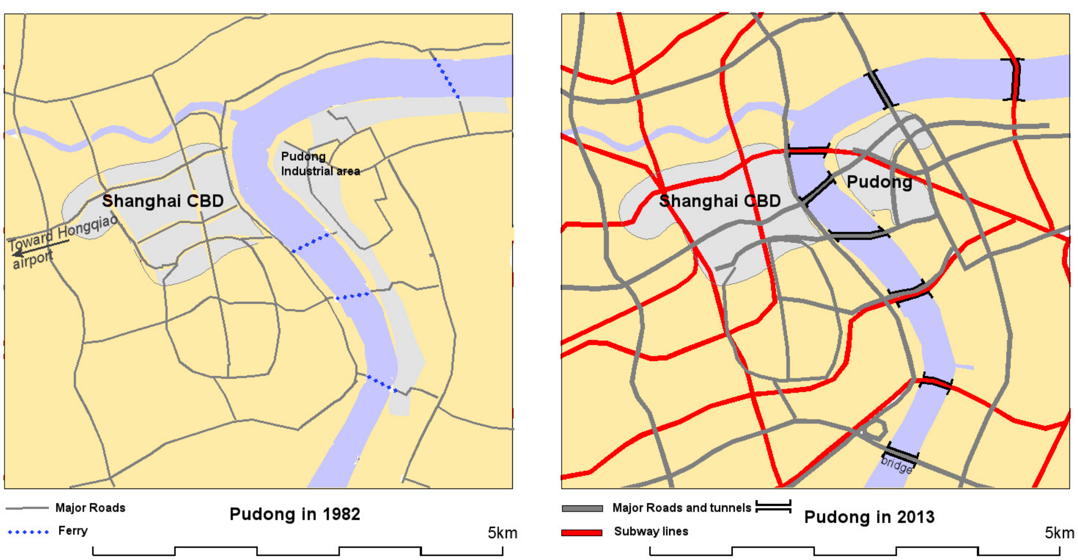
Tall, thin buildings constitute a large part of the skyline's esthetic attraction. A concentration of tall buildings is always the product of market forces. In Pudong, due to high demand, land is expensive, and as such, developers are obliged to substitute capital for land by building tall buildings. Tall buildings are more expensive to build per square meter of floor space than are squat buildings. However, each additional floor built decreases the cost of land per unit of floor space. Therefore, where land is expensive, the high price of land obliges developers to substitute capital for land by constructing taller buildings. In aggregate, therefore, the skyscrapers of Pudong are not created by design but by market forces. In the absence of market demand for office space, there would be no skyscrapers. If land had been cheap in Pudong, there would have been no skyscrapers, only squat office buildings of 3 or 4 stories as are seen in suburban office parks!

Developers hired architects to design individual buildings on specific plots of land. They told the architects how much floor space they had to accommodate on each land parcel. Variations in the height and shape of a building depend both on the shape of the original lot and on the financial risk a developer is willing to take in projecting demand and sale prices. The first buildings in Pudong were only moderately high. When the demand for office space in Pudong became more firmly established, land prices increased and developers became bolder. Ready to take more financial risk, developers commissioned architects to build taller, more expensive buildings. Thus, the variety of building heights, shapes and textures, which define Pudong's aesthetic quality, is the product of market forces, but, the design ability of individual architects is still apparent in each building. Markets produce a great variety of design because economic conditions change over time and therefore require different design. In addition, innovative designs in newer developments attract tenants or buyers through more attractive buildings. Markets imply competition; competition stimulates innovation in technology and design. Compare Pudong's skyline to Le Corbusier Plan Voisin for Paris or to the neighborhoods of Chandigarh and Brasilia shown on Figure 7. The diversity of building shapes and heights in Pudong suggests markets, while the uniformity of building shapes and heights in Chandigarh and Brasilia suggest government design. However, Pudong could not have been built without some initial infrastructure design provided by government.

DESIGN CONTRIBUTION TO THE DEVELOPMENT OF PUDONG FINANCIAL DISTRICT

While market forces were responsible for the construction of skyscrapers in Pudong, the design and construction of roads, bridges, tunnels, and underground metro lines were responsible for the changes in land prices that triggered these market forces.

