WORKSHOP ON

"URBANIZATION, SUSTAINABILITY AND PROSPERITY"

SCHOOL OF SUSTAINABILITY,
ARIZONA STATE UNIVERSITY,

APRIL 17 – 19, 2013

REPORT

COMPILED BY
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Contents
1. Executive summary
2. Background
3. Summary of the main themes of the workshop
Annex 1: Instructions for participants
Annex 2: Agenda and list of participants
Annex 3: Responses to pre-workshop questions
Annex 4: Challenges to be tackled
Annex 5: Powerpoints (distributed separately)

1. Executive Summary of the discussions

1. The effects on "planetary boundaries" of the ongoing (and seemingly inexorable) process of urbanization unfolding in Asia and, Africa and Latin America needs to be urgently studied. The challenge of sustainability, as many other challenges facing humanity, is inherently an urban challenge. [Whether such understanding would have an effect on policy is an entirely different issue.]

2. Of particular urgency is to understand the energetics of urbanization and urban life ("urban metabolism").

3. Humanity's urbanization process may soon (end of the century) come to an end --- Why? What will the implications of this be for the processes of invention, innovation and economic growth?

4. There was general agreement that a "theory of cities" (or "theory of agglomeration") --- understood as a formal treatment of what are processes common to cities and urban life over the past 10,000 years or so --- would be useful, and there are enough tantalizing hints and incipient efforts to suggest that it is possible. But the proof will be in the flan.

5. What is sustainable urban prosperity? This question was largely ignored, a casualty of the difficulty of specifying what "sustainability" and "prosperity" are (but see below in the report on pre-workshop contributions).

6. Multi-disciplinarity was celebrated but the difficulties in carrying out multidisciplinary work were illustrated by the transaction costs of trying to understand each other and unpack our various methodological and epistemological stances.

7. Engagement with policy-making: Do we have something to say to policy-makers? How central to our research concerns should policy-matters be? Is building a "science of cities" use-centered research? A variety of strongly held and divergent opinions were voiced on this topic.

8. Going Global & Data challenges: We all want to go global (meaning take our metrics and models outside the geographic confinement of North American and Western Europe) and we all want to capture the interactions among cities. But how? There are severe data limitations at play here, as well as spatial definition issues: what are the equivalent of MSAs for India (for example). --- And while there are intense efforts going on at building adequate proxy measures for urban extension and urban life (such as the use of night time lights data) or the use of cell phone data to reveal networks of information flow linking urban dwellers across the globe ---data constraints on model and theory building are severe.

9. What next? Participants expressed an interest in staying in touch and continuing the conversation -- which needs to get more precise. Did a research agenda emerge? Will new research collaborations emerge for the workshop? Time will tell. Participants are engaged in ongoing efforts -- for these to merge or be combined into new ones will require effort and resources.

2. Background

This workshop was organized against a backdrop of rapidly growing renewed interest in the theme of urbanization, which was characterized by Simon in the 1980's as "the major challenge for [organization] sciences in the 20th century". To be clear, that does not in any way reduce the importance of the huge amount of work that has already been done on this theme, both in Europe and in North America, in part by participants in this workshop (Batty, Pumain, etc.).

But this work is now reaching a different stage, in part due to the application of complex systems theory to this domain as a result of the work first initiated in the ISCOM project (funded by the ICT directorate of the EU, and led by Lane, van der Leeuw, Pumain and West as PI's), which seems to be pointing to the possibility that the community may actually be reaching a mature stage in which a theory of urbanization is achievable.

Clearly, this renewed activity is also driven by the fact that the percentage of the world's population that is living in cities continues to rapidly increase, and that many cities are now so large that a whole new set of challenges arises.

What researchers are currently aiming for, with some hope that this may ultimately be realized, is nothing more or less than a 'science of cities', a conceptual framework about all cities no matter when or where, that is predictable of the properties of urban agglomerations and falsifiable. It would bring predictability about the future of cities, enabling us to provide practical guidance to what makes a "good" city, both in terms of defining "good" but also in terms of understanding the linkages between design and outcomes. That would prepare cities for future developments by determining norms that can be adopted to carry out systemic urbanization (e.g. deciding upon appropriate population densities and urban layout).

Clearly, such an ambitious aim involves (a) that the approach be based on urban data from across the world, and (b) that this huge mass of data (true Big Data) be dealt with by newly developed, sophisticated methods of analysis, representation and modeling that use current computation on a much grander scale, and in many different ways than is currently possible.

This workshop has begun discussions on what the questions might be that need to be answered, how one might begin to design such a theory, and which kinds of data are going to be required to implement this approach.

We have invited for the workshop a number of specialists from a range of different disciplines, including archaeology, geography, complex systems science, ICT, economics and other disciplines, in this case both from Europe and the US.

As is usual at the beginning of such kinds of discussions, these have some time to go before they will reach the stage where a formal plan of action can be launched. But there was remarkable synergy between the participants, who desire to keep this effort going with a number of smaller workshops in different locations, and eventually a second workshop of the same kind as the present one, again to be held at ASU in a year's time or so.

Finally, the organizers would like to express their profound gratitude to the Walton Sustainable Solutions Initiative for its financial and logistical support.

3. Main themes of the workshop

In discussing these themes, we make a distinction between the ones proffered by the participants before the start of the workshop and the ones suggested towards its end (respectively detailed in the 'responses to pre-workshop questions', and in 'challenges to be tackled').

One important goal of the pre-workshop questions was for then organizers to assess the degree of convergence on the definition of certain crucial concepts, and to inventory any related questions and challenges. The concepts were:
- Urbanization
- Resilience (in the context of cities)
- Prosperity
- Sustainability
- Innovations in Energy Technologies
- Science of Cities
- Smart Cities

To also allow space for issues that we did not initially put on this list, we included an 'open' category, which we labeled:
- Any other terms you feel are important to this conversation

The reader can convince herself of the original degree of convergence in the detailed text of the 'responses', which at the request of the participants themselves have been included without their names.

But we have tried to enhance that convergence a bit in order to focus the discussion. Admittedly, that has involved making numerous choices, and the responsibility for these is ours and ours alone. We hope the participants will accept this as part of our role as organizers of the workshop.

Urbanization

Under '*urbanization*', we find an emphasis on population migration to high-density centers, where they find 'a better' more dependable' living by securing and increasing resources through innovation. This process leads to the construction of dense, multi-scalar and overlapping interaction networks made possible by proximity and extended beyond the urban perimeter by transportation and communication networks. It results in the expansion of the urban perimeter and the densification of the urban core, and change across multiple dimensions (political, demographic, infrastructure, land use, economy, etc), which favors inequality. In these places, land use and human activity are not directly related to natural resources or processes, but to the creation, accumulation, trade-off and direct/indirect use of distinct types of capital (physical, human, financial, ecological) from near-by or distant locations.

Urbanization can be characterized in terms of non-equilibrium thermodynamics as expanding dissipative structures that depend on flows of energy and matter into, and information out of them. Because it is self-organized, it progressively generates a common anthropogenic dynamic

in systems of cities whose development become more and more interdependent despite the diversity of historical and ecological contexts of their development. Urbanization therefore works against global sustainability.

Resilience

Resilience (in the context of cities) is the ability of a city to adapt and evolve in response to internal or external disruptive perturbations (whether physical, economic or social) in such a fashion so as to preserve its integrity and maintain and potentially enhance the quality of life and interactivity of its citizens. It can be expressed in terms of the time taken for the city to recover from a shock.

The resilience of cities and urban systems is rooted in their diversity and openness as systems, which enables all three layers of the city (physical, social and economic) to absorb information about the environment outside the city, so as to enable adaptive structural changes in the functional purpose of each layer. In this manner, the urban systems stays 'in tune' with its ecological niche so that the two interactively reinforce each other.

The virtuous circle between social, economic and physical is broken if outside dynamics strain any one of them without leading to adjustments in the others. The inability to acquire and process information may be one of the principal reasons why one or more of the layers loses its functional utility in sustaining urban life.

Once resilience is established the system becomes sustainable if, either voluntarily (thanks to proper political action) or involuntarily (the main vectors defining the three layers happen to be aligned), a protocol is established where the constant information from the outside is disseminated properly across the components in each layer, and reaction to the new information is reassembled leading to change at macroscopic level.

Sustainability may be then understood as the repeated exercise of uncovering the system requirements leading to resilience.

Prosperity

Prosperity is the ability and encouragement to pursue one's vocations and interests within an urban society. Cities are points of maximum concentration for the power and culture of a community. They control, accumulate and direct the excess (economic, but also cultural and social) capital of their (global) hinterlands. In the urban context, prosperity implies success in terms of balanced social, economic and environmental wellbeing of its inhabitants, including the satisfaction of physiological needs, attaining a level of assured safety and security, and "higher" levels of belonging/love, self-esteem, and self-actualization/creativity. Hence, prosperous cities have been centers of art, culture, and spirituality, technological innovation and ramifying productivity, as well as exemplars of social organization in varying forms.

Prosperity is a relative concept. Temporally, it implies hope or belief in progress along valued dimensions such as happiness, wellbeing, utility, etc. But it is also socially relative. Individuals' sense of prosperity only truly increases when it does so relative to others. This sets up a perpetual conflict between individual and social prosperity, which nowhere is more

visible than in the confines of a densely urbanized matrix. Markers of community or neighborhood prosperity include collective action, freedom from negative social forces such as poverty and crime, and resilience to shocks.

At the systemic level, urban prosperity implies that the social processes are in harmony with the physical and built environments because information effectively circulates among all three layers of the urban fabric.

Sustainability

Sustainability (in the context of economic and social development, urbanization and city life) is a most challenging term to understand adequately. In very different ways, both the second law of thermodynamics and history teach us that there is no such thing as absolute sustainability. Sustainability is therefore a relative term that invokes the human capacity to [temporarily] 'beat' the second law of thermodynamics by increasing organization and information flow and reducing entropy. Hence the conception of urban systems as dissipative flow structures.

One definition of sustainability we like is "Living our [collective] lives as if we expect to be there for the long term". Urban sustainability is then defined as the longevity of settlements and groups. Generically, this implies maintaining, and potentially enhancing, the prosperity and resilience of cities according to ways of life we value. In practice, this involves the capacity to absorb and transform arrivals into more prosperous versions of themselves isn't degraded over time by either environmental or socio- economic factors. This can only be attained [however temporarily] in an integrated, continuously adapting systemic framework where the city is recognized as a landscape of which the infrastructural and network constructs facilitate interaction leading to innovation.

Sustainability thus implies designing for change that is able to accommodate a complex pathway between the three almost always contradictory or even conflictual objectives of economic growth, social justice and environmental quality. The normative element requires answering the four questions of sustainability:

- Sustain what?
- For whom?
- For how long?
- At what cost?

The question about costs acknowledges that not all values can be maintained. Tradeoffs are required, and some values must be prioritized over others. Achieving sustainability seems in part, to depend on a process of convergence of human understanding that will create solutions to problems that threaten the life support systems of the planet and promote human prosperity.

(Renewable) Energy

Energy [flow] is foundational to the survival of human individuals and societies, and has been a constraint on urbanization for as long as cities exist. The rapid explosion of urbanization that we observe since the industrial revolution is due to the fact that introduction of fossil energy lifted that constraint. As we become aware that fossil energy is not limitless, and produces greenhouse

gases and other kinds of waste, the search for (a) reduction in energy consumption and (b) potential new sources of energy is becoming of major concern.

Jevons' Paradox suggests that efforts to reduce energy consumption through efficiency are bound to fail, or at least backfire because the rebound effects are greater than the savings. (At least that was the case with coal, and it may be the case with shale natural gas.) Moreover, they are likely to increase complexity and associated costs. It is essential to develop clean, infinitely renewable sources of energy. This implies rethinking the way we do things, including (but not limited to) implementing solar, wind, and algae (or other single-cellular "factories") as sources of energy.

A science of cities?

A core issue for the workshop was the question: "*Can we develop a science of cities*?" A conceptual framework about all cities no matter when or where, that is predictable of the properties of urban agglomerations and falsifiable. It would bring predictability about the future of cities, enabling us to provide practical guidance to what makes a "good" city, both in terms of defining "good" but also in terms of understanding the linkages between design and outcomes. That would prepare cities for future developments by determining norms that can be adopted to carry out systemic urbanization (e.g. deciding upon appropriate population densities and urban layout).

Cities are the ultimate complex adaptive social system, in which evolution takes place at every scale imaginable at a pace that accelerates non-linearly with a city's size. There is no domain of reductionist science that cannot look to cities for interesting questions. However, the challenge is twofold: cities need to be studied from a holistic perspective as singular living, evolving, and adapting entities. A science of cities requires a shift to the principles and methods of complexity science.

A critical feature would the integration of this paradigm, inspired by the mathematical, physical and biological sciences, with the wealth of traditional, sometimes more qualitative and phenomenological, ideas and concepts that have been successfully developed in the social sciences including geography, urban planning, economics, sociology, etc., to investigate the major dimensions of cities and urbanization. These dimensions include size, urban form, social life, and urban functions.

That would provide us with a body of language that allows different people with different methods to communicate unambiguously about the phenomena that occur in cities, and to test and put into question the explanations about the "hows" and "whys" of such phenomena. It should enable us to document the variability in cities across space and time, including rich studies of interactions, values, and their embodiment in the urban fabric, and to explain that variation using causal mechanisms anchored in both the features of cities and contextual or structural variables. If there is to be such a science of cities it may be through the use of network theory and the collection of real-time location and activity data through smart phones and other hand-held devices to construct real-time maps of social networks moving through urban space.

Such a "Grand Unified Theory of Sustainability" (with cities and urbanization at its core) would integrate the multiple challenges we face across the entire spectrum from global warming and the environment to questions about populations growth, energy and resource considerations.

Smart cities

This concept has recently undergone a fundamental bifurcation, which prompts us to distinguish two of its senses.

First of all, smart cities are a term that is used to denote cities that excel not only in the organization of their physical infrastructure but also in terms of attracting the creative resources to build a competitive advantage. To sustain the infrastructure, one needs the pool of creative resources, which can build upon the infrastructure to bring about positive social and environmental impact as well as economic prosperity. This may mean cities where the 'science of cities', as mentioned above, is optimized in terms of movements and quality of materials and energy. But a smart city also has diversity in technology and scale, to maintain a certain amount of robustness and resilience over time. In this sense, smart cities have always existed, even though their relative 'smartness' in the urban system has fluctuated through time. At 'smart' times, they outcompete other cities in a Darwinian struggle for survival, at other times they are the most resilient cities in their system.

But the term is also used to characterize greater cities that use automation of technology and information processing to make better decisions than people can presumably make alone, and thus improve the running urban services. Some, particularly [but not only] in the business community see this development [positively] for developing and testing an incipient Science of Cities (and sustainability) as well as for its obvious enabling impact on monitoring and mitigating urban problems and making decisions regarding development, policy and growth.

But there are reservations among the majority (but not all) in the group about this concept of 'smart cities'. Technology and innovation are developed and implemented to support socially constructed values and priorities. In order to have smart cities we need smart citizens. More data and information" does not equate to 'smart'. 'Big Data' without 'Big Theory' (a "unifying" integrated conceptual "scientific" framework which recognizes cities as complex adaptive systems) may well create even greater problems and unintended consequences. Moreover, there are serious privacy/control/etc. issues with the way many people speak of this (massive anonymous data collection, monitoring, etc.).

Hence, the following statement may serve for the moment as a concluding one on this topic. "The complex urban systems including people, businesses and services, environment, as well as governance, provide efficient conditions for innovative digital information and communication technologies to monitor their interaction, not only adequately responding to the requirements of the system components, but preferably outstripping them in becoming a source of development and innovation for each of the parts. Sustainability and resilience as well as creating the synergetic effect of the interaction between parts of the system are the necessary conditions for the smart city system. On the other hand the smart city system concept also implies the requirement for the active system components [...people ...] to be aware of the whole system's objectives, sharing them and maintaining the activity with respect to those objectives."

Any other terms you feel are important to this conversation

As the responses under this category are both much more complex, and reflect the opinions of individual participants, we have not here tried to summarize those. They have been included 'as is' for the reader to consult.

Challenges raised during the workshop

It seems that, apart from the presentations (see the relevant chapter), one useful way to measure the impact of the workshop is to summarize some of the questions raised by the participants at the end of the second day (these are noted in full below). For the sake of easy reading, we have again grouped these into a few categories, well aware that there are major overlaps:

Evolutionary change mechanisms
- How similar or different are pre-modern and contemporary cities?
    - Are the empirical patterns the same, and/or do the same theories/concepts apply?
    - Are there common dynamics but specific path-dependent trajectories leading to different designs?
    - Why do cities emerge in the way we observe them to (in terms of different parameters like size, population, etc.)?
- How do cities gain advantages?
    - What would drive emergence or attraction of specific/certain sectors/industries within a city?
    - What is the role of 'name' or 'branding'?
    - What is the role of migration as a factor in city growth?
    - Can we design integrated urban mobility solutions for dense cities?
- How do networks of cities evolve?
    - Why do they look the way they do?
    - What feedbacks exist between a city and its position/connectedness in a larger network?
    - What fundamental commonalities exist between networks of systems of cities and networks/systems of other "organic" entities?

Macroeconomics of cities and their performance evaluation
- How do economic, social, and political processes factor into a "science of cities"?
- Can the "macro performance" of an urban region be usefully predicted as the emergent outcome of the actions of individual agents?
- What is the impact of the configuration of the built environment (density, segregation of uses, topographical factors, etc.) on urban productivity?
    - Are informal housing markets inevitable in rapidly growing cities?
    - How does this relate to socio-economic variables (including "creative class" factors)?
- Which policies would build an ecosystem for growth and prosperity within cities?
- How to convince politicians that regulating financial activity is a condition for improving the quality of urban dynamics?

Science of cities and networks
- How to develop a "Grand Unified Theory of Sustainability" with cities and urbanization at its core that integrate the entire spectrum of dialogue we face from global climate change and the environment to population growth, energy, resources, etc.

- o How to develop a conceptual framework for understanding the integration of information network dynamics and organization (the "genomics" of cities) with energetic resource infrastructural or network dynamics (the "metabolics" of cities) in a unified, quantitative, materialistic theoretical framework?
  - o Can we determine the coarse-grained parameters and dynamics that determine and can be determined in a way to address the plethora of issues?
  - o What are the "distinct laws" of social, ecological, and infrastructural systems in urban settings.
  - o How do we conceptually integrate each of the systems?
  - o Such a theory should consistently link urban to global, intra urban to interurban, a city system to the system of cities.
  - o How do you operationalize the new science of cities for sustainability policy?
  - o How can plans for new cities be informed by novel conceptualizations that emerge from this community?
- How do you best model the connections of urban areas to distal places (and in particular land use/cover changes)?
- Do these connections pose a challenge to a view of new science of cities that centers on the identification of 'scaling' or 'power' laws?
- How to construct the global multi-layer network of cities with respect to different kinds of interaction between them? (data availability?)
  - o How do we connect the various networks that model a city?

Sustainability and resilience
- Are there studies that try to integrate models of cognition together with dynamics of the city?
  - o How about models of social change vs. city change?
- To what kinds/sizes of hazards are cities and networks of cities naturally resilient, and to what kinds/sizes are they vulnerable?
- How to balance the degree of urbanization of cities with population growth to attain optimal resilience?
  - o How to balance urbanization in India with making lives better for urban population

Understanding the context
- How do we define our objects of interest?
  - o We need clear rules for how to define cities for different purposes, and we need agreement about these.
  - o How to define the city borders based on human activity?
- Would our analyses or conclusions change if cities were seen as a dependent variable situated within contexts, rather than as independent variables?

Urban metabolism
- What drives the growth of urban areas?
- How/where do urban areas and cities get their resources?
  - o What is their global or regional reach?
- How and to what extent can one influence on the urban metabolism in order to be more sustainable?

Urbanization metrics and distributions

- What are the statistical distributions of urban metrics across cities of the same population size or conditional in other metric?
    - And how about for each city across time?
- How does global energy use relate to urbanization pre-1965?
- What is the relationship between Zipf's laws and a general theory of socioeconomic growth (at a national level)?
    - Why are primate cities typically exceptions to Zipf's law?
- What are the statistics of urban qualities inside cities and how do explain them?
- Which parameters of the cities affect human activity of different kind within them and how?
- What influence does the number (or diversity) of services provided by a city have on the population/development of a city over time?
    - And does this correlate with prosperity or resilience of the urbanized environment?
- Are there cities that differ from the norm in interesting ways?
    - Cities that recurrently find themselves in the tails of distributions, positive or negative?
    - What cities?
    - Why?
    - Can we address a set of hedonic characteristics or a set of network characteristics elucidating such outliers?

Annex 1: Instructions to participants

TO: **Participants of "Urbanization, Sustainability and Prosperity"**
                   Workshop, School of Sustainability, Arizona State University,
                   April 17 – 19, 2013

FROM: **Sander van der Leeuw, Kevin Stolarick, José Lobo**

RE: **Preparation for workshop**

Date: **2/17/2013**

Thank you for agreeing to participate in the upcoming workshop "Urbanization, Sustainability and Prosperity." To help ensure that our time together is as productive as possible I would like to set the thematic context for the workshop and solicit your opinions ahead of time so as to start seeding our discussions.

As pointed out by our colleagues at NYU's "Urbanization project", humans are engaged in an urbanization project begun about 10,000 years ago and which most likely will conclude sometime around the year 2100 by which time most of humanity will reside in urban areas. The global challenges of economic, ameliorating poverty, sustainability generating prosperity, adapting to climate change, developing new energy technologies, minimizing he human impact on the natural environment (and many others) are all intimately and intricately linked to cities. All of these processes, as well as urbanization itself, have been the subject of much research effort.

We are not seeking to revisit, redo, or undo this body of work, nor are we looking to forge a grand synthesis (at least not yet). What we are looking to do is to start building a research framework that would allow us to understand how to effectively promote the development of resilient, sustainable, prosperous cities/urban areas. (Maybe the list of what can and should be done is rather large or maybe it might turn out to be rather small.) Our starting premise is that urbanization is unfolding, and wealth is being concomitantly created; but it might not be occurring in a way that "sustainable" and "resilient." What these two buzzwords actually refer to in the context of urbanization should occupy much of our energies during the workshop.

The workshop will not be about presentations and reactions—it will be about jointly building shared vocabulary, metrics and models; we should not be afraid of disagreements. We will ask some people to present but those presentations will be geared toward generating discussion. The workshop will be a working meeting, with most of the time spent on free-flowing but rigorous discussions (in plenary session and in small groups) informed by multidisciplinary perspectives, centered on what we don't know, focused on the empirical and theoretical challenges confronting us as we seek to understand "sustainable urban prosperity", and with the intention of forging ongoing research collaborations.

One week before the workshop begins, we invite each participant to send (to José and Kevin) a one to three page document addressing the following questions (those who don't send this in will not get sustainably-grown organic coffee and horribly unhealthy donuts).

- Define the following concepts, based on your own research, the research of others, your own opinion (or whatever source of inspiration moves you):

    o Urbanization
    o Resilience (in the context of cities)
    o Prosperity
    o Sustainability (in the context of economic development, urbanization and city life)
    o Innovation in energy technologies
    o Science of cities
    o Smart cities
    o Any other terms you feel are important to this conversation

- Describe in text, equation(s), charts, or graphs the relationships among the items defined above.

In addressing these questions we ask you to please focus on your understanding and approach to these concepts. Do not worry about defining them in a way that others will necessarily agree with. In fact, we encourage you to "poke the hornets' nest" and develop models and definitions that will challenge both your tacit and explicit assumptions and those of the other workshop participants. (We will not share your submission with your name attached but we will share your submission as an anonymous document.)

We hope that the discussions at the workshop will be so vigorous and stimulating that we feel the need to produce a written summary, either as a white paper or as a formal co-authored publication.

Yours

Sander van der Leeuw
Kevin Stolarick
Jose Lobo

Annex 2: Agenda and list of participants

Urbanization, Sustainability, Resilience, and Prosperity: Towards a New Global Research Agenda

School of Sustainability, Arizona State University (ASU), Tempe, Arizona, USA

April 17 – April 19, 2013

Sponsored by the Rob and Melani Walton Sustainability Solutions Initiatives

Schedule:

Tuesday (April 16) 7pm dinner/reception

Wednesday (April 17) 9am-5:30pm; dinner at 7pm

Thursday (April 18) 9am-5:30pm; dinner at 7pm

Friday (April 19) 9am-2pm

Light breakfast and lunch will be provided each of the three days. Meetings and break-out sessions, as well as lunch, will take place at the School of Sustainability (4th floor, Wrigley Hall). Participants will be able to access wireless service. For those staying at the Courtyard Hotel, the School of Sustainability is an approximately 15 minutes long (pleasant) walk.

Detailed Agenda

Some participants will give brief (20 minutes maximum, ruthlessly enforced) presentations meant to seed the discussions: summarize what is known, emphasize outstanding questions, identify methodological and empirical challenges. The agenda lists themes and suggested presenters. Other participants will be asked to act as "Discussion leaders" whose role will be crucial in igniting discussion (the assignment of discussants is still not finalized). Roles (and responsibilities!) for presenters, discussants, integrators and group leaders are described below.

Tuesday April 16, 2013

Location: University Club
425 East University Dr
Tempe, AZ 85281 *map*

7:00 pm   Dinner/Reception

Wednesday April 17, 2013

Location: Wrigley Hall, Room 481
800 S Cady Mall, Tempe, AZ 85281 Map
Break Out Rooms: Wrigley Hall, Room 370 & 418

8:30 am   Breakfast, coffee

9:00 am   Welcomes; Introductions
                Sander van der Leeuw, Dean, School of Sustainability
                Patti Reiter, Director, Sustainability Solutions Initiative

9:30 am   Sustainability, *Sander van der Leeuw*
                Urban Prosperity, *Kevin Stolarick*

10:30 am   Discussion and break, Discussion Leader: *Deborah Strumsky*

12:00 pm   Lunch

1:00 pm   Summary Results of Solicited Discussion Inputs, *Kevin Stolarick*
                    Formation of Discussion Groups and Assignments

1:45 pm   Group work (imbedded break during this time as needed)
                    Group Topics and Leaders to be determined

4:00 pm   Group presentations

5:30 pm   Break

7:00   Dinner
                Location: Café Boa
                398 S Mill Ave., Tempe, AZ 85281

Thursday, April 18, 2013

Location: Wrigley Hall, Room 481
Break Out Rooms: Wrigley Hall, Room 418 & 470

8:30 am   Breakfast, Coffee

9:00 am   Urban Metabolism, *Chris Kennedy*
                Global City Hierarchies, *Michael Batty*

10:00 am   Discussion and break, Discussion Leader: *Denise Pumain*

11:30 am	Integration: Sustainability, Prosperity, Metabolism, Hierarchies, *Geoffrey Cape*
12:30 pm	Lunch
1:30 pm	Urbanization in India and China, *Karen Seto* Urban Scaling, *Luis Bettencourt*
2:30 pm	Discussion and break, Discussion Leader: *Amit Kapoor*
4:00 pm	Integration: Sustainability, Prosperity, Metabolism, Hierarchies, Urbanization, Energy, *Eric Miller*
5:30 pm	Work time/break
7:00 pm	Dinner Location: Casey Moore 850 S Ash Ave, Tempe, AZ 85281

Friday, April 19, 2013

Location: Wrigley Hall, Room 481
Break Out Rooms: Wrigley Hall, Room 418 & 470

8:30 am	Breakfast, Coffee
9:00 am	Energy and Sustainability, *Joe Tainter* Studying the "Real Time City", *Stanislav Sobolevsky*
10:00 am	Discussion and break, *Brandon Fuller*
11:30 am	Empirical Challenges, *José Lobo*
12:00 pm	Summary and Integration: Sustainability, Prosperity, Metabolism, Hierarchies, Urbanization, Energy, Scaling, Innovation, Modeling *Carlo Jaeger & Mike Smith* Working Lunch (12:00)

1:30-2:30 pm Next Steps, *Kevin Stolarick & José Lobo*

Confirmed Participants

1.	Filippo	Addarii	Euclid Network
2.	Michael	Batty	Centre for Advanced Spatial Analysis, University College London
3.	Luis	Bettencourt	SFI

4. Geoffrey	Cape	Evergreen Foundation
5. Mihnea	Costantinescu	Schack Institute of Real Estate, NYU
6. Fonz	Dekkers	GSSC site manager
7. Melanie	Fasche	Martin Prosperity Institute, University of Toronto
8. Michail	Fragkias	Boise State
9. Brandon	Fuller	Urbanization Project, Stern School of Business, NYU
10. Sandeep	Goyal	Martin Prosperity Institute, University of Toronto
11. Carlo	Jaeger	ASU
12. Amit	Kapoor	Institute for Competitiveness India; Prosperity Institute of India
13. Chris	Kennedy	Department of Civil Engineering, University of Toronto
14. Greg	Lindsay	http://www.greglindsay.org/about/
15. Eric	Miller	Department of Civil Engineering, University of Toronto
16. Denise	Pumain	University Paris I Panthéon-Sorbonne
17. Karen	Seto	School of Forestry & Environmental Studies, Yale University
18. Stanislav	Sobolevsky	Senseable City Lab, MIT
19. Kevin	Stolarick	Martin Prosperity Institute, University of Toronto
20. Deborah	Strumsky	Department of Geography & Earth Sciences, UNC-Charlotte
21. Joseph	Tainter	Utah State University
22. Temis	Taylor	Utah State University
23. Geoffrey	West	SFI
24. Hugh	Kelly	Schack Institute of Real Estate, NYU

ASU Participants

25. Brad	Allenby
26. Chuck	Redman
27. Ben	Ruddell
28. Michael	Smith
29. Patricia	Reiter
30. Mikhail	Chester
31. Andres	Gomez-Lievano
32. Jose	Lobo
33. Sander	van der Leeuw

Roles/Responsibilities

"Presenter" – 20 minute presentation; focused on specified topic; **NOT** a presentation of a paper, rather a presentation of the "state of the art" of research on that topic; what do we really know? what don't we know; what are the points of contention?; what are the open questions?

"Discussion Leader" – 20 minutes of summarizing, dialoging with and questioning the two presenters; then, lead a one-hour discussion across the whole group on the two presented (and other related) topics. Each discussion leader should include a ½ hour break.

"Group Leader" – work with and coordinate your group on the assigned topic. Each group will have 2:15 to build a 15 minute presentation to be given to the rest of the group. The group leader does not have to present. The group leader should keep the group focused on the assigned topic and work to ensure involvement of all participants.

"Integration Leader" – lead a discussion across the whole group that integrates the information and ideas presented and discussed so far. This does not have to be limited to the presentations but can include informal discussions and other information. This is not to be a formal presentation of any kind, rather it should be focused on integrating information and ideas toward the creation of a new global research agenda focused on urbanization, sustainability, resilience, and prosperity.

"Overall Integration" – Summarize and integrate all of the information and ideas presented and discussed, both formally and informally, during the entire workshop.

Annex 3: Compilation of Pre-work Submissions

Kevin Stolarick (University of Toronto)

Contents

1. Urbanization
2. Resilience (in the context of cities)
3. Prosperity
4. Sustainability
5. Innovations in Energy Technologies
6. Science of Cities
7. Smart Cities
8. Other Terms
9. Integrated Responses

1. Urbanization

Response 1
1. Shifting of people from rural regions to urban regions for better income, infrastructure and life-style
2. Shift in focus and attention of the people from farming to other occupations, which are more predictable, have better earnings and lack seasonality
3. Industrialization and Urbanization are inter-connected as is evident from past and present
4. Y2050 - 65% of developing economies and 85% of developed economies will get urbanized. A big contrast from today taking the example of India, where 70% of the people still live in rural areas, so called non-urbanized regions and lack access to formal market ecosystem for their basic needs.
5. Debatable point here is that whether urbanization should be seen as expansion of the boundaries of cities and concentration of the people in these cities or should be looked at from the perspective of expanding the infrastructure access and reach in smaller cities and towns and villages to balance the load on big cities in the name of urbanization.

Response 2
Urbanization refers to a tendency over human history to settle in relatively dense clusters. This is now the majority situation for humankind. Cities are made possible by economic specialization, and are self-reinforcing in promoting that specialization. A historical pattern has been established whereby trade with local hinterlands and with other cities is a defining feature of urbanization. That pattern has intensified in recent decades. "Urbanization" is a term that admits of degrees: cities can be more or less specialized; can vary considerably in density and size; can develop differing patterns of land use; can develop various degrees of complexity in their socio-economic networks (both within the city, and in relation to other cities); and may admit of a taxonomy in which the genus, "*urbs*," may encompass distinguishable species (i.e., there may be differences in kind, as well as in degree).

Response 3
Urbanization – the ongoing dynamics of the human propensity to gravitate towards high population centres. Accompanying this gravitation are all the ancillary phenomena we typically ascribe to urbanization, non-linear acceleration of dynamics, tightening of linkages, rapid evolution, and generation of culture, ideas, disease, crime which is exported to non- urbanized areas.

Response 4
Urbanization refers to the number of people living in cities and towns.

Response 5
The growth of cities (primarily in terms of population). Usually this growth is taken in relative terms so that looking at a nation we see a larger percentage of people living in larger cities.

Response 6
Ten thousand years ago, humans started reorganizing their social and physical worlds; we began what Shlomo Angel calls the urbanization project (Angel, 2012). Like any project, it reflects human intention. Building dense settlements was something that we decided to do. Like any project, it also has a beginning and an end. An almost incomprehensible amount of work remains to be done. Nevertheless, the end is near. Urbanization deserves urgent attention from policymakers, academics, entrepreneurs, and social reformers of all stripes. Nothing else that humans do will create so many opportunities for social and economic progress. Though it is hard to comprehend how much work remains, it is even harder to comprehend how quickly this work is now being done. The unique opportunities created by rapid growth in the urban population will soon pass but it takes some explicit calculations to appreciate the urgency.

A casual look at human history would seem to suggest that we have lots of time. The urbanization project got started after the transition some 11,000 years ago from the Pleistocene to the milder and more stable Holocene interglacial (Richerson, Boyd, Bettinger,

2001). As the climate began to favour sedentary agriculture, humans started building urban settlements. It then took until 2010 to reach a 50% share for the world's urban population and a total urban population of 3.5 billion.

Looking forward, the worldwide population is likely to stabilize at more than 10 billion. The limiting value of the urban population may exceed 8.5 billion. If it took 100 centuries to get to 3.5 billion urban residents, isn't it safe to assume that it will take us many centuries to make room for another 5 billion? Actually no. The total urban population is increasing at a rate of roughly 60 million new city dwellers per year, and is soon likely to increase to 70 million per year. Even if we allow for an inevitable deceleration in the influx as the urban population approaches its limiting value, a reasonable estimate suggests that we could add 5 billion new urban residents in a single century.

It is not just the incredible growth implied by these numbers that challenges the imagination, but also the rapid deceleration that follows soon after. In our lifetimes, we will build urban accommodation at a faster pace than ever before. We will also have to prepare for a foreseeable future in which the urban population has stabilized and we have many fewer options for spurring progress.

The urbanization project is already close to completion in the rich countries of the world. The remaining urban growth will play out almost entirely in the countries of the developing world. In 2010, the urban population in these countries stood at 2.5 billion. In 100 years, its urban population could be nearly three times larger. Moreover, as Angel shows, the historical pattern of urban growth suggests that urban density in the existing cities of the developing world could easily fall to half its current value.

Response 7
The spatial aggregation of people, activities, and authority (power).

Response 8
The analogy to urban systems should be relatively straightforward to consider. One of the dimensions of sustainability where this convergence of knowledge is important is the formation and growth of cities. Urban areas have been and are likely to continue to be the dominant settlement pattern globally. *Urbanization, in my view, is the process of creation, accumulation, (appropriation?), trade-off and direct/indirect use of distinct types of capital (physical, human, financial, ecological) existing in near-by or distal locations; the urbanization process has to originate in populations concentrating in specific geographical areas (at various degrees of density) but can includes the effects that populations have in far- away places.* We expect about 3 billion people to be distributed primarily on 1-2 square kilometres of urban land that, given existing trends, will be materialize primarily in the developing world. The results of the new trans-disciplinary science and practice on sustainability will play out to a large extent in urban areas.

Response 9
The process of increasing growth (i.e., density, area) and change in places people live where land use and human activity is not directly related to natural resources or processes.

Response 10
Urbanization is the process by which the effective contiguously interconnected physical infrastructural and collective social network interactions that define and epitomize a city increase in both time and place. (Any definition of Urbanization surely requires an operational definition of "city").

Response 11
The spatial agglomeration of people whose primary activity isn't agriculture or any other form of land cultivation, but exchange — of goods, services, and information. Maybe the most important feature of urbanization is the construction of dense and overlapping social networks made possible by proximity and extended by transportation and communication networks. These networks are largely responsible for the agglomeration benefits and perceived super-linearity of cities.

Response 12
A city is a place, an entity, with administrative boundaries. Urbanization is a process that involves change across multiple dimensions (political, demographic, infrastructure, land use, economy, etc).

Response 13

The challenge is that cities are, or are like, dissipative structures (Schneider & Kay, 1994; Rees, 2012). Time series data shows that global energy use is directly proportional to urban population on the planet (Bristow and Kennedy, 2013). This can be explained on the basis of non-equilibrium thermodynamics (a possible contribution to the **science of cities**). Urbanization (i.e., the process of increasing urban population on the planet) using 20th century technologies, therefore works against global sustainability.

Response 14

It is a material growth process, mostly in terms of area, by which humans change and create an environment in order to turn it suitable to their social life. Thus it is the material construction of buildings, roads, etc. I posit that if cities do not grow in area, we cannot speak of urbanization. Increase in density as a result only of population growth, deserves a different word.

Response 15

Increasing the fraction of human activity taking place in the areas of dense human agglomerations within artificially transformed environment. At the same time the level of environmental transformation is also being increased (from nearly natural environment to the more and more artificial urban space) responding the accommodation and logistic requirements of denser human and business agglomerations. Which in turn causes the qualitative transformation of human life spent within the transformed environment? As one of the consequences – social interactions and literally all types of the individual activity are boosted up.

Response 16

The high end of a continuum of settlement density, settlement size, economic differentiation and interaction, and complexity of administration.

Response 17

The increase of living *and* working in a man-made area. Urbanization is therefore the process of concentrating human activities in places without (physical) interaction with the local ecosystems. Nature is not the driving force of the existence of urbanized areas.

Response 18

A process (and what it produces) of collective intelligence aiming at securing and increasing resources through innovation by developing multi-scale networks of broader and broader scope for inhabiting the Earth. Although (or because!) self-organized it generates progressively a common dynamics in systems of cities whose development become more and more interdependent despite the diversity of historical and ecological contexts of their development. Until now this process generates more and more spatial concentration of population and resources and while raising the general level of prosperity and tending to unify living conditions all over the world it also creates large inequalities among and inside societies. One difficult question that is of interest for me: to what extent are the inequalities necessary for the pervasiveness of the urbanization process? Would simply differences just do the same?

2. Resilience (in the context of cities)

Response 1
1. Ability to withstand the future shocks and unforeseen circumstances / disturbances.
2. Planning, Systems and Processes to withstand the inequities and variations, which can potentially affect the balance of the city.
3. Eliminate or Minimize

> 3.1 Social Inequities pertaining to gender bias
> 3.2. Economic Inequities pertaining to income gap and divide between rich and poor
> 3.3. Environmental Issues like earthquakes, global warming, dependency on fossil fuels, pollution etc.

4. Develop capacity and systemic plan (global level, country level, city level) to identify the potential challenges (internal / external) and create plan to target those challenges in a systemic manner.

Response 2
Resilience (in the context of cities) may be considered the ability to absorb and recover from threats to the wellbeing of a place, whether that threat is endogenously derived or posed by an exogenous shock. On a biological analogy, cities may display more or less well-developed "immune systems" for maintaining healthy functioning, and for coping with traumatic threats.

Response 3
I view resilience as a descriptive term for the ability of a city or neighbourhood to withstand an external shock (social or natural) by surviving or changing in a positive direction. Reliable scientific knowledge about urban resilience is very thin. Much of "resilience theory" seems to consist of untested assertions claiming the "resilience" of positive social values. Empirical patterns of resilience can be usefully studied in a "natural experiment" framework, as in urban disaster research

Response 4
The ability to weather shocks without sustaining much damage; this usually translates into preparedness against short term shocks which vary from city to city (often security and energy are the worst vulnerabilities), and it translates into economic diversity and growth to respond to macro and long term shocks. Also, connectedness of cities can either improve or damage resilience.

Response 5
This means to me that an entity can survive a crisis *well* and quickly afterwards regain its full functionality. The problem is that there are many types of crises and many shades of how well one survives them. E.g. I'd say NYC has shown itself to be a very resilient city under 9/11 or Sandy, while Detroit, Pittsburgh or Manchester (UK) were not very resilient to the loss of their main industries. But these are very different events and different expected paths to recovery.

Response 6

The capacity for a city or a system of cities to absorb and recover from (or potentially thrive on) shocks — natural, security, demographic, social, political, economic.

Response 7

The ability of an urban system to accommodate to shocks or stresses and maintain its essential functions and identity. I like to equate resilience in this context with adaptive capacity. The application of this to contemporary cities is confused by the complexity of interactions within urban systems, e.g., cores of cities may degrade, while suburbs flourish, or cities receive subsidies from overarching administrative units (i.e., states, nations) that delay or thwart collapse.

Response 8

The process of continuously adapting, mitigating or recovering in response to change. Not a static condition. This contributes to sustainability and creates complexity. Requires reserve problem solving capacity.

Response 9

I am sympathetic about the fad-ishness of this term, plus the enormous diversity of things against which we might need to be "resilient" (we might make NYC flood-proof, only to have it wiped out by a pandemic). However, it may be a more robust, actionable concept than sustainability. Which is more cost-effective: to "flood-proof" a city or to clean up the mess afterwards (possibly time after time).

Response 10

Resilience (in the context of cities) is the ability of a city to adapt and evolve in response to external (or possibly internal) disruptive perturbations (physical, economic or social) in such a fashion so as to preserve its integrity and maintain and potentially enhance the quality of life and interactivity of its citizens.

Response 11

The much-hailed "immortality" of cities (versus the mortal lifespan of corporations) is most likely rooted in the resiliency of their social networks even in the face of environmental catastrophe (New Orleans), war (Berlin 1945), and even nuclear obliteration (Hiroshima). While many at the workshop should and will discuss resilience in physical terms (should New York City build storm gates post-Hurricane Sandy) real resilience is found in activating these networks in the face of catastrophe — think Occupy Sandy, rather than any gates.

Response 12

System openness is a fundamental requirement for resilience. Resilience is a synonym for sustainability. The ability to withstand shock through modification of the inner processes is one of the defining characteristics of city (see connection to point 1). This ability, when present in all three layers of the city (physical, social and economic) allow the built structure to maintain value and utility even when the favourable conditions which led to its emergence have disappeared. This is possible when information about the environment outside the city is

absorbed by the layers (the system is open and exchanges information with its environment) and leads to structural changes in the functional purpose of each layer. The inability to acquire and process information may be one of the principal reasons why one or more of the layers loses its functional utility in sustaining urban life. The virtuous circle between social, economic and physical is broken if outside dynamics strain any one of them without leading to adjustments in the others. Once resilience is established the system becomes self-sustainable if, either voluntarily (thanks to proper political action) or involuntarily (the main vectors defining the three layers happen to be aligned), a protocol is established where the constant information from the outside is disseminated properly across the components in each layer and reaction to the new information is then reassembled leading to change at macroscopic level. Sustainability may be then understood as the repeated exercise of uncovering the system requirements leading to resilience.

Response 13
I think it's difficult to discuss resilience in the context of cities as a whole. Cities are comprised of distinct communities within them, and it may be more appropriate (or useful) to discuss the resilience of a community or neighbourhood. In India, I took my students to a landfill where they met with the waste pickers who live in and on top of the trash. The community rebuilt their homes one year after their settlement had been razed by a fire. Is this resilience?

Response 14
The resilience of a city can be expressed in terms of the time taken for it to recover from a shock. With respect to climate change, some strategies that reduce greenhouse gas emissions can also increase the resilience of cities (Sugar et al. 2013; Kennedy & Corfee-Morlot, 2012, 2013).

Response 15
The capacity to resist shocks and stay the same and indifference to noise and change.

Response 16
Property of the complex urban systems, assuming the possibility of adequate response (automatically or with minimal intervention into the normal operation) to various social, environmental, economical and technological challenges of urban development meeting the human expectations of the changing life style under conditions of increasing human density, mobility, interactions and other activity.

Response 17
 "The *Shorter Oxford English Dictionary* offers three definitions of resilience, of which number three seems conceptually useful: 'The ability to recover readily from, or resist being affected by, a setback, illness, etc.'"

Response 18
Resilience is the adaptive character of an area. Like an ecosystem, a city should have a diversity of systems. When species get extinct (by natural causes) the ecosystem will be able to replace its niche. In an urban area, the same principle could be applied where buildings

should not be dependent on one technology. Diversity makes it possible to evolve over time and therefore adaptive to change.

Response 19
As urban systems have an open evolution I prefer the idea of adaptive capacity (which of course is not a passive reaction or adjustment but a pro-active process involving decisions of many actors attached to maintaining and amplifying the values (all kinds, in terms of power, wealth, quality of life, symbolic images…) of urban assets.

3. Prosperity

Response 1
1. Condition of being successful in terms of social, economic and environmental well-being of the people, the society, the city, the country and the world. Just like atoms and cells making up the body, prosperity need to be looked across a chain starting from the individuals (living beings) and progressing upwards towards the global boundaries.
2. Countries and cities are termed as prosperous from a limited view of economic growth, overlooking the social and environmental imbalances with-in. Prosperity has to be measured across three dimensions - social, economic and environmental. Just like a 3-legged tripod, a balance is needed across these 3 dimensions to bring prosperity to the individuals leading to prosperity of the cities, countries and globe.

Response 2
Prosperity entails the accumulation of some surplus over and above the level of requirements simply sufficient for survival or subsistence. Abraham Maslow's five-level needs hierarchy (for individuals) may be suggestive: a base of physiological needs must be satisfied, then a level of safety and security assured, before "higher" levels of belonging/love, self-esteem, and self-actualization/creativity can be brought to the fore. Later theorists have sought to place other human needs within the hierarchy, viz., intellectual / cognitive, aesthetic, transcendence/generativity. Prosperity certainly reflects an economic condition, but may not be simply a matter of wealth per se. Peter Hall has stressed that, besides material affluence, prosperous cities have been centres of art, culture, and spirituality, have been centres of technological innovation and ramifying productivity, and have been exemplars of social organization of varying forms. I would add that the breadth of prosperity is also a signal feature: the greater proportion of the inhabitants rising on the "hierarchy", the more prosperous the city.

Response 3
Prosperity is the most difficult of these concepts to tackle. It implies an increase in some objective measure of well-being, happiness, longevity, wealth, etc. Yet a gross oversimplification typically applied to these concepts is that "more is better". In fact behavioural research shows that happiness, well-being, utility, etc. is only truly increases for an individual when it does so relative to others. This sets up a perpetual conflict between individual and social prosperity and nowhere is it more visible that in the confines of a densely urbanized matrix.

26

Response 4

Prosperity is the ability of a group to provide goods and services that enable people to lead a good life. It contains two dimensions: economic and social. At the household level, prosperity corresponds to Amartya Sen's concept of quality of life, which consists of income/wealth (economic) and the capability of individuals to fully exercise their capabilities (social). At higher levels the economic dimension can be summed from the constituent lower units, but the social dimension is more complicated. Markers of community or neighbourhood prosperity include collective action; freedom from negative social forces such as poverty and crime; and resilience to shocks. These same features mark urban prosperity, along with other measures like population growth and economic productivity.

Response 5

This is a normative concept that has something, but not much, to do with money

Response 6

I do like a variation on Amartya Sen's "definition" (of development) here. Prosperity should be seen as individual freedom and the ability and encouragement to pursue one's vocations and interests within an urban society. This defines any forms of exclusion, violence or political barriers as obstacles to development, along with more familiar aspects of economic achievement.

Response 7

Perhaps prosperity is the good fortune to choose among several good options. In the context of a largely urbanized population, an intermediate step might be a world where every family can choose to live in one of several well run cities, each of which is competing to attract them as residents.

Response 8

The word implies to me economic measures of success, but in a sustainability framework we should extend it to other important characteristics (e.g., nutrition, health services, education, cultural identity, etc.)

Response 9

This seems to vary more on what is measured than how it is conceived.) A period of stability where social processes are in harmony with the physical and built environments, wealth is distributed in a way that provides for the well-being of citizens and people are secure from hazards or violence.

Response 10

GDP-based concepts are inherently flawed; and yet this is what drives all current policy. What about justice? Equity? Opportunity/accessibility?

Response 11

Prosperity (as a state of a city) connotes the sense of a flourishing citizenry manifested in multiple inter-related characteristics including its economic, health, "happiness", social, innovative and "spiritual" well-being. (It is often mistakenly identified primarily with economic, financial and infra-structural growth).

Response 12

More than some baseline measure of health, wealth and education (as you can argue endlessly over what the baseline of each should be), prosperity is a trajectory — the hope and belief in progress and material advancement. (Greater Cleveland has a GMP of $100 billion, but would one describe it as "prosperous?")

Response 13

The city is "a point of maximum concentration for the power and culture of a community" (Mumford, 1961). Cities control and direct the excess capital of their (global) hinterlands. Much of the capital accumulates in cities themselves. Cities can achieve different levels of **prosperity** (= a successful, flourishing, or thriving condition, especially in financial respects; dictionary definition). The wealth of cities can be quantified by the value of the assets of their citizens (Kennedy, 2011).
The economic growth of cities is also related to the physical design of cities (Kennedy, 2011): "... it is an increase in autonomous consumption associated with urban form that largely explains the historical growth in per capita GMP

Response 14

The wellness of society and environment would be my first answer. However, since wellness seem to imply stability, which is an illusion (society changes, environments change); I prefer to limit my definition of prosperity to the circumstance in which all human beings can live a life without suffering.

Response 15

In the urban context - providing adequate opportunities for personal and economical growth for the city residents, both – individuals and businesses – in the manner beneficial for the whole system as well.

Response 16

Prosperity is, in my opinion, not solely connected to economy, but a matter of how everyone is capable of pursuing his/her own happiness in the future. This can either mean good health (healthcare, food, water, clean air...), safety, access to education, social well being, etc. This relates to the pyramid of Maslow, which states that the highest need is the one of Self-actualization. In order to achieve this capability of pursuing happiness, money can be a valuable tool though.

Response 17

A positive situation that includes economic wealth, welfare and quality of the citizen's life and environment, excluding too large social inequalities and conflicts.

4. Sustainability
(In the context of economic development, urbanization and city life): what is it? What exactly is being sustained?

Response 1

1. Linked to actions and measures which leads to long term economic growth of cities and nations having a fair distribution of wealth across the value chain of stakeholders involved in value generation activity. The fair access to economic wealth among all the stakeholders involved in value generation is being sustained via fair-distribution.

2. This holds importance to prevent the after-effects of economic and social inequities resulting in creation of slums by migration of people looking to tide over the economic imbalances.

3. Sustainability however can't be limited to economic development because anything action pertaining to economic development has social and environmental implications. For Example: setting up industry will generate jobs (economic impact) but will also lead to environmental pollution.

Response 2

Sustainability is one of the most challenging terms to understand adequately. At some minimal level, it may merely mean the achievement of some equilibrium between resources and consumption, so that we do not "eat our seed corn." Modification of consumption patterns has often been the initial approach toward that putative equilibrium. Expansion of resource availability, however, is critical to taking "sustainability" beyond the tweaking of the status quo in some mildly positive way. Expanded food production, for instance, was the solution to the crisis proposed by Malthus, and the dynamic increase in output during the industrial revolution was the force blunting the fears of the Luddites. In our own generation, public and private investment in the post-World War II period helped "sustain" economic growth first for the millions of GIs returning from the military and then for their children, the "baby boomers." The "resource expansion" strategy, of course, is not without its own limits.

We are now in a period where the late 20th century paradigm is apparently dissolving, and a new challenge of sustainability is before us, one in which the model of "dynamic equilibrium homeostasis" may not suffice for our population and for our urban areas.

Response 3

Sustainability (in the context of economic development, urbanization and city life): what is it? What exactly is being sustained? – well, this is the question isn't it? What is it that people want to sustain? The human race? An aggregate level of wealth or well-being? A per-capita level of well-being? Or is it something less tangible such as accumulated social capital? Cultural identity? Interpersonal networks? At the most basic level, sustainability of a city is simply perpetuation of some entity - a city as a demarcated complex adaptive system.

Response 4

Sustainability is most usefully viewed as longevity—how long does (or can) a city or neighbourhood last? The notion of prosperity is usually bundled into definitions of sustainability (survival while maintaining prosperity), but this just muddies the situation by creating a composite concept with inconsistencies and contradictions. If sustainability is defined as the longevity of settlements and groups, however, then it has to be admitted that scholars today know very little about the topic.

Response 5

The ability of the people of a city to keep doing what they're doing (and maybe or maybe not change the way you are doing it) for many human generations

Response 6
This usually means the continuous and open ended ability to make the lives of individual people more prosperous, but without causing damage to the Earth's natural environment. This is seen as "having your cake and eating it too". However if prosperity is measured in terms that are not purely material it may be possible to achieve. Certainly it will happen first in cities, where life is already the less material, more informational.

Response 7
I like the Steps Centre definition that suggests sustainable development to be related to economic wellbeing, social justice, and environmental integrity.

Response 8
Transdisciplinarity has been identified as a major pillar of sustainability science - the knowledge required to deal with problems such as climate change and biodiversity loss cannot be found neatly organized within the walls of a single scientific discipline. The concept of cross-fertilization of knowledge across distinct disciplines is not limited to the field of sustainability. National scientific organizations – including the American Association for the Advancement of Science – are exploring the concept of convergence – the idea that engineering, physical sciences and life sciences can come together for solutions to problems in health care, energy and other fields. *Sustainability, thus, to me is, in part, a process of convergence of human understanding that will create solutions to problems that threaten the life support systems of the planet and promote human prosperity*.

Response 9
The perpetuation of ways of life we value. These are dependent on the four questions of sustainability (Sustain what? For whom? For how long? At what cost?). The question about costs acknowledges that not all values can be maintained. Tradeoffs are required, and some values must be prioritized over others.

Response 10
I am increasingly worried about much more mundane elements of "sustainability":
Jobs/employment: It is fine to say that the manufacturing jobs are gone and won't return and that information/creativity/etc. is the present and future name of the game. But, as Michael Batty has noted in his editorial, it is unlikely that this will generate enough jobs for all people. We don't "need" many people to produce goods and (increasingly) services. What are people to do?
Urban form/housing prices: A ticking time bomb. No-one is discussing / dealing with this. Politics ("public stupidity", increasing evidence of the rise neo-fascism in many countries (including, arguably the US …). Cf. the Kansas attempt to "outlaw sustainability". Includes increasing bureaucracy, aging of our institutions; can we break the "cycle" in the rise and fall of cities, nations, empires?
Energy: Energy is fundamental to human existence. The rise of civilization ties very directly to the development of improved energy systems (with some caveats). We have always traded

environmental degradation for increased energy. We are, for the first time in history, trying to do something very different: grow & "prosper" in more energy-efficient ways, perhaps even with reductions in absolute energy use. It is far from clear whether this is practically possible (for a variety of technical, social, political reasons). The current very rapidemergence of "fracking" with very, very little debate/concern raises very, very serious concerns about our attitudes towards energy versus environment.

Financial/economic sustainability: – can we "afford" to maintain our current standards, especially given current accepted wisdom concerning markets, regulation, etc. In very different ways, both the 2nd Law of Thermodynamics and history teach us that there is no such thing as absolute sustainability.

Response 11
Generically, this implies maintaining, and potentially enhancing, the Prosperity (and Resilience) of cities in the holistic sense described above. Sustainability needs to be viewed in an integrated, continuously adapting systemic framework where the city is recognised as the landscape whose infrastructural and social constructs facilitate social interaction leading to innovation and buzz.

Response 12
A sustainable city is one in which its capacity to absorb and transform arrivals into more prosperous versions of themselves isn't degraded over time by either environmental or socio-economic factors. A truly sustainable city isn't just one that boasts a zero-carbon footprint, but is also inclusive. (Otherwise, Manhattan's Upper East Side and London's Belgravia are well on their way to being two of the world's most sustainable neighbourhoods — by being districts entirely composed of *pied-a-terres* which are dark every night.)

Response 13
Sustainability is "development without increases in the throughput of materials and energy beyond the biosphere's capacity for regeneration and waste assimilation" (Goodland and Daly, 1996). At the global scale, Rockström et al (2009) discuss nine planetary systems of concern, noting that human impacts of biodiversity loss, climate change, and the nitrogen cycle already exceed planetary capacity. With respect to the carbon cycle, human existence in its current form may be unsustainable in the (very) long run, because, if thermodynamic equilibrium is reached, the atmosphere will be saturated with CO_2. (Kleidon, 2009, 2010) With some innovation in energy technologies and infrastructure (though largely using existing technologies with innovation in policy), it is technically possible, and perhaps economically possible, to construct low carbon cities (Sugar et al., 2013, Kennedy 2011) and to develop a low carbon global infrastructure system (Kennedy & Corfee-Morlot, 2012, 2013).

Response 14
Sustainability: Ways of living so that the probability of having a better life (i.e. without suffering) in the future is never less than it is in the present.

Response 15

Property of the complex urban system organization, assuming the possibility of the crisis free development, sustaining quality of life of the inhabitants, social integration, environmental health, viable business environment and economical growth.

Response 16
"The term 'sustain' comes originally from the Latin *sustinere*, and into English through the Old French *soustenir*. Both terms mean literally 'to hold underneath'—in other words, to uphold or support. The *Shorter Oxford English Dictionary*, sixth edition, lists nine definitions of "sustain." Two of these read "Cause to continue in a certain state; maintain at the proper level or standard" and "Support life in; provide for the life or needs of." The second is consistent with, indeed underpins, biologists' conceptions of sustainability: the maintenance of ecosystems and life-support systems. The first suggests a broader application, consistent with the idea that sustainability goals arise from human values. Both definitions are consistent with the original Latin and French terms: To sustain something is to support its continuation."

Response 17
Doing the right things right. This sounds double, but I think sustainability is not only about doing the right things, but also about doing them in a right way. It would be both intentions and actions. The question arises what are the "right things"?! After years of experience and debating this matter, I think that sustainability could best be seen as a subjective mindset which has different meanings all over the world. What do you think is right?

Response 18
A complex pathway between the three almost always contradictory or even conflictual objectives of economic growth, social justice and environmental quality that requires political intervention.

5. Innovations in Energy Technologies

Response 1
1. Urbanization has close link with adoption and evolution of energy technologies.
2. Urbanization from demographic perspective involves migration of people from villages to towns and cities. From economic perspective, this involves increased access to better income opportunities for the people moving to cities.
3. Now, in developing economies, this also marks the transition from usage of bio-fuels (cooking and lighting) to fossil and renewal energy sources (solar, coal-based, gas etc.).
4. As Industrialization progressed, the energy technologies reflect change / evolution from bio-fuels to fossil fuels (still account for major source of energy) to renewable and clean energy sources (wind energy, solar energy, LED, hydro energy etc.)
5. There is a common realization to replace fossil energy by renewable energy wherever possible in due course of time to ensure a sustainable mode of urbanization.

Response 2
Energy is foundational to human economies, and of the utmost importance; cheap, plentiful, clean, sustainable energy is foundational and must be a primary goal of reforms and research.

Conservation and systems approaches are useful for efficiency, at the margins, but cannot solve the fundamental problem that we need more and more energy.

Response 3
The ability to generate energy (power) with improved performance metrics, such as lower carbon emissions per unit of power produced, lower money costs, greater coverage, etc. But remember, cities were never built to save energy. I don't believe that cities of the future will spend a lot less energy (and if they do it is because of efficiency gains, not loss of functions), but this energy needs to be obtained "sustainably".

Response 4
To me innovations may just imply new or altered ways of doing things. I would rather see the word, innovation, reserved for changes where indirect or cascading implications are evaluated in a normative framework (this would be very contextual, and hence, innovation in some places and times might not be innovations in other places and times). I would tie it to the definition of sustainable development above. My fear is the current and envisioned 'innovations' in energy technologies will reinforce the current socio-economic system of those with wealth and power seeing it increase while the disadvantaged become more disadvantaged.

Response 5
Improvements in obtaining useful work and reducing the losses inherent in extraction, concentration, transitions and use of energy. Increases complexity and associated costs. The laws of thermodynamics apply. Jevon's Paradox applies to improvements in efficiency. Diminishing returns apply to technology and innovation in use, collection and distribution, and for non-renewable resources.

Response 6
Jevons' Paradox suggests efforts to reduce energy consumption through efficiency are bound to fail, or at least backfire when the rebound effects are greater than the savings. (At least that was the case with coal, and it may be the case with shale natural gas.) It's essential to develop clean, infinitely renewable sources of energy, e.g. solar, wind, and hopefully liquid fuels produced by algae (or other single-cellular "factories") fed a diet of waste biomass. It's the only way to have our development cake and eat it, too.

Response 7
Innovation in energy technologies: The development of technologies that relies in solar energy, as the unique source of unlimited energy (in practice).

Response 8
Technological advance in generation, transmission, distribution, storage and/or consumption of energy while optimizing efficiency and maintaining environmental friendliness. This is provided that an advance in any of these two fields - efficiency or environmental friendliness - should not cause the decline on the other side.

Response 9

I think the words 'innovation' and 'sustainability' lost their value because they are used too much. To me, innovations in energy technologies are actually *new concepts* of energy generation or reuse. Rethinking the way we do things. For example if we could generate electricity out of lightning, nuclear fusion or from our own body heat. 'Innovations' in PV technology are usually just more (cost-)-efficient PV cells, meaning cheaper or more efficient versions of the same concept.

6. Science of Cities

Response 1
1. Science refers to any knowledge base having predictable outcome and testable propositions/ hypothesis.
2. Science of cities denotes adding predictability in the future of cities as per urbanization trends. That means inducting proactive philosophy towards preparing the cities for urbanization.
3. Global economies, especially developing ones, have a reactive approach to urbanization. The migration of people to cities is not foreseen and planned properly by corresponding capacity building with respect to infrastructure (transportation, electricity generation, water supply, housing etc.). The result is overload leading to suffocation and scarcity of resources thereby creating socio-economic and environmental imbalances.
4. Science of cities in fact talk about the need to determine norms, which can be adopted by different countries for carrying out systemic urbanization like deciding upon appropriate population density so as to have the optimum network and increased adoption of public transportation etc.

Response 2
Science of cities – in many aspects cites are the ultimate complex adaptive social system, completed with intricately interwove human social and ecological subsystems. Evolution takes place at every scale imaginable in cities and its pace only accelerates non-linearly with a city's size. I can think of no domain of reductionist science that cannot look to cities for interesting questions. However, the challenge for me is in the holistic approach to cities as a singular living, evolving, and adapting entity. To truly understand cities – and to hope to sustain them – requires the shift to this holistic lens that many other domains of science have embraced by adopting the principles and methods of complexity science.

Response 3
A science of cities should be a comparative, historical social science that investigates the major dimensions of cities and urbanization. These dimensions include size, urban form, social life, and urban functions. A science of cities should strive to document the variability in cities across space and time, and to explain that variation using causal mechanisms anchored in both the features of cities and contextual or structural variables. This body of scholarship does not currently exist, although some constituent parts are well developed. The domain labelled "science of cities" by Batty, West, and Bettencourt constitutes one small part of a comprehensive science of cities.

Response 4

Nobody knows what this is, but it has something to do with anthropology. Cities have many dimensions, but they are built (and destroyed) for purely social reasons. People seem to prefer to do what they do in concentrated social groups, and bigger, more complex groups provide more of those benefits. It is difficult to separate causes and effects in cities. I argue that the causes are all social, and the economic, governance, and resource issues merely facilitate the social ends.

Response 5
A conceptual framework about all cities no matter when or where, that is predictable of the properties of urban agglomerations and falsifiable. I think we already have a general science of cities: It is just not very predictive yet in detail. How predictive can a theory of cities be and of what exactly can be predicted remains the challenge.

Response 6
Each city has unique features but all cities share commonalities. The science of cities is in part about identifying the commonalities. As Solly Angel puts it: "When you fall ill, your desire to be unique disappears. All you want is to have a common disease with a common cure. Cities are in the same predicament. Everyone thinks of their city as unique...When people look at cities and think of them as unique, they think that the lessons that apply to all cities don't apply to them. But when we look at all the other cities we see that what happens in one city is often similar to what happens everywhere else. Where there are similarities the same policy responses can travel from one city to another — cities can learn from all other cities."

Response 7
This could be almost anything to me. I see the point of developing metrics to compare and track cities and urban development, but I would also like to see the 'science' to involve rich studies of interactions, values, and their embodiment in the urban fabric.

Response 8
A new science of cities provides the foundations for thinking about cities in their multiple dimensions/indicators and across scales under a new unifying framework - as a collection of self-similar blocks and networks that lead to emergent laws. For example, urban scaling laws or a formal institution (a specific version of capitalism for example) operate a scaffold for a national urban system, defining the range of outcomes that individual or groups agency can bring about; a power law may operate as a scaffold for an inter-city system of neighbourhoods.

Response 9
The study of systems and processes inherent in cities. A reflexive process of understanding people, values, patterns and behaviors in biophysical and scalar contexts.

Response 10
Agree that it needs to present testable hypotheses. But it also should provide practical guidance to what makes a "good" city, both in terms of defining "good" but also in terms of understanding the linkages between design and outcomes. Aerodynamics is a testable science; it also allows us to build and fly airplanes.
A science of cities must deal explicitly with: The spatial nature of cities (i.e., evolution of urban form; processes in both space and time). Networks.

Systems of systems. Explain differences among cities (not just their macro similarities).

Response 11

One component of a Science of Cities is an idealized conceptual framework based on underlying principles that leads to a quantitative, predictive, unifying, coarse-grained, baseline understanding of the structure, dynamics, growth and organization of cities including their inter-relationship both within and across different urban systems. Among its many features it would recognize Cities as multi-dimensional complex adaptive systems whose emergent properties act over many spatio-temporal scales A critical feature would the integration of this paradigm, inspired by the mathematical, physical and biological sciences, with the wealth of traditional, sometimes more qualitative and phenomenological, ideas and concepts that have been successfully developed in the social sciences including Geography, Urban Planning, Economics, Sociology, etc.

A corollary and extension to this, which relates back to the previous questions, is that we ultimately need to develop a "Grand Unified Theory of Sustainability" (with cities and urbanization at its core) that integrates the multiple challenges we face across the entire spectrum from global warming and the environment to questions about populations growth, energy and resource considerations.

Such theories, if successful, would indicate what the essential features are that we can "tune" in order to develop successful, exciting and sustainable cities and serve as a point of departure for addressing problems for individual cities.

Response 12

The first of two terms I insist we put in scare quotes — which science are we talking about? There has been a science of cities since Robert Park and the Chicago School (at the very least). I think we're using the term to describe efforts led by the likes of Geoff West and Paul Romer (to name two of the most visible advocates) to study cities using the mathematical formalism of physics and economics, respectively. If there is to be a science of cities (and I doubt there can be, at least any more than the "science" of economics can explain the totality of human behaviour can, compared to physics and natural phenomena) it will be through the use of network theory and the collection of real-time location and activity data through smart phones and other hand-held devices to construct real-time maps of social networks moving through urban space.

Response 13

Science of cities: A body of language that allows different people with different methods to communicate unambiguously about the phenomena that occur in cities, and to test and put into question the explanations about the "hows" and "whys" of such phenomena. It can be argued that, historically, a science is possible once a theory emerges that has far reaching explanations and predictions (e.g. theory of classical mechanics and physics, theory of evolution and biology, the theory of plate tectonics and geology, the Ptolemaic theory of celestial bodies and astronomy, etc.), not just models. Previous to this moment, there has to be a recollection of vast amounts of data and observations, with clear identification of unexplained patterns.

Response 14

Multidisciplinary study of cities as complex systems of human technology-environment (including human2human) interaction in the context of urbanization.

Response 15
A city can be seen as a complex system with countless agents. Modelling traffic patterns, human activities, technological processes, environmental impacts and even the weather patterns (wind fluid dynamics, heat stress) all have interactions. The modelling of the city's movements is the science of it.

Response 16
Pluridisciplinary knowledge produced by the application of the reducing views from specialized scientific fields to the same complex object. It should be rooted in observation and comparison and avoid too quick generalization, although a plurality of theories is necessary for generating both epistemological advances and experimental (real world) actions.

7. Smart Cities

Response 1
Smart cities are something which excel not only in physical infrastructure setup but also in terms of attracting the creative resources to build a competitive advantage. To sustain the infrastructure setup, one need the pool of creative resources, who can build upon the infrastructure setup to bring about positive social and environmental impact besides the economic impact. For example, setting up smart grid to integrate the fossil energy and solar energy. Also, enabling the consumers to act as producers by generating solar energy via solar panels installed at homes.

Response 2
Smart cities – yes what is a "smart" city? To me it is simply a city that is outcompeting other cities in a Darwinian struggle for survival. But I will be happy to learn how others approach this concept.

Response 3
A buzzword/term. Cities have always been smart, intensively managed, and full of communication, but today some of that is being automated with computers. It is a difference of degree, not of quality.

Response 4
I expect that this means cities that are efficient at realizing their main urban functions. Such functions are primarily socioeconomic, and those being equal they should be realized at lower costs in terms of energy, time and other resources. This is usually not what is meant by smart cities, which in my experience is a term used to characterize greater use of technology and automation in running urban services. Let's make it crystal clear that technology is not smart, people with technology can be… but no guarantees.

Response 6

This is same as resilient cities. The capacity for a city or a system of cities to absorb and recover from (or potentially thrive on) shocks — natural, security, demographic, social, political, economic

Response 7
The implication to me is the development of sensing and implementation mechanisms that would "increase" the efficiency of urban activities. This scares the wits out of me. First, will greater efficiency, in fact, make urban life better and, more ominously, what are the implications of a smart city for protection of privacy and the building of a platform for authoritarian control!

Response 8
Using automation of technology and information to make better decisions than people can presumably make alone. Technology and innovation are developed and implemented to support socially constructed values and priorities. In order to have smart cities we need smarter citizens.

Response 9
There are serious privacy/control/etc. issues with the way many people speak of this (massive anonymous data collection, monitoring, etc.). Need to take the definition out of the hands of IBM/Cisco. "Data/information" does not equate to "smart". What about "smart design": building "better" cities, not just trying to add "efficiency patches" on top of existing (inherently badly designed) systems/cities

Response 10
Wonderful idea both for input for developing and testing an incipient Science of Cities (and Sustainability) as well as its obvious utilization and impact for monitoring and mitigating problems and making decisions regarding development, policy and growth. **But**, Big Data without Big Theory (meaning a "unifying" integrated conceptual "scientific" framework which recognizes cities as complex adaptive systems) may well create even greater problems and unintended consequences.

Response 11
A term of art that by now might as well be a registered trademark of IBM. (And I believe "Smarter Cities™" is.) "Smart cities" needs to be retired from the discourse, as it contains too much baggage stemming from the technology companies relentlessly pushing the idea. The phrase sprang into existence in its current form in November 2008 when IBM announced its "Smarter Planet" initiative. Since then, Cisco, Siemens, and many others have taken up the cause under various banners. In many ways, "smart cities" is simply a new label for old visions (i.e. ubicomp, "digital homes," etc.) that were never rooted in urbanism, and instead extend from the remorselessness of Moore's and Kryder's Laws — smaller, cheaper processes and larger, cheaper storage inevitably means everything will be "instrumented" (to borrow IBM's phrase) and every scrap of Big Data will be stored and analyzed. This has the benefit of selling a lot of processors, servers, routers, and analytical engines. Because it's also easier to sell directly to mayors, presidents, or (best of all) autocrats to sign deals covering entire cities, it's unsurprising that the self-proclaimed models for "smart cities" — whether Songdo, PlanIT Valley or any number of others — are greenfield sites administered by single technology integrators (e.g. Cisco and Living PlanIT) and decreed by government fiat. They have little to

do with how life is actually lived in cities. Rather than "smart cities," we need networked urbanism — extensible frameworks for the piecemeal creation and integration of technologies any citizen can use and access.

Response 12

Smart cities are those that can navigate their way through all of the above! Hollands (2008) provides a light critique of smart cities. The notion of an informational city has perhaps been developed further (Stock 2011).

Response 13

Cities whose elements (people, buildings, etc.) collect digital data.

Response 14

The complex urban systems including people, businesses and services, environment, as well as governance, provide efficient conditions and innovative digital information and communication technologies for their interaction, not only adequately responding the requirements of the system components, but preferably outstripping them becoming a source of development and innovation for each of the parts. Sustainability and resilience as well as creating the synergetic effect of the interaction between parts of the system are the necessary conditions for the smart city system. At the other hand the smart city system concept also implies the requirement for the active system components to be aware of the whole system objectives sharing them and maintaining the activity with respect to those objectives.

Response 15

A city where the 'science of the cities', as mentioned above, are optimized in terms of movements and quality of materials and energy. A smart city also has diversity in technology and scale, to maintain a certain amount of robustness and resilience over time.

Response 16

At many times in history innovations were provided to make cities "smarter". As there is no optimal size for a city if there are sometimes any genuine entirely "smart cities" they probably will not stay that way for very long. But the initiatives that are labeled under this term make sometimes very relevant innovative contribution to the improvement of urban life and intelligent use of technologies in the urban realm. So let us make all cities smarter everywhere and ever!

8. Other Terms

1. Economic Agglomeration and the Built Environment

Since the work of Alfred Marshall, the concept of agglomeration has powerfully elucidated systemic relationships in industries, in labour markets, and in urban economies. Michael Porter's popular work on clustering is a natural outgrowth of agglomeration studies, as is the more recent formal study of "networks." Clustering algorithms have proven useful analytical instruments across several disciplines.

Effective economic agglomerations may be viewed as "small world networks" having particularly short path lengths separating agents or nodes. If such is the case, cities provide an

excellent laboratory because location in space is identifiable with paths that are physically measurable and that can be mapped. In the past 25 years, a large urban economic literature has developed that attempts to measure agglomeration economies by their effect on productivity, wages, urban growth and entrepreneurship. Usual arguments representing unobserved agglomeration economies include concentration of population, employment (total or of particular industries), patents or other proxies for knowledge spillovers. Data on real estate transactions may assist in measuring such agglomeration economies, based upon the theory that observable transaction prices (including rents and property sales) incorporate the value of location externalities as well as asset hedonics.

The Alonso-Mills-Muth model of urban spatial development may be viewed as an entropic model of final equilibrium. For most of the 20th century this model was an effective descriptive and predictive tool, especially in studying the growth of suburbs and the decline of center cities. Over the past 25 or 30 years, however, several U.S. cities have exhibited anentropic tendencies, including the rising incidence of polynodal conurbations (multiple "edge cities") and, more particularly, the re-invigoration of a relative handful of downtown areas. Some may see this as a phenomenon of "emergent self-organization." Real estate transaction data appear to support such an interpretation.

Panel data analysis of so-called "24-hour cities" clearly demonstrates the ability of such cities to command sustained levels of higher rents for commercial property, compared with a set of 9-to-5 cities, and with a "control" set of the balance of the 25 largest urban areas. (Figure 1). Data on investment returns shows that the 24-hour cities have outperformed the 9-to-5 cities since 1987 (Figure 2). Superior rents and returns have led to a disproportionately high level of investment, with Lorenz Curves for investment significantly more convex for transaction volume than for the inventory of property across the set of major American cities (Figure 3). Transaction prices per square foot, when analyzed by multivariate correlation, have been

found to match a four-factor model (population density, crime level [negative], number of Edge Cities, and regional distinctiveness [Markusen and Shrock], with an adjusted r-square value of .805 and a robust F-statistic of 14.417. We may have the opportunity to test the hypothesis that such cities are advantaged by superior socio-economic networks. The higher and more stable tax bases supported by high property values, in turn, can provide higher levels of urban services, potentially creating a virtuous public policy circle, leading to sustainable economic advantage.

Figure 1: CBD Office Rents (constant dollar) Show Statistically Significant Difference between 24- hour Panel and other Large US Cities


24- hour CBD Rents   — 9-to-5 CBD Rents   balance of top 25 CBDs
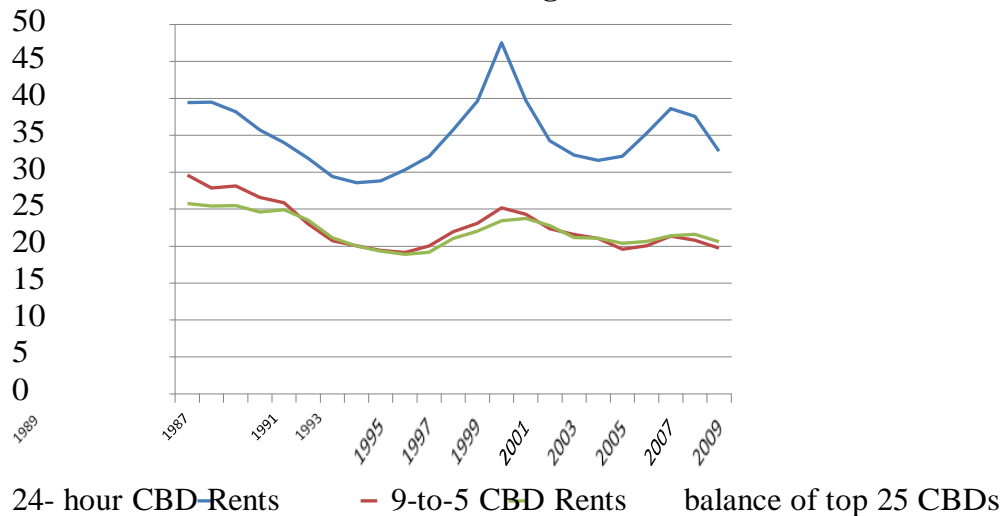
Source: Data courtesy of CBRE-EA; analysis by Hugh Kelly

Cumulative Returns since 1987
    Downtown Offices in NCREIF Database
Total Returns Index: 1Q1987 = 100

Difference in CumulativeTotal Return as
of First Q 2011 = 111.3%
4 CBD Office 9-5 CBD Office
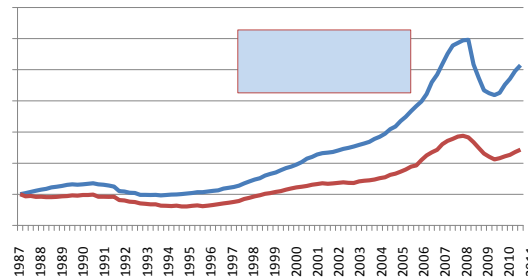
Source: NCREIF Custom Query Tool; parameters defined by Hugh F. Kelly, CRE
At CBD Level, Office Investment Activity Is Even More Highly Concentrated
Five Downtowns Account for 66% of All Sales Volume (2001 – 2008)

CBD Inventory = 0.604466
CBD Sales Volume = 0.742028

—CBD Office Inventory —Base —MSA Office Sales Volume
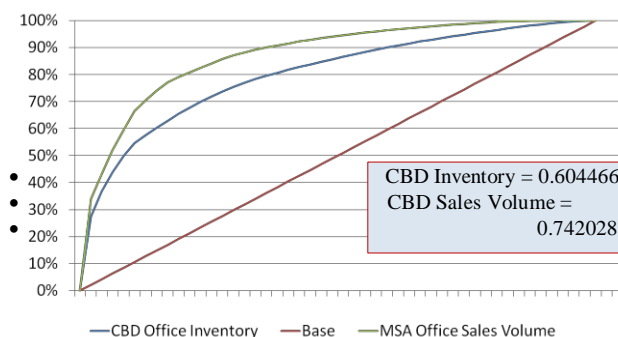
Sources: Inventory from CBRE Econometrics; Sales from Real Capital Analytics; calculation of Gini Coefficients using P. Wessa statistical software, version 1.1.23-r5, URL http://www.wessa.net/

2. Effects of Technology/Innovation

By this I mean as an exogenous variable and its effect on the 10,000 year trajectory of urbanization. To clarify, we should discuss ideas such as, even as cities grow larger and denser than ever, the technological revolution of the last 25 years is making humans, in many aspects, more physically isolated as their existence transfers more and more to cyberspace. People increasingly shop, chat, socialize, meet, share ideas, etc. all online even as the world becomes increasingly urbanized. What can we expect from this trend in regards to cities of the futures?

3. Social Science Research & Social Dynamics

If one accepts the importance of urban human capital and the dynamic role of density in urban prosperity and sustainability, then scholars need to pay more attention to social science research on life and social dynamics in cities. Here are a few relevant concepts:

Neighbourhoods

Life in cities takes place in neighbourhoods, which operate as buffers or cogs between the individual/household level and larger urban and extra-urban forces. Despite online communities and pronouncements of the "death-of-distance" advocates, neighbourhoods remain crucial settings with many implications for individuals and cities. Neighbourhoods are one of the few urban universals.

Urbanicity

The term "urbanicity" is used in the public health literature to describe the effects of living in cities on individuals. This concept can be expanded beyond health to describe economic and other urban effects on individuals and households. It can also incorporate the forces known in sociology as "neighbourhood effects."

Social problems (negative neighbourhood traits)

Crime, poverty, delinquency, violence, segregation, and other urban social problems are often spatially concentrated in particular neighbourhoods. These social-spatial problem areas can be persistent across generations, and their solution may require massive investments of resources (drawing on Robert Sampson here).

The urban built environment

Many aspects of the urban built environment affect larger processes in cities. These aspects include the nature of housing and its density; the types and abundance of open spaces; the design and layout of neighbourhoods; and urban infrastructure. Spatial and physical features of the built environment can promote or hinder social interactions in ways that impact prosperity and social life in cities.

4. Networks

Cities do not exist in isolation but are rather hubs on social and economic networks. These networks are essential to understand everything about cities, and may actually be THE key to urban science.

5. Emerging Economies

I would like to emphasize the view that if we want to be serious at studying cities we need to look primarily at where the phenomenon of urbanization is most spectacular and problematic, and that is in places like India, China, Latin America, etc. I think such cities present challenges of integration that show that simple measures of human capital.

6. Security

I would explicitly include security as well. The nexus of emerging technologies, from google glasses to drones; the challenge of networked non- state actors with very different norms and agendas; the rise of the modern security State; the implications of cybercrime and cyber warfare for wide open nets and technologies that will increasingly combine the

human and the machine (and thus enable hacking of techno- human systems); and the undermining, abetted by emerging technologies, of traditional and usually implicit norms, laws, and cultural practices – all will have enormous impacts on society and urbanization. Also, we should be careful to try to identify the implicit assumptions about stability of various norms, practices and institutions that our analyses and projections rely on. In five years, probably limited change (although some shifts such as the erosion of privacy and autonymity created by google glasses and the like may be somewhat discontinuous). But in 25 years, the human will become a design space in far more profound ways than we understand, with the result that we will not just be designing the city for the human, but the human for the city. Institutionally and psychologically, we are poorly prepared for this level of complexity and reflexivity between designers and designed.

7. Environmental or ecological imperatives of a city

I would like us to discuss the implications of "legacies or inertia (path dependencies)" in an urban context. I also am impressed that despite the great differences in the details of cities, that worldwide there appear to be some fundamental similarities in the trajectories, structures, and driving forces of cities. If this is true, are they unchallengeable? Can they be redirected?

8. Urban Scaffolds

Related to sustainability and resilience, can we discover main typologies of sustainable "urban scaffolds" that fit best particular biomes, levels of economic development and cultures as we attempt to solve pressing problems that threaten life support systems? Are there scaffolds that assist or obstruct in achieving prosperity today and allowing future generations to achieve their goals? Can we start thinking about "repairs" or "improvements" of the urban "tissue" – and in our case, along well-established principles of sustainability?

9. When does a village become a town and when does a town become a city?

Although a trivial question, there is a lack of agreement in the literature on a workable hierarchy of the above. I would argue this a fundamental problem which has been rather ignored leading to confusion, different taxonomies and contradicting epistemologies. Many of the definitions of the city list a number of criteria to be fulfilled, but these criteria look at fixed quantities as benchmarks: number of people, surface area, presence or absence of hinterland, etc. This is the approach taken on in archaeology (proposed by Childe, V.G. in "The Urban Revolution") which made its way into urban economics, sociology and geography. We face a dilemma of potentially not knowing how to define a city but recognizing it as soon as we see it. By focusing on the end-product (the working city) we miss the process of transformation revealing how the city acquired all the working parts. My hypothesis is that we may be dealing with a continuum rather than a dichotomy (city vs. non- city) with transformations being gradual rather than abrupt therefore leading to a lack of clear distinction between town and city when looking only at fixed quantities such as the number of people, buildings or monuments. My interest would be to explore a definition of the city encompassing the dynamic nature of the

process taking place inside it rather than, as it is commonly done now, structuring the definition around fixed variables (see point 3 for a tentative definition).

10. The morphology of urban structures and the disconnect across scales
There is a profound disconnect among the body of knowledge studying national economies and their development and evolution (mainly represented by macroeconomic models), regional economies (in which it is not economists but mainly geographers the group shaping the discussion) and urban studies (where equally important we identify sociologists, economists, physicists, and geographers). If we identify the nation as the all-encompassing concept of regional and urban dynamics (and this may have been more appropriate in the 70s when internationalization turned into globalization), we should have a unified framework of analysis allowing us to shift from national to regional and then further down to urban levels. I am not proposing that we should have a grand theory explaining the processes across all three levels (there may be more levels of analysis each with its own class of processes) but recognition of the importance in the connection that exists between them. This forces then theory and practitioners to explicitly model and analyze the feedback mechanisms that exist between the three levels without assigning to city magical abilities (what would New York City be if the dollar were not the world reserve currency to fuel its finance industry? What would London be today if it weren't for the pound performing the same function in the 19th century?) We have attempts of proposing fractality at the physical space level as a workable concept but we may talk at best about quasi-fractality (due to the quasi-similarity of structures). The phenomenal changes in economic activity of the last 30 years have not produced similar magnitude of changes in the geography of developed economies. We still observe the same cities with a fairly constant urban layout and more or less the same infrastructure. Of course, major differences exist between North American cities where the high obsolescence leads to frequent rebuilding and European cities where the core of the city is persevered and new development is usually forced outside the core (see La Defense or Canary Wharf). I would argue that the focus solely on geography misses the constant interaction between physical, social and economic structures. Physical structures have remained very much the same because the heavy load of transformation has been taken on by social structures (the decline in the traditional concept of family and the rise of the single adult as the working cell) and by economic structures (the distribution in the size of companies has become much more bimodal with a few large and many more small firms than before and the functions performed by both firms and markets have been reshuffled).

11. What is progress?
How do we conceptualize urbanization *and* progress rather than urbanization *as* progress? What urban and urban growth theories, concepts, and analyses based on the North American and European experiences apply to contemporary Asia?

12. Antifragility
I suggest that this term, coined by Nassim Taleb in his book Antifragile: Things that gain from disorder (2012, Random House, New York), is an important one. It resonates with some of the ideas brought about by Eric Beinhocker in his book Origin of Wealth: Evolution, Complexity, and the Radical Remaking of Economics (2007, Harvard Business Review Press). The terms fragile, resilient, and antifragile can be viewed as lying in a continuous line referring

to those things that break with stochasticity on the one hand, to those that are indifferent to it, to those things that actually grow stronger with it, respectively. Do we want a resilient society? Or an antifragile one?

13. Cities, as opposed to other terrestrial ecosystems, are unusual in their "environmental fluidity".

I use the term fluidity as an analogy with physics: solids are those materials whose elements remain in place, whereas fluids are those materials whose elements move easily. Correspondingly, in cities we see crowds of moving people, vehicles of varying sizes and speeds, construction and removal of buildings, huge spatial heterogeneity, and different periodicities (days, weekdays, months) by which these flows change, all subject to strong stochasticity. In the spirit of this analogy, cities are more like a (strange) fluid than like a solid. Hence, a science that can describe and explain cities has to be probabilistic and statistical in its essence, with time as an important dimension to consider, and should avoid using single numbers to describe them such as averages, per-capita measures, aggregation indices, etc.

What are the patterns we have not been able to explain about cities? In my research, I am most interested in the search for the statistics that cities display (all of them, not just the largest ones), and the possible explanations of them. My most general question would be the following: Cities are suitable to be described as sums of different random variables (e.g. the Gross Metropolitan Product is the sum of all the services and goods produced by the city, or the total number of homicides being the sum of homicides that all its inhabitants commit, etc.). The central limit theorem applies when we consider sums of independent random variables that have finite variance, and results in gaussian distributions. What limit distributions should we expect to see in cities, given that we are faced with dependent random variables (are they dependent in predictable and specific ways?), that might have no variance (presumably, individual incomes)?
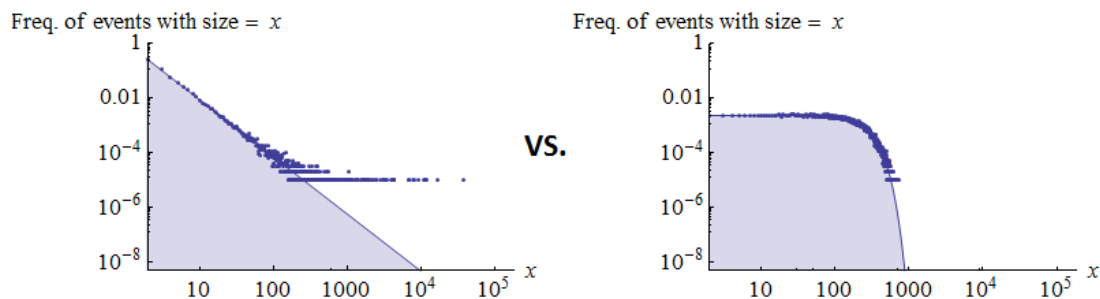

Figure 1: Two different worlds. Both have 100,000 observations, same mean and same variance.

If these were describing individual wealth, or the number of homicides from one year to the next, which one would you prefer? Given that cities are highly interconnected systems, is your chosen world even possible?

In discussing the policy implications (in the hypothetical case of having an understanding of the processes giving rise to the distributions we see) we are faced with two questions:

1. Do we want to implement policies that change the parameters of the distributions? For example, do we only want policies that conduce to less homicides rates, more patents on average, more scientists, more parks, etc.? Or,

2. Do we want to change the distributions themselves? By changing the distribution, we can change things like robustness or the fragility of the city, since we change structurally

For example: of large events. What we should be asking is, thus, what we can do to change the probability distributions that describe cities at the systemic level, not the particular numbers we see reported every year for cities decontextualized from the system they are embedded in. In other words, by having an understanding of the distributions of the urban quantities, we not only can tackle the extent or degree of a problem, but its structural properties. I submit that the question about sustainable urbanization is not a question about what numbers do we want to see in our economic or environmental reports, but rather, what are the probabilistic distributions we want our lives to be ruled by?

19. Innovation
All innovations that became socially adopted. The major driving force of urbanization (together with emulation, i.e. cooperation and competition)

9. Integrated Responses

Response 1: Cities as a Design Problem
This is a point of view on the roles on information flows in cities that lead us to propose "Cities as a Design Problem" as the core theme of the Urban Systems Collaborative meeting in London on 10-11 September 2013. It is simply a collection of ideas and hypotheses with no claim to academic or any other kind of rigor.

The Smart City community – and also the Open Data community – have approached cities in terms of municipal agencies and have often focused on bringing to agencies the kinds of industrial optimization that have been applied for some decades in industrial enterprises. This is has proven to be a very effective means to improve operating efficiencies, to improve the quality of service to citizens, and to reduce operating and maintenance costs. However, we believe that operating efficiency alone is a narrow perspective on the opportunity to improve municipal well-being. We believe, in fact, that improving the flows of information in cities through the use of information technology (IT) can improve many other aspects of city life. We therefore frame the use of IT in urban systems as an emerging tool to be applied to designing and re-designing the interactions between inhabitants and other stakeholders and the capabilities of the city.

Cities are – and have been since time immemorial – information processing systems. They serve to generate, aggregate, share, and act upon a wide range of information among individuals, government, and enterprises. As a general principle, information enables these parties to make decisions of many kinds. By improving the flows of many kinds of information, we may hope to improve the speed and quality of those decisions.

As individual inhabitants, for example, make decisions or choices about living their lives in a given city, each is confronted with finite possibilities and from these possibilities emerge

patterns of behaviour. How individuals and other parties make these decisions and hence exhibit these patterns of behaviour is an interesting field of study which is today little understood.

To some degree we may posit rational behaviour by the parties in taking decisions to maximize some set of objective functions, which may be quite complex – efficiency, convenience, avoidance of threats, crime, or bad weather, greenness, least cost, least time or the chance to interact with others, and so forth. For a given individual or other party, the mixture of these objective functions seems likely to be influenced by factors such as age, cultural or ethnic origins, gender, and so forth as well as more immediate considerations such as health, weather, time pressures, and so forth.

Very little is known about what these objective functions might be. On the Web we find many indices for Quality of Life, Ease of Doing Business, and Civic Well-Being that are claimed to be indicators of the overall attractiveness of cities. However there are no consistent bases for these metrics and no research that relates them to what individual, governments, and enterprises are really seeking. We might consider them to be a proxy for the each party's set of objective functions.

In addition to such rational behaviour, it seems probable that these rational parties sometimes make counter-rational decisions and that some fraction of the parties that consistently makes counter-rational decisions. Given the lack of knowledge about these behaviours, we may take as a starting point a hypothesis that rational decisions predominate.

Note that these decisions are not static but can evolve in time and under other circumstances as the city's capabilities evolve or as the attractiveness of a given choice rises or falls, depending, for example, on the number of passengers trying to board a given bus.

What then would be relationship between rational decision-making and improved flows of information? While many of these flows of information have existed for centuries, if not millennia, they have until recently been invisible – word of mouth exchanges among people who collide accidentally or by plan. The rapid transition to digital media as means of communication is resulting in much of this invisible communication becoming in principle visible, although great care is required here to protect the privacy of individuals. We call this "rendering the invisible visible". Hence the use of IT to improve the flows has two effects:

1) to increase the quantity and quality of information available for each decision and 2) to increase the rate at which knowledge of changes in capabilities or the attractiveness of specific capabilities propagates within the city.

As a starting point, we could make a simplifying assumption that, in seeking a city in which to live or remain, each party seeks to maximize some overall metric. For an individual we may call this "Quality of Life", for an enterprise "Ease of Doing Business" or "Good Market", for a government "Civic well-being". So the set of objective functions that guides each party's decision-making is (unconsciously) intended to support that party's overall metric, for example "Quality of Life", that represents that party's overall experience of the city. So our overall hypothesis is that by improving the flows of information in cities, we can enable each party to improve the maximization of its objective functions and thereby its overall experience of the city. Note that this outcome is distinct from any actual improvements in the city's capabilities that may result from "rendering the invisible visible". We might express this also by saying that a Smart City provides an improved user interface between these parties and the capabilities of the city by enhancing the flows in both directions – city to party and party to city. In design terms, we might say that improving the user interface enables better mutual adaptation of the city and the parties.

Cities compete at local and global levels to retain and attract the most innovative individuals and businesses that will maximize the economic potential of the city. While it is possible to estimate the "GDP" of a city or region, this turns out to be difficult data to acquire in most countries; the USA is a notable exception and even there it is difficult to define accurate geographic boundaries.

This improved adaptation may also lead to improved attractiveness of a given city to a broad range of parties, each of whom can now achieve greater satisfaction of its metric of satisfaction. It might even allow the city leaders to "tune" the city's attractiveness to specific types of parties that they seek to attract. In general it may be expected to foster the overall economic well-being of the city, both in terms of economic activity as well as property values.

Response 2

Sustainability is "development without increases in the throughput of materials and energy beyond the biosphere's capacity for regeneration and waste assimilation" (Goodland and Daly, 1996).

At the global scale, Rockström et al (2009) discuss nine planetary systems of concern, noting that human impacts of biodiversity loss, climate change, and the nitrogen cycle already exceed planetary capacity.

With respect to the carbon cycle, human existence in its current form may be unsustainable in the (very) long run, because, if thermodynamic equilibrium is reached, the atmosphere will be saturated with CO_2. (Kleidon, 2009, 2010)

With some innovation in energy technologies and infrastructure (though largely using existing technologies with innovation in policy), it is technically possible, and perhaps economically possible, to construct low carbon cities (Sugar et al., 2013, Kennedy 2011) and to develop a low carbon global infrastructure system (Kennedy & Corfee-Morlot, 2012, 2013).

The challenge is that cities are, or are like, dissipative structures (Schneider & Kay, 1994; Rees, 2012). Time series data shows that global energy use is directly proportional to urban population on the planet (Bristow and Kennedy, 2013). This can be explained on the basis of non-equilibrium thermodynamics (a possible contribution to the science of cities). Urbanization (i.e., the process of increasing urban population on the planet) using 20th century technologies, therefore works against global sustainability.

The city is "a point of maximum concentration for the power and culture of a community" (Mumford, 1961). Cities control and direct the excess capital of their (global) hinterlands. Much of the capital accumulates in cities themselves. Cities can achieve different levels of prosperity (= a successful, flourishing, or thriving condition, especially in financial respects; dictionary definition). The wealth of cities can be quantified by the value of the assets of their citizens (Kennedy, 2011). The economic growth of cities is also related to the physical design of cities (Kennedy, 2011):

"... It is an increase in autonomous consumption associated with urban form that largely explains the historical growth in per capita GMP. Our habits are shaped by the environment around us; our consumption is governed by the size and shape of the physical space that we inhabit and the paths and distances we must travel to satisfy human wants and needs." The resilience of a city can be expressed in terms of the time taken for it to recover from a shock. With respect to climate change, some strategies that reduce greenhouse gas emissions can

also increase the resilience of cities (Sugar et al. 2013; Kennedy & Corfee-Morlot, 2012, 2013). Smart cities are those that can navigate their way through all of the above!

Hollands (2008) provides a light critique of smart cities. The notion of an informational city has perhaps been developed further (Stock 2011).

Synthesis

Bristow and Kennedy (2012) have a review paper "Towards thermodynamic sustainability with the science of cities" which attempts to bring some of these concepts together. Citing from the abstract:

"Emerging from this review is a theory of local urban and global energy sustainability based on the sub-discipline of open system thermodynamics. Specifically this area of study suggests that sustainability in terms of energy is a varying phenomena related to the context defined by the available resources, technology, and waste reservoirs. It is proposed that a global thermodynamic competition between cities continuously plays out that both drives the evolution of cities and the energy context. Ultimately the cities that remain are those that are adaptable to this context."

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Response 3

I consider that by the end of this century the world will be entirely urbanized and that we must then distinguish much more clearly between cities and urbanization. In my little commentary that I circulated "When all the world's a city" I essentially said that by then, probably well before, we need to distinguish much more clearly between different types of cities and really grapple with the spatial problem of defining what a city is. I believe then that we must move to thinking of cities as disjoint entities – due of course to globalization – where bits of Tokyo, New York, London and so on, say, define a world city of sorts related to say global finance and that we begin to work with concepts where we no longer think that spatial contiguity is necessarily as important as it was. To an extent, we are already beginning to do this but I think we need to do it more formally with data and with our models of our how cities function. In short, I think in the next 100 years, we will break the idea that we think in terms of spatial (and even temporal) sequences where contiguity and adjacency in space and time are basic. Of course networks are central to this idea and slowly we are beginning to fashion coherent approaches to cities using ideas of relation rather than location, interaction as well as action.

To an extent, these ideas would be key to what is being called 'A' or 'The' Science of Cities. Now my view of this terminology and emphasis is that the term science of cities is appropriate not because it is well formed and ultimately definable at present, far from it, but that it is because we need to focus on what science in its old and new forms can do in terms of providing new perspectives on cities. I don't believe a science of cities can be all embracing in this sense – it is the perspective that has been developed for many years traditionally in urban economics, location theory, transportation and land use modelling built around ideas about interdependencies – mainly economic manifested in physical terms and informed by social physics from the time of Comte onwards. But it is coming together quite fast at present. The reason why it is significant now is because it is attracting many different perspectives from the physical sciences to explaining the why and wherefore of cities and also because it is being informed by new approaches such as scaling, network science, and new notions of economic and social interactions that are being fashioned in economics. I think it is a term worth using because of this but I do not believe that this privileges this science over other approaches. Cities are kaleidoscopes of change and there must almost be by definition many approaches to this variety. And of course a science of cities should reach out to many other approaches to urban studies and the city that address some of the big questions more directly than the kind of science of cities I have in mind tends to, which inevitably has much more formal and technical content. This often swamps the 'big ideas' messages from this science

and I think we must work hard to keep these upfront. Issues such as resilience, prosperity, equity, sustainability and efficiency are all key.

Now my vision of this science is also being tested by the emergence of what one might call the smart cities movement. In parallel with the move to everything being some sort of city, ICT is spreading out into the city. Nearly 20 years ago I first wrote about this in an article called "The Computable City" (still online at http://www.acturban.org/biennial/doc_planners/computable_city.htm & some links are gone). Computers are becoming embedded in cities and beginning to spew out data in real time as streams leading to Big Data. This is changing the focus of what we are interested in cities. In the past decade the focus on the longer term – 10 plus years on) is being complemented by the very short term – what happens during the working day, the next hour, the next few minutes even and ICT in cities is very much making the study of the very short term possible. How this scales in time to the long term is a major issue because in principle as we get more and more real time data, over the longer term we will begin to have a sense of how the short term and the long term merge and evolve. It will support our notions that cities evolve which is key to complexity. Of course our models of the short term which are rudimentary are very different from those of the long term and there is a major challenge of extending a science of cities to deal with the short term. Smart cities are driven by big data, by digital participation, by ideas about crowd sourcing of which relate to networks of course and some of the elements of a science of cities but do not easily fit within the social physics approaches that are key to this science as I see it.

So a major intellectual challenge is to see how what is happening in terms of cities getting smart through ICT informs us about our science. At present the two movements are rather different with different sorts of people and approaches but with a common base in terms of the use of computers and probably big data in its diverse forms as being one way of linking them together. The challenge is in my view to see how our theories can be fashioned more comprehensively so that we can see how smart cities focusing on the very short term can scale into our science of cities, which is more about the long term. What is very different from 30 years ago is that both these approaches take the ideas of cities in motion, of dynamics as central, and statics tends increasingly to be a curiosity from the last.

Annex 4: Key Urbanization Related Challenges for the Future

Category	Question	By Whom
Evolutionary Change Mechanism	How similar or different are pre-modern and contemporary cities? ☐ Empirical patterns ☐ Conceptual theories (do the same theories/concepts apply?).	Michael Smith
Evolutionary Change Mechanism	The hypothesis I am trying to test: systems of cities have a common dynamics but specific trajectories depending on their historical path, leadings to a global diversity of urban models and design	Denise Pumain
Evolutionary Change Mechanism	How do we model urban migration patterns as a function of city growth AND …assuming we can, is it possible to make prescriptive policy for optimizing migration?	Greg Lindsay
Evolutionary Change Mechanism	Balancing geographical competitiveness through attracting businesses and creating wealth for people across the spectrum	Amit Kapoor
Evolutionary Change Mechanism	What would drive emergence of specific/certain sectors/industries within a city (geographic) location	Amit Kapoor
Evolutionary Change Mechanism	Developing city advantages/branding for cities	Amit Kapoor
Macroeconomics of cities	How to convince politicians that regulating financial activity is a condition for improving the quality of urban dynamics?	Denise Pumain
Macroeconomics of cities	How do economic, social, and political processes "factor into" a "science of cities"?	Eric Miller
Macroeconomics of cities	Policy, that would build an ecosystem for growth and prosperity within cities	Amit Kapoor
Performance Evaluation	Can the "macro performance" of an urban region be usefully predicted	Eric Miller

	as the emergent outcome of the actions and interactions of individual agents?	
Science of Cities / Networks	Determine the Lagrangian for cities?	Geoffrey West
Science of Cities / Networks	To develop an underlying principled conceptual framework for understanding the integration of social (network) dynamics and organization (the "genomics" of cities) with energetic resource infrastructural or network dynamics (the "metabolics" of cities) in a unified, quantitative, materialistic theoretical framework. For quantitatively understanding the coarse-grained properties? Growth variation of cities as a base - live for long term collective and individual policy decisions.	Geoffrey West
Science of Cities / Networks	"Grand Unified Theory of Sustainability" with cities and urbanization at its core that integrate the entire spectrum of dialogue we face from global climate change and the environment to population growth, energy, resources, etc. Can we determine the coarse grained parameters and dynamics that determine and can be determined in a way to address the plethora of issues?	Geoffrey West
Science of Cities / Networks	How do you best model the connections of urban areas to distal places (and in particular land use/cover changes)? Do these connections pose a challenge to a view of new science of cities that centers on the identification of 'scaling' or 'power' laws?	Michail Fragkias
Science of Cities / Networks	How to construct the global multi-layer network of cities with respect to different kinds of interaction between them? (Data availability?)	Stanislav Sobolevsky
Science of Cities / Networks	Internet—not just cities but networks of cities. How do they evolve? Why do they look the way they do? What feedbacks exist between a city and its position/connectedness in a larger network?	Shade Shutters

	What fundamental commonalities exist between networks of systems of cities and networks/systems of other "organic" entities?	
Science of Cities / Networks	How do we connect the various networks which model a city? (Employment vs. social interactions vs. financial flows) and what are the characteristics of the interlocking networks of the existing network?	Mihnea C.
Science of Cities / Networks	A theory of the science of cities showed link consistently urban to global, intra urban to interurban, a city system to the system of cities	Michael Batty
Science of Cities / Networks	How do you operationalize the new science of cities for sustainability policy? How can plans for new cities be informed by novel conceptualizations that emerge from this community?	Michail Fragkias
Science of Cities / Networks	Since cities represent aggregations of all kinds (spatial, social, economic, etc.), what are the "limiting distributions" we should expect?	Andres Gomez-Lievano
Science of Cities / Networks	Why do cities emerge in the way we observe it (in terms of different parameters like size, population, etc.) –Zipf, Christaller, etc.?	Stanislav Sobolevsky
Science of Cities / Networks	Integrated urban mobility solutions for dense cities	Amit Kapoor
Sustainability / Resilience	Difficulty of conceptual integration of social, ecological, and infrastructural systems in urban setting. What are the "distinct laws" of each of the systems?	Chuck Redman
Sustainability / Resilience	Are there studies that try to integrate models of cognition together with dynamics of the city? How about models of social change vs. city change?	Mihnea C.
Sustainability / Resilience	To what kinds/sizes of hazards are cities and networks of cities naturally resilient, and to what kinds are cities vulnerable?	Ben Ruddell
Sustainability / Resilience	What is the impact of built environment configurations (density, segregation of uses, topographical factors, etc.) on urban productivity? How does this relate to socio-economic variables (including "creative	Hugh Kelly

class" factors)?

Sustainability / Resilience	The conundrum that sustainability seeks community input to define objective, yet also is based on certain necessary outcomes, e.g. zero waste	Chuck Redman
Sustainability / Resilience	How to balance the urbanization of cities with population growth? (Resilience of cities) This is especially important for high growth population driven economies, where urbanization leads to migration and creation of slums.	Sandeep Goyal
Sustainability / Resilience	The challenge of urbanization in India and making lives better for its population	Amit Kapoor
Understanding the Context	The discussion seems to treat cities as independent variables. Would the analyses or conclusions change if cities were seen as dependent variable situated within contexts?	Joseph Tainter
Understanding the Context	How we define our objects of interest is critical? RE: definitions of cities, spatially, temporally and so on. We need clear rules for how to defuse cities for different purposes and we need agreement about these.	Michael Batty
Urban Metabolism	Why do cities grow?	Chris Kennedy
Urban Metabolism	What drives the growth of urban areas?	Karen Seto
Urban Metabolism	How/where do urban areas and cities get their resources? (What is their global or regional reach?)	Karen Seto
Urban Metabolism	How and to what extent can you influence urban metabolism mechanisms in order to be more sustainable in material wage? Like the Zurku example of 6000 W-2000 W, can this be done for materials as well?	Fonz Dekkers
Urban Metabolism	How does global energy relate to urbanization pre 1965?	Chris Kennedy
Urban Metabolism	How does the socio-economic relate to and/or control the urban	Ben Ruddell

metabolism?

Urbanization Metrics and Distributions	What is the relationship between Zipf's laws and a general theory of socioeconomic growth (at a national level)?	Luis Bettencourt
Urbanization Metrics and Distributions	What are the statistics of urban qualities inside cities and how do explain them?	Luis Bettencourt
Urbanization Metrics and Distributions	What are the statistical distributions of urban metrics: across cities of the same population size or conditional in other metric? And how about for each city across time?	Andres Gomez-Lievano
Urbanization Metrics and Distributions	What parameters of the cities affect human activity of different kind within them and how?	Stanislav Sobolevsky
Urbanization Metrics and Distributions	What influence does the number (or diversity) of services provided by a city have on the population/development of a city over time? And does it have correlation to prosperity or resilience of the urbanized environment?	Fonz Dekkers
Urbanization Metrics and Distributions	How does urban form (size, layout, planning) relate to urban life and society?	Michael Smith
Urbanization Metrics and Distributions	Are informal housing markets inevitable in rapidly growing cities?	Brandon Fuller
Urbanization Metrics and Distributions	Why are primate cities typically exceptions to Zipf's law?	Brandon Fuller
Urbanization Metrics and Distributions	How to define the city borders based on human activity?	Stanislav Sobolevsky
Urbanization Metrics and Distributions	Are there cities that differ from the norm in interesting ways? Cities that recurrently find themselves in the tails of distributions, positive or negative? What cities? Why? Can we address a set of hedonic characteristics or a set of network characteristics elucidating such outliers.	Hugh Kelly