The Relevance of Urban Dynamics to Singapore's Success Story: Lessons for Moving Beyond the Crisis[1]

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Abstract

This paper seeks answers to a question implicit in the theme of The 28th International System Dynamics Conference Program: "how can humankind move "Beyond the Crisis" towards political economies that are more resilient, sustainable and humane?" Its focus is cities, which are seen both as the principal loci of the crisis and pointing paths to moving behind it. Those concerned with urban challenges need new ways of viewing the problems they face. In seeking new ways, they should consider what Dr. Louis Alfeld has called "perhaps the most insightful System Dynamics application ever developed": Jay Forrester's urban dynamics model. This representation of cities as living systems seeking equilibrium with their environments offers lessons that are timeless and needed. A notable development success story, Singapore illustrates applications of these lessons by leaders who were not even familiar with Forrester's work. This further highlights the value and contemporary relevance of the worldview of the urban dynamics model.

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Introduction: Moving Beyond the Crisis

What is "the crisis" that humankind must move beyond?

This paper seeks answers to a question implicit in the theme of The 28th International System Dynamics Conference Program: "how can humankind move "Beyond the Crisis" towards political economies that are more resilient, sustainable and humane?" Its focus is cities, which are seen both as the principal loci of the crisis and pointing paths to moving behind it. Our point of departure is two memorable addresses delivered by Dennis Meadows at The 27th System Dynamics Conference. (Dennis Meadows, 2009a, b) Both drew lessons from a professional lifetime in which defining "the crisis", understanding its dynamics, pointing out pathways that might lead beyond it and persuading policy makers to follow them, have been major priorities.

His advocacy role began with publication of *The Limits to Growth* (Donella Meadows, et. al., 1971). Now, in presentations throughout the world,[2] he is drawing lessons from the third iteration, *Limits to Growth: The 30-Year Update* (Donella Meadows, et. al., 2004). Often, he begins with the "reference scenario" from *The Limits to Growth*. A modified version of this, used in one of his addresses (Meadows, 2009c) is shown in Figure 1 below.

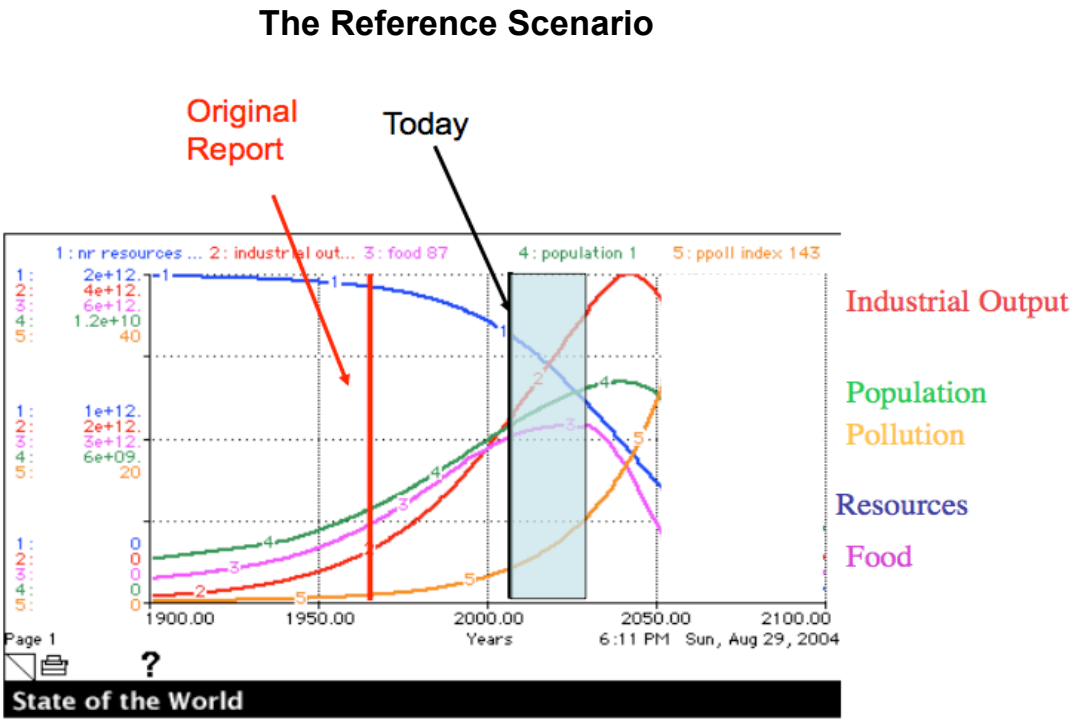

Figure 1

Comparing this scenario with present global trajectories of population, non-renewable resource use, pollution and humanity's ecological footprint in relation to the earth's carrying capacity, he

[2] We have viewed several of these presentations, either personally or on line and also discussed the issues they raise personally with Professor Meadows.

concludes that "things seem to be developing more rapidly than we (the authors of *The Limits to Growth*) expected" (in 1972). If one seeks to describe "the crisis" humankind must move beyond, a comparison of *The Limits to Growth* reference scenario with corresponding trajectories of real-world data is a good place to begin.

"Reference mode" graphs, as such diagrams are sometimes called, do not provide an explanation, of course. Explanation requires System Dynamics models that reproduce behavior modes of interest. When one provides explanations of problematic behaviors (such as those depicted in *The Limits to Growth* reference scenario), especially to non-modelers, one often highlights important themes that the model depicts, rather than focusing on more technical details of the model structure. Such themes typically emphasize dominant positive feedback loops that generate exponential growth or collapse and dominant negative loops that generate goal-seeking or resistance to interventions and delays that produce misperceptions at decision points and unstable behaviors such as oscillations, overshoot and collapse.[3]

Explanations of the crisis provided by global models: overshoot and collapse

Explanations of the crisis provided in *Limits to Growth: The 30-Year Update* trace their origins to a preliminary model, *World1*, which was first sketched out by Jay Forrester on a return flight after meetings with leading Club of Rome members in Switzerland (Forrester, 2007a). This led to the *World2* model described in *World Dynamics* (Forrester, 1971), and the *World3* model described in *The Limits to Growth* and subsequent iterations. What is remarkable about this body of literature, now spanning nearly 40 years, is the degree to which explanations of the crisis emphasized in Forrester's original work have been repeatedly echoed in subsequent iterations, in many other publications by the same authors and in publications by authors who have built other global models as well. (Donella Meadows, 2007)

Though the models and generated scenarios are viewed as complex by many, the fundamental explanation of the crisis that all provide is not: the source of the crisis is the physical, ecological, and social pressures being generated by exponential growth in population, capital, the extraction of finite resources and the waste products human society generates on a finite planet.

It is hard to improve upon the powerful metaphor that Jay Forrester, writing in 1971, chose to capture the challenge he saw humankind facing *at that time*:

> "People are in the position of a wild animal running from its pursuers. We still have some space, natural resources and agricultural land left. We can avoid the question of rising population as long as we can flee into the bountiful reservoir that nature has provided. But the reservoir is limited. Exponential growth cannot continue. The wild animal flees until he is cornered, until he has no more space. Then he turns to fight, but he no longer has room to maneuver. He is less able to forestall disaster than if he had fought in the open while there was still room to yield and to dodge."(p. 124)

Among those who acknowledge that there is a crisis and that the root cause of the crisis is pressures generated by the exponential growth of population, consumption and pollution, there are two other areas of consensus. The first is that the behavior modes of growth must be replaced by behavior modes of equilibrium. *The Limits to Growth* authors emphasized that this does not mean that human activities not requiring a large flow of irreplaceable resources or

[3] See Donella Meadows (2008, pp. 44, ff.) and for a more comprehensive discussion of the relationship between feedback loop structures and behavior, Richardson (1991).

producing severe degradation – for example: education, music, art, religion and basic scientific research – could not continue indefinitely (p. 176, ff.). The second is that "any deliberate attempt to reach a rational state of equilibrium by planned measures, rather than by chance or catastrophe must ultimately be founded on a basic change of values and goals at individual, national and world levels." (Executive Committee of the Club of Rome, 1972 p. 188)

Club of Rome Executive Committee Members, along with many who created global models and sought to publicize their results, believed that presentation of model results, coupled with a growing weight of evidence confirming the results, would change attitudes. They believed that changes in attitudes would produce changes in policies and that there was sufficient time to mitigate the social and political-economic momentum impelling humankind toward overshoot and collapse. Dennis Meadows reports that 40 years of experience provides little evidence to support that view. He now observes: "If you marshal enough facts to disprove an objection, then the critics will just find another objection. There are an infinite number of objections, so you are never going to come to the end of the process." Here is his current appraisal of the circumstances facing humankind given in a recent address: (Meadows, 2009c, Slide 4)

- Growth has continued until we are now past sustainable levels.
- Global society will change more over the next 20 years than in the past 100.
- There is a need to design policies for what is coming, not what has been.
- Climate change and resource scarcity, especially fossil fuels and water will be the main forces for change.
- The most important scarcity is *the absence of a longer-term perspective*.
- Many indicators point to the conclusion that we have reached overshoot, sooner than anticipated. Where we once only had models, we can now get confirmation from the newspapers.

Manifestations of the crisis: global and universal problems

What are those seeking to play a role in helping humankind move 'beyond the crisis' to do in the light of this somewhat pessimistic appraisal? Dennis addressed this question in an address to a Ph.D. Student Forum entitled "Opportunities for a Career Modeling Limits to Growth 2010-2030" at the 27th conference. He sees two classes of problems that humankind will face as the pressures created by overshoot, leading to collapse, intensify with unpredictable consequences. *Global problems* affect everyone and can only be solved by international effort. These include climate change, ocean fish depletion, nuclear proliferation, and, we would add, stabilizing the international financial system. *Universal problems* affect everyone but can be solved by local efforts. We would particularly emphasize scarcity of water and the rising costs of energy, population growth, migration, chronic poverty and social instability created by rich countries, and the rich within all countries, to protect their way of life in a time of increasing social turbulence, at the expense of the poor.

Seeking solutions: preventive and adaptive policies

Meadows has also identified two broad classes of solutions for addressing global and universal problems. *Preventive policies* are intended to avoid future problems. *Adaptive policies* are intended to reduce the harmful consequences of problems already being experienced. Preventive policies require the longest time horizon. Much of global modeling has been directed at promoting preventive policies, intended to solve global problems with global leaders (including

President and Prime Ministers of major powers) as the target audience, but the results from these efforts have been disappointing. Sustaining consistent policies is difficult when there are seismic shifts in a nation's ideological terrain, as in the United States, when national administrations change. Failure to address global problems with preventive policies imposes the need for institutions lower down in the decision-making "food chain" to respond with adaptive policies. For example, the low-lying Republic of the Maldives is responding to global warming by creating an artificial island, adjacent to her international airport that is several meters higher above sea level than the island on which her capital, Male, is located. Along with those of other island nations, her pleas in international forums to make preventive policies addressing global warming a priority have mostly fallen on deaf ears.[4]

While global problems must be addressed at a global level, universal problems may be addressed with both preventive and adaptive policies and such policies may be implemented at various levels. Meadows argue that, paradoxically, it is at the level of individuals and families that, when given the opportunity, time horizons may be most future-oriented. Parents are concerned with the welfare of their children and, often, their grandchildren as well. Confucian traditions that have been influential in China and among Chinese diaspora communities place a strong emphasis on intergenerational responsibility. (D.C. Lau, trans., 1979; Lee Kuan Yew, 2000, esp. Chapt. 7) But individuals and families have the fewest resources and are in the weakest position, relative to challenges posed by overshoot and collapse, to implement preventive and adaptive policies. Normally, the best they can do is to sporadically mobilize collective effort to pressure political and business leaders. The inability of international and national organizations to cope with universal problems matches their inability to cope with global problems and for the same reasons.

Meadows's intermediate and most promising remaining category is "communities" and we include cities as well. These fall in a middle ground. While their time horizon may be shorter, their resources are greater than those of individuals. Cities and communities may offer greater hope of moving beyond the crisis, but policy failures at the community and city level are also major contributors to overshoot and the potential for collapse. While the problems that cities represent may be matters of global concern, they are of even greater concern to their own citizens. Nowhere is this more true that in the growing megacities of Asia.

Using Cities as a Focusing Lens

We believe cities can provide a focusing lens to sharpen our understanding of how the human race can better respond to the threat posed by global overshoot and impending collapse. They are major sources of the problem, and as Dennis Meadows argues, they may also provide feasible and practical points of leverage for those seeking solutions. What are the challenges and opportunities that cities pose?

Unprecedented urbanization

Urbanization has been occurring at an unprecedented scale. Cities have grown in importance as key drivers of economic growth in their regions and countries, with rapidly growing industry- and service-related economies providing employment opportunities for millions of people. The

[4] Richardson viewed this island, Hulhumale, and discussed global warming with Maldives government and business leaders during a brief consulting visit to the Republic in summer 2006.

21st century has been named "The Century of the City" (UN- Habitat, 2008/9), reflecting the prominent place that cities occupy in the global economy as well as the fact that cities are now populated by more people than ever before than in humankind's history. Today, there are more than 400 cities with a population of over 1 million, compared to only 16 such cities in 1900. 50% of the world's population now lives in cities, compared to 30% in 1950, 14% in 1900 and 3% in 1800. Migration into cities is most rapid in developing countries, with an average of 5 million new city residents every month. (Population Reference Bureau, 2009)

The consequences of urban growth

This unprecedented growth of cities - both in the number of cities and the sizes of their populations – has two major consequences. Firstly, cities are placing greater strains and demands than ever before on the earth's resources. Cities occupy only 2% of the world's land, but consume 75% of its resources. 60% of the earth's water, 75% of the world's energy and 76% of industrial wood use is consumed by cities. (Hargroves and Smith, 2005) If every member of the human race shared the earth's resources equally, the sustainable footprint would be about 1.8 hectares per person. The average ecological footprint in rural People's Republic of China (PRC) is 1.6, but in Shanghai it is already 7.0 and in a typical United States city, it is 9.7. Cities also generate 75% of the earth's wastes, such as air pollutants, solid waste, GHGs and toxic effluents. This includes nearly 80% of the world's carbon dioxide (CO_2) emissions.

Secondly, with exponentially rising populations and limited resources, cities themselves are in danger of overshoot and collapse. The strains and pressures of uncurbed population growth have already taken their toll on many cities. In Asia, more than half of all city residents lack a reliable drinking water source. Untreated industrial wastes pollute local drinking water supplies and contaminate food sources such as coastal fisheries. Globally, poor environmental conditions are responsible for 25% of preventable health problems. Two-thirds of those impacted are children. Dire housing shortages have led to rising numbers of slum dwellers in these cities. Poverty, traffic congestion and deteriorating infrastructure are common not just in cities in the developing world, but in the developed world as well. (Managing Asian Cities, 2008)

Thus, cities are central to the issue of global environmental sustainability. The lower the capability of cities in withstanding the pressures of urban expansion, the greater their negative impact will be on the earth, and the slimmer our chances are of collective survival as a human race. Unless city leaders build their capability to cope with pressures of urban expansion, the collapse of cities will occur sooner, preceding and precipitating an eventual collapse at the global level.

Looking to cities for answers

Many cities have endeavored to strengthen their adaptive capacities, usually through devoting resources to alleviate the effects of urban pressures or to avert crises triggered by them. In the late 1980's, the South Korean government sponsored one of the largest environmental clean-up programs in Asia to restore the supply of potable water from the Han River, which had for decades been a receptacle for urban and industrial refuse. (Roberts and Kanaley 2006, p. 3) Faced with inter-district problems of transportation, waste, drainage and water supply, Sleman, a district in southern Java, took a leadership role in developing stronger and more institutionalized cooperation with the Regency of Bantul and the city of Yogyakarta. Together, they set up a joint

secretariat, Kartamantul (from the names Yogyakarta, Sleman and Bantul) that has since found many effective solutions for their urban woes (Roberts and Kanaley, 2006, p. 178-179). While strengthening urban management processes is necessary, remedies must be more fundamental and far-reaching. In seeking remedies, we must delve deeper, to grasp at the societal motivations and values that have driven humankind into this unsustainable pattern of collective behavior in the first place. As Jay Forrester proposed in his paper "Should we save our cities?", a long-term remedy is one that would involve "the generation of laws, attitudes, morality, and folklore that will establish the most desirable of the feasible equilibrium societies." (Forrester, 1972, p. 61) Donella Meadows et. al. suggest "changing the information links in a system: the content and timeliness of the data that actors in the system have to work with, and the goals, incentives, costs and feedbacks that motivate or constrain behavior." (Meadows D.H., 1992, p. 191)

Cities may offer a point of entry by which we can deepen our understanding of the situation at hand and move closer towards sustainable remedies. The manifestations of overshoot and collapse are more immediate and visible in cities than at the national or global levels. In response to these manifestations, cities exhibit a range of coping behaviors and capacities. Leaders and inhabitants have vastly different stances and approaches towards urban expansion and sustainability, and have encountered vastly different outcomes. Most importantly, underlying these distinctions in approaches and outcomes are the goals and values linked to the differing political and socio-cultural contexts of cities.

Do these goals and values extend to the well-being of present and future generations? How consistently are these goals and values applied in the way the city is governed? Is there a sense of collective ownership of and responsibility towards the global issues? Is there a willingness and ability to take stock, reassess past decisions and adapt to soon-emerging and future changes and trends? Seeking answers requires that cities be understood as complex, living systems, interacting with their environment, with their populations and physical infrastructures tracing development trajectories over decades (Seetharam and Yuen, 2010, esp. Chapts 1 & 11). But tools to facilitate such understanding are rarely encountered and even more rarely used effectively. One of the most powerful - the model described by Jay Forrester in *Urban Dynamics* (1969) - has mostly faded from view, even among members of the System Dynamics modeling community. Those seeking to guide and lead their cities "beyond the crisis" must give serious attention to the lessons and analytical tools that *Urban Dynamics* has to offer.

Lessons from Jay Forrester's *Urban Dynamics*

The rise and fading from view of urban dynamics

While the 21st Century may be labeled "The Century of the City," the issues raised in the UN-Habitat report, *State of the World's Cities 2008/9,* are not new. Many echo concerns that preoccupied US political leaders and urban planners in the mid to late 1900s. They were captured in the title of Edward Banfield's 1970 classic, *The Unheavenly City* (Banfield, 1970)[5] and in the bleak appraisal of the 1968 (US) *Kerner Commission Report*: "Our nation is moving toward two societies, one Black, one White – separate and unequal."

It was in this climate that 8 year Boston Mayor John F. Collins, who had chosen not to run for re-election, accepted a one-year MIT appointment as Visiting Professor of Urban Affairs. His

[5] Though Banfield's appraisal was less pessimistic than the title suggested

presence catalyzed extended discussions between Jay Forrester and urban political leaders, leading to the publication of *Urban Dynamics* (Forrester, 1969). It was the first widely circulated application of Industrial Dynamics to a non-private-management problem (Forrester 2007, pp. 348-349). The public attention it received, the positive response accorded it by many policy-makers and the hostility accorded it by many academics presaged similar reactions that would greet *World Dynamics* and, on a much larger scale, *The Limits to Growth*.

In "Urban Dynamics: The First 50 Years" (Alfeld 1995), Dr. Louis E. Alfeld, who directed urban dynamics research and applications for MIT's System Dynamics Group recounts the story of this work, during the relatively short period of time when it was a subject of interest among those concerned with urban development. He describes five urban planning projects in five different cities that produced mixed results, highlighting successes, shortcomings and useful lessons learned. His appraisal of the model is compelling: "It is…, perhaps the most insightful System Dynamics application ever developed." (1995, p. 199) But it was subjected to scathing criticism by more traditional modeling communities, including members of a US Department of Housing and Urban Development (HUD) committee tasked to appraise it. Those who might have been its defenders were preoccupied, in wider forums, with resisting similar assaults by critics of *World Dynamics* and *The Limits to Growth*. There is a note of pathos in his description of how the urban dynamics model faded from view: (*Ibid*.).

> "The past twenty-five years have not treated *Urban Dynamics* kindly. Had HUD initially endorsed it, urban dynamics might have become the institutional foundation for the training of a new generation of urban leadership. Instead, it has become a curiosity, a relic of the past that few have heard of and most dismiss. But it is too early, I think, to write it off, to consign urban dynamics to the archives of academia. Although I mourn its history, I firmly believe in its future."

A less-than-comprehensive but revealing search using Google and Google Scholar confirms Alfeld's appraisal. There are few references after the 1970s.[6] Even in the *System Dynamics Review*, recent references are sparse and of historical interest, with only one exception (Eskinasi et. al., 2009). Thus, we must assume that knowledge of the *Urban Dynamics* model and its insights is somewhat limited, even among at least younger members of the System Dynamics Community. A brief recapitulation is necessary, before highlighting important lessons that this pioneering work emphasizes.

The *Urban Dynamics* model structure

Urban Dynamics sought to explain and offer remedies to problems faced by many US cities where a period of growth had been followed by a stagnant and often blighted equilibrium. The city modeled was generic, but similar in broad outline to those whose problems motivated the project. Forrester argued that "when first modeling a social system, it is usually best to model the general class of system rather than a specific system… this means a model to represent the processes common to all urban areas rather than to represent those of a specific area." (1969, p. 14). The city's land area is 100,000 acres or about 400 km² (which compares with Singapore's land area of about 580 km^2 at the time of independence.) In the model's 250-year run that serves as a baseline for subsequent 50-year runs that examine policy options, its population peaks at about 5.5 million and then declines to about 5.1 million (1969 p. 4).

[6] There are other references to "urban dynamics" that have nothing to do with Forrester's work and do not cite it.

The city exists as a "complex, self-regulating system" functioning in a state of equilibrium with an "environment" that is assumed to be both "limitless" and a point of reference (p. 17). By choosing this representation, Forrester focuses attention on how the attractiveness of the city, as it develops, differs from the "normal" circumstances of the environment.[7] When the city is more attractive to investors, developers and migrants of different classes, inward flows of resources and population increase. When it is less attractive, inward flows decrease and become outward flows. Thus, dynamic behavior trajectories of a city are partly explained by the fact that it is an equilibrium-seeking system, *vis a vis* its environment.

An important implication of this view echoes findings from Forrester's earlier modeling of instabilities in corporate growth trajectories, in relation the markets they serve. He found that it was the behavior of decision-makers within the corporation that explained those instabilities, though they were often attributed to external factors not under the decision-makers' control. (Forrester, 1962, 1975, 2007, p. 348) Similarly Forrester emphasizes that cities are, in large degree, responsible for their own destinies. Whether they are vibrant and regenerating or stagnant and decaying, whether they serve the well-being of their residents well or badly will be largely due to decisions made by leaders and residents *within the city*.

Forrester represents the social/economic structure of his city as interrelationships between three sectors – enterprise, housing and people – and between these sectors and its environment. Since links between the population and other sectors are strongest and population behavior modes are strongly emphasized in the policy analysis discussions, it is useful to describe this section first.

Urban Dynamics provides one of relatively few examples of a social class structure in the System Dynamics literature. While respective class members do not earn income, the relative value-added of their respective contributions to the city is clear. *Managerial-professional* class members work preponderantly in high value-added industries (*new enterprises*) and live preponderantly in *premium housing* (assessed value US$30,000). They have smaller families (average size 5) and relatively low birth rates (average 7.5 per 1000 families, per year). Since city revenues come from property taxes, personal income is not recognized explicitly. However, premium houses (and new enterprises) have the highest assessed valuation and pay the highest taxes. The cost of