Figure 9: Pudong – The Design and Construction of Roads and Subway Links to Pudong



Pudong is located on the East bank of the Huangpu River, about 500 meters across the river from "the Bund," the traditional CBD of Shanghai. Before 1991, ferries provided the only link between Pudong and the rest of Shanghai, and Shanghai had no underground metro before 1993. Because of its poor accessibility and lack of infrastructure, Pudong was only partially developed with a few low-rise industrial buildings and warehouses linked to the port. Agricultural land still occupied large areas east of the river, less than two kilometers from Shanghai CBD (map on left of Figure 9). In the eighties, the demand for new office buildings in Shanghai was mostly met along an east-west corridor between the traditional CBD and the old Hongqiao airport. The poor accessibility of Pudong kept land prices low, and this explained the existence of low rise, low value buildings.

The land in Pudong started to increase in value in 1991, after the municipal government decided to build the first bridge across the Huangpu River, linking "the Bund" and Pudong. Eventually, the construction of two more bridges, four road tunnels, and four underground metro lines put Pudong within a few minutes of Shanghai's traditional CBD (map on right of Figure 9). The increased accessibility of the new Pudong financial district, combined with the dynamism of Shanghai's economy, increased demand for office space in the area, further raising the land values and triggering the construction of the skyscrapers that gave shape to today's stunning skyline.

By themselves, roads, bridges, and tunnels do not increase land values; they do so only if they provide access to land for which there is a potentially high demand. In the case of Pudong, the designers of the bridges and tunnels correctly anticipated the reaction of markets to the increased accessibility created by the new transport infrastructure.

The infrastructure linking Pudong to the rest of Shanghai was created by design not by market forces, but the anticipated increases in land market value in Pudong guided the design and justified the government's investment. Markets could not have provided the transport infrastructure linking Pudong to the rest of Shanghai because the beneficiaries of this infrastructure were dispersed throughout the entire city and because no direct cost recovery was possible except through some form of government taxation. The development of Pudong illustrates perfectly the complementary role of markets and design in the most successful cities. Planners are able to design and build the infrastructure that will support the densities created by markets.

The areas devoted to roads and public open space within Pudong business district were allocated by design and are therefore arbitrary, even if the road areas were designed with the help of models simulating future traffic. Theoretically, it is possible to conceive of an optimum equilibrium between infrastructure investments and the use and price of land and floor space. Unfortunately, there are no known market mechanisms that could create the "right" quantity of roads, bridges, tunnels and metro lines to connect the Pudong financial center with the rest of the city. Because roads, bridges and tunnels are not submitted to market forces, they do not increase in size and quantity where and when the demand is high. They do not shrink where the demand is low. Their "designed" width and length is fixed. More demand creates more congestion, not an increase in supply.

The example of Pudong shows how markets and government design should interact to expand cities. The government let the price of land determine both the building heights and FAR while providing the large infrastructure investment that was required for the price of land to reach its full potential given the short distance between Pudong and the Bund. Government planners in the case of Pudong understood the mechanism of markets and designed and built the infrastructure that would maximize the value of land across the river.

1.4 URBAN MANAGERS SHOULD UNDERSTAND HOW MARKETS AND DESIGN INTERACT TO ALLOW CITIES TO ADJUST TO CHANGE

CONFUSION BETWEEN MARKET AND DESIGN: THE PLANNING OF DENSITIES

Planners advocating "smart growth" dream of a clever design arrangement that would achieve an optimum trade-off between land consumption and commuting distance. They usually advocate designs with "higher" population densities[8] in order to reduce commuting distances. If densities are the object of design, then there must be "good densities" and "bad densities," just as there is "good design" and "bad design."

8 Urban population densities are typically measured in people per hectare. For instance, a density of 50 people per hectare corresponds implicitly to a land consumption of 200 square meters per person (10000/50=200). The higher the density, the lower is the land consumption per person.

In reality, it is only markets[9] that determine land and floor consumption and, therefore, population densities. Indeed, households' decisions concerning their consumption of land and floor space are based on prices and locations, which themselves are based on supply and demand, the variations of which are determined by the market. The area of floor space that a household consumes is dependent on its income –the demand side— and on the price of floor space and the cost of commuting—the supply side. The equilibrium between supply and demand for floor space evolves over time and certainly cannot possibly depend on the design choice of a genial planner.

For instance, densities, in historical parts of New York, Paris and Shanghai, have decreased over time by more than half. These changes in densities are entirely due to market mechanisms, reflecting, in part, improvements in transport and an increase in income. These changes in densities could have been foreseen or expected, but they could not have been designed.

This distinction between markets and design has practical, operational implications in the management of cities. Imagine a city in which the mayor considers it a priority to increase the consumption of floor space per household (as was the case in Chinese cities in the 1980s). If we agree that consumption is a market issue, then planners could consider a number of possible solutions based on market mechanisms that would increase consumption. For instance, planners could increase the supply of developed land by opening more land to development, by increasing the speed of transport or by increasing the productivity of the building industry by decreasing the transactions costs linked to building permits and land acquisition. Planners could also use a demand side approach, stimulating demand by increasing access to mortgage credit or, even, by indirectly causing an increase in salaries by opening the city to outside investments in manufacturing or services. By contrast, a design solution might establish a minimum regulatory house size to prevent developers from building small houses or require the government to subsidize and build a sufficient number of large apartments for low-income households every year in order to increase the average consumption of floor space. As the consumption of floor space is a market outcome, design solutions, which aim to increase consumption, never work in the long run.

9 In this paper, I will use the word 'market' as an abbreviation for real estate market.

2. A SIMPLE MODEL ESTABLISHING THE LINK BETWEEMN MARKETS, DESIGN AND URBAN STRUCTURE INDICIATORS

A simple model (Figure 10) could help differentiate the role of markets and design in the development of cities. The model should be helpful for understanding the geometric relationship between people, jobs, floor space, land, and road infrastructure within the framework that I have been using: differentiating between markets and design.

From this model, we will be able to derive the three most important urban indicators that will allow for monitoring spatial changes and comparing different urban spatial structures. The three indicators are the population density, the built-up floor area ratio and the road space per capita.

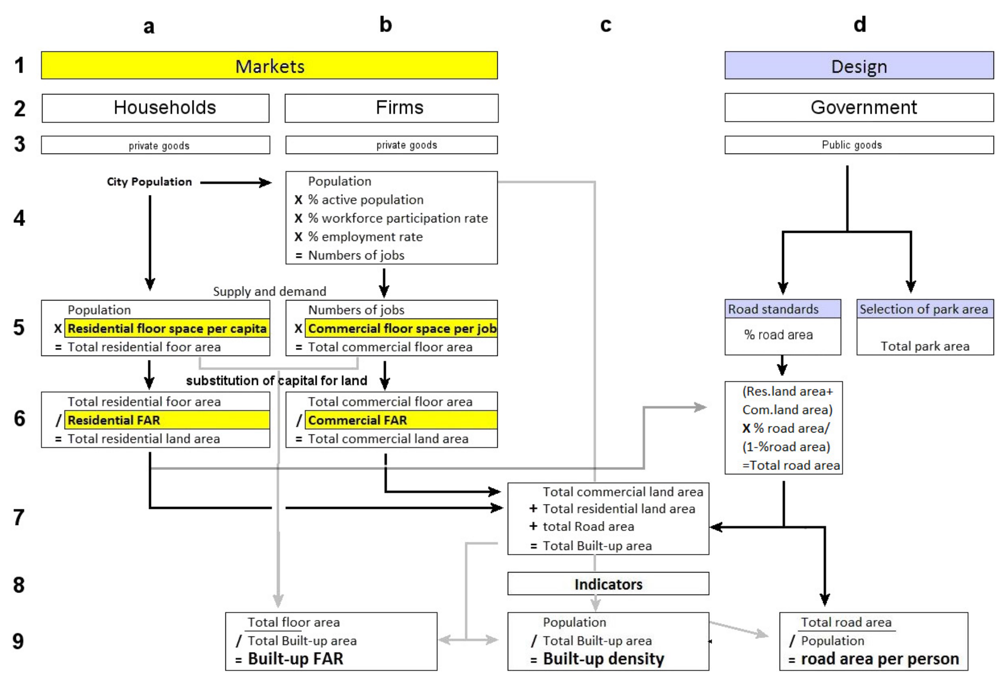
- The population density measures the spatial concentration of people per unit of land, but it is also a measure the consumption of land per person[10] in cities.
- The built-up floor area ratio[11] (abbreviated as FAR) establishes the numbers of units of floor space that are built on one unit of land area, including land used for streets and utilities.
- The road space per capita is calculated by dividing the total road area by the total population of a city. The road space per capita is directly linked to mobility and could be used as an indicator to measure the compatibility of street area per person with different modes of transport.

I will show that a city's average population density is entirely dependent on markets and, therefore, is not subject to planners' designs. The built-up floor area ratio should be entirely determined by markets; however, its maximum value is often constrained by regulations. The road space per capita is dependent on both design and markets: road design norms and regulations set by governments and population density determined by markets.

2.1 THE ORGANIZATION OF THE MODEL

The model shown on Figure 10 is divided vertically into two streams—markets and design. Columns "a" and "b" correspond to the market stream; column "d" corresponds to the design stream, and column "c" contains intermediary results and indicators. Horizontally, the model is divided into 9 rows of "boxes" that contain categories such as "households" or formulas such as "population X residential floor space per capita = total residential floor area." Arrows indicate the relationship between input and output variables. In the explanation of the model, "box b 5," for instance, relates to the box located in column "b" on row 5.

Figure 10: Pudong – The Design and Construction of Roads and Subway Links to Pudong



QUANTITIES OF PRIVATE GOODS ARE DETERMINED BY MARKETS, WHILE QUANTITIES OF PUBLIC GOODS DEPEND ON DESIGN

The built space of a city contains two types of goods: private goods and public goods (rows 1,2 and 3 on Figure 10). Residential and commercial buildings are private goods. Private goods are bought and sold on the market. For private goods, the quantity and unit price of the floor space built and the land developed depend on supply and demand i.e. markets. By contrast, roads and large public

10 Urban population density, d, is usually expressed in people per hectare. As a hectare is equal to 10,000 square meters, the consumption of land per person, c, is equal to 10,000/d. For instance, a population density of 50 people per hectare is equivalent to a land consumption of 200 square meters per person.

11 The built-up floor area ratio is the ratio between the total floor area built in a city and the total land area developed, including roads but excluding large open spaces. It differs from the plot area ratio which measures the ratio between the area of floor space built on a private plot and the area of the plot, excluding the roads around the plot.

open spaces are usually public goods. Contrary to private goods, the quantity of public goods produced is determined by design, not by markets. Because users do not pay for public goods, it is impossible for markets to determine the quantity that should be produced in order to reach equilibrium between supply and demand. Instead, governments rely on design standards, projections, and norms to provide the "right quantity" of public goods.

Firms' and households' floor and land consumption drive urbanization, not governments or urban planners

Firms and households are consumers of private goods. Households consume residential floor space while firms consume commercial floor space. I have included under the label "firms" all buildings such as offices, shops, warehouses, and factories. Amenities, like museums, theatres, and restaurants function like firms; their employees are part of the labor force, and their patrons are consumers. Less obviously, I have also included under "firms" government-owned and -operated facilities such as government office buildings, schools, hospitals, jails, post offices etc. For the purpose of the labor market, they function exactly as firms. In a school, teachers and staff are the labor; the school is a firm that sells education, a service, to the students who are the consumers. This is the case even when parents indirectly pay for the service their students consume through their taxes. More generally, I consider all levels of government to be firms; they employ labor that distributes services to their customers, the citizens. For the same reasons, government-owned facilities are under the "market" category, as the real estate they represent should easily be bought, sold, or rented at market price. The fact that only a few governments sell land back to the public or rent buildings from the private sector[12] should not justify putting them in a different category. Nothing should prevent governments from selling or renting land and floor space or from leasing land and floor space from the private sector. It would be quite healthy for governments to routinely assess the capital values of their land holdings and to estimate whether they are using urban land efficiently.[13]

Let us now look at the model itself. We will have two streams of quantitative relationships: the first one concerning the provision of private goods through market forces, the second concerning the provision of public goods through government design.

2.2 THE FLOW OF PRIVATE GOODS SUPPLIED BY MARKET MECHANISMS

The driver of urbanization: number of people and jobs (line 4, A and B)

The first input is the city population (line 4), which is exogenous to the model. The size of the population determines both the number of people who will consume residential floor space and the number of workers consuming commercial floor space. The population multiplied by the percentage of active population (people between 16 and 65), times the labor participation rate,[14] times the employment rate is equal to the number of jobs. In the model, this would be equal to the number of workers requiring commercial floor space.

Market independent variable: consumption of floor area per capita (line 5, A and B)

Firms and households consume floor space. The consumption of floor space per person and per worker depends on supply and demand. This consumption is not fixed but varies constantly, depending on economic conditions. Most regulations set minimum norms for floor consumption based on "optimum" design, but in reality, the floor area actually consumed is entirely defined by that which firms and households can afford given their income and the current land and construction prices. Land and construction prices depend on the supply of land and on the productivity of the real estate industry. The consumption of floor space per person and per worker is, therefore, purely determined by markets; it is not a design parameter.

Population times residential floor space per person provides the total area of residential floor space. The number of jobs times the commercial floor space per worker is equal to the total area of commercial floor space. We can see that the total floor space, residential and commercial, built in a city depends entirely on markets and is not subject to design. This total floor space will change with time, depending on population and market conditions. The prosperity of a city will depends on the elasticity of the supply of floor space as economic and demographic conditions are changing. The

12 The government of Singapore regularly rents or buys space in shopping malls for the greater convenience of its citizen. This practice allows the government of Singapore more transparency in its operating costs, as the rents of its real estate properties are valued at market rate.

13 Unfortunately, most governments consider that their land assets are unalienable. There is no reason to think so. South Africa and New Zealand are, to my knowledge, the only countries in the world that value government land assets at their market value and levy a municipal tax on them. Even if the tax is often underestimated, it is an excellent step forward in forcing government to value their land assets and, eventually, to sell them when not needed.

14 The labor participation rate is expressed as the percentage of people that are employed within the age group 15 to 65. The labor participation rate varies a lot from country to country; from a low of 42% for Jordan to a high of 85% for Ethiopia. The world average in 2012 was 64% (World Bank http://data.worldbank.org/indicator/)

quantity of floor space cannot be contingent on a fixed design established in advance in a master plan.

MARKET INDEPENDENT VARIABLE: FAR THE SUBSTITUTION OF CAPITAL FOR LAND (LINE 6, A AND B)

The area of land required for building the total floor area calculated in boxes 5a and 5b depends on the floor area ratio in residential and commercial areas as discussed at the beginning of this paper. The floor area ratio depends on the price of land relative to the price of construction. If a unit of land is more expensive than a unit of construction, then it will be necessary to substitute capital for land, i.e. building taller buildings with high floor area ratio. The floor area ratio is therefore a parameter best set by markets. However, planners often restrict floor area ratio because of the possible negative externalities generated by tall buildings.

Total residential floor area divided by the residential floor area ratio will be equal to the total area of residential land. We will do the same operation for the commercial floor area to obtain the total area of commercial land. As we have seen, these two areas depend entirely on market conditions. In cities where FAR is heavily restricted by regulations (i.e. by design), the land consumption will be higher per person or per worker than in cities where it is not.

2.3 THE FLOW OF PUBLIC GOOD DEPENDENT ON GOVERNMENT DESIGN AND INVESTMENT

The areas occupied by public goods in this model are reduced to two components: total road area and total public open area (column d). Both components are created by design, as there is no known market mechanism that could accurately supply an area of road, which corresponds to its demand. The same could be said for large parks and open spaces and for the protection of cultural heritage sites or exceptional environmental assets. The identification of these public goods and the quantities provided can only be done by arbitrary design or norm. Once the norm has been decided, there will be no market mechanism that can adjust supply or demand. Only a revision of the original design, as arbitrary as the first, would be able to modify the supply of public goods.

DESIGN INDEPENDENT VARIABLE: URBAN ROAD STANDARDS (LINE 6, D)

Governments usually set urban road standards for highways, arterial roads, secondary and tertiary roads. Master plans, norms or regulations usually establish the desired distance between each type of road. The result of the various norms can usually be summarized by the percentage of total area developed that must be used for roads. For instance, a norm mandating the creation of a grid system of arterial roads 30 meters wide every 800 meters would implicitly require that 7.6% of the total area developed be devoted to arterial roads. In Manhattan's grid, a typical block is 920 feet long with 100-foot wide avenues and 60-foot wide streets, corresponds to a street area of 33% of the total area developed (measured from the four intersections of the axis of streets and avenues). Obviously, the norms for roads are based on rules of thumb, and assumptions about the multiple functions of streets: providing light and ventilation for buildings, handling pedestrian and vehicular traffic, providing recreational space and parking, allowing for the planting of trees, etc. There is neither a "scientific" nor a market approach for the allocation of land for street space.

In the model, I assume that the various road regulatory norms are summarized as a single number representing the percentage of the total built-up area (line 5 d). This percentage applied to the residential and commercial land area allows for calculating the total road area corresponding to the regulatory norm (line 6, d).

DESIGN INDEPENDENT VARIABLE: PARK AND OPEN SPACE STANDARDS

Parks and open spaces are sometimes the object of a regulatory norm in land subdivision regulations, but most of the provisions for parks and open spaces are opportunistic. For instance, a river bank or sea frontage is often allocated as public space. The quantity of land provided as open space often depends on what I will call topographical or historical opportunities. For instance in Seoul, most of the public open space has been allocated because of topographical opportunities along the Han River and on the slopes of undevelopable hills. In Paris, by contrast, most of the large open spaces, Bois de Boulogne, Parc de Vincennes, Tuileries and Luxembourg gardens, were originally part of the royal domain and were latter transformed into public parks. The area and location of parks in Paris are, therefore, the results of an historical opportunity.

The provision of open space is typically a designed component of urban land use. Because of the idiosyncratic nature of large open spaces, I do not include large parks into the calculation of the built-up areas of cities.

2.4 DEPENDENT VARIABLES: THE TOTAL CONSUMPTION OF FLOOR SPACE AND LAND AND DENSITY INDICATORS

The demographic, market and design inputs of the model, as described above, allow us to calculate the dependent variables, which are: the total built-up area and the three indicators,

1. Average built-up density
2. Average built-up FAR,
3. Average road area per person

These indicators are the most important for monitoring the way a city structure evolves in time. Below, I will explain why these indicators are so important and how to use them to monitor the evolution of cities, in particular, with regards to maintaining affordability and mobility. These indicators measure the impact of the combined effect of markets and design on a city's structure.

Indicator built-up average FAR (line 9, a and b)

The average built-up FAR measures the number of units of floor space that can be built per unit of land. It is the average rate of conversion between land and floor space. As floor space is the real end product of urban development and land is often the most expensive input to produce it, this is a very important urban indicator. The demand for urban land depends very much on the value of this indicator. For the same population, a doubling of the average FAR decreases the demand for land by half.

In spite of its importance, to my knowledge, the average built-up FAR[15] is never part of a city's urban indicators, and master plans never mention it.

Master plans usually constrain the maximum FAR value on individual private lots in different ways depending on location (New York's zoning plan has more than 20 different values for maximum FAR in various zoning categories). However, for some reason master plans never aggregate the overall impact of these detailed regulations on the overall demand for land, and therefore fail to evaluate the maximum area of floor space that users can legally build within a master plan area. The average FAR is important in planning because it allows forecasting of the demand for land based on the projected demand for floor space and on the design norms for roads.

Indicator: average population built-up density (line 9, c)

The average built-up density is an indicator of land consumption per person. It combines the impact of markets and design (in the form of roads) on the overall consumption of land.
Contrary to the average built-up FAR indicator, population density is a routinely measured indicator. However, planners often consider that density is a design option rather than a market outcome. This confusion is clearly apparent among the advocates of "smart growth" who think that planners can increase urban population densities by increasing regulatory FAR values. FAR will increase only in those areas where a low FAR has been constraining demand for floor space. An increase in the permitted FAR will have no impact in areas where the ratio between land price and construction cost is low because in these areas there will be no reasons to substitute capital for land.

As the model has shown, population densities are also dependent on the consumption of floor space per capita, another exogenous market variable. Population density is a useful indicator to project demand for land in the future, but there is no reason to consider higher densities or lower densities as a desirable planning objective. However, removing regulatory constraints on land supply might result in lower population and job densities.

Indicator: road area per person (line 9, d)

The road area per person is a consumption indicator that depends mostly on markets and partially on design. Because the area of roads usually does not change after they have been designed and built, variations in the road area per person depend mostly on the change in densities, which is a market variable.

The measure of the road area per person is an indicator of potential congestion as commuters consume road space at peak hours to travel to jobs. Because the area of roads cannot be adjusted easily after they have been built, the road area per person is a useful guide for transport system designers.

15 *The average built-up FAR measures the ratio between the total floor area of an entire neighborhood or an entire city and divides it by the built-up area of the neighborhood or the city. The average built-up FAR therefore includes private plots as well as street areas and small open space within the built-up area. By contrast, FAR regulations measure only the ratio between floor space and private plots, and therefore grossly underestimate the total area of land required for building one unit of floor space.*

Transport systems should be designed to adjust to current spatial structure, not the other way around, as is often advocated. Let us remember that, except in contemporary Chinese cities, the possibility of increasing the street area of large cities seldom exists; the operation conducted in Paris by Haussmann in the middle of the 19th century is extremely rare, because its financial risk and high social cost.

2.5 BUILDING A MORE COMPLEX MODEL

The objective in developing the land use model described above was to demonstrate that population densities are the result of market forces, themselves reacting to exogenous events. I recommend that planners make densities projections to evaluate, for instance, the likely future demand for land to be converted to urban use. However, planners must base their projections on credible markets scenarios based on income and prices and not on their own design's preferences for low or high densities.

In order to be able to make more credible density projections, planners might want to make the model more complex. For instance, disaggregating the population by income group would allow for differentiation between floor and land consumption for several household's income interval. In the same way, disaggregating commercial land use into various land use types-retail, office, and industrial, would make the projection more realistic.

3. PLANNERS SHOULD UNDERSTAND THE ROLE OF MARKETS AND DESIGN IN SHAPING CITIES

Most master plans, prepared at large expense to tax payers, are often ineffective and soon irrelevant; this is particularly true in the cities that are developing fastest. The confusion between the impact of market and that of design is mostly responsible for this dismal record.

PROJECTIONS SHOULD NOT BECOME REGULATIONS

However, this does not mean that advance planning is useless. To the contrary, plans able to project urban growth and to mobilize the resources to address this growth are indispensable. However, to be effective, plans must rest on credible projected consumption levels based on realistic market assumptions, not on utopian design preferences or populist dogmas.

Planners too often transform their land use projections into regulations. For instance, often projections for industrial land, based on past demand, become zoning laws, fixing the boundaries and the area of future industrial land. Projections are just that, they are always a guess, even if based on past trends. Planners should therefore constantly monitor demand through the evolution of land prices and rent, and adjust their projections accordingly. Zoning plans often misallocate land in spite in obvious demand change because erroneous demand projections were changed into zoning laws. The contrast between the attitude of the planners in Mumbai and Hong Kong, that I described above, illustrates the advantages of monitoring demand to allow land use change.

Planners should therefore fully understand market mechanisms. Every planning department should monitor the spatial distribution of changes in real estate prices. Particular attention should be given to the supply side: the elasticity of land supply, the productivity of the real estate industries, and the reduction of transactions costs imposed on building permits and property title transfers, etc.

PLANNERS CAN INFLUENCE CONSUMPTIONS BY USING MARKETS NOT BY IMPOSING NORMS

Clearly separating markets from design in the development of cities does not mean that planners should just passively monitor markets. For instance, planners should certainly be concerned by very low housing consumption among lower income households and should take action to increase it. However, they should know that the way to increase housing consumption is through market mechanisms, such as increasing supply or lowering transactions costs, rather than through regulatory design, such as fixing by law a minimum floor area or lot area. If planners want to have more influence over urban development they should develop a set of indicators such as land prices, rent, average commuting time under different mode. These indicators should be considered as "blinking" when they pass a certain threshold. Planners should immediately respond to these alert levels by removing supply bottlenecks. These supply bottlenecks might include obsolete regulations but also insufficient investments in roads and transport infrastructure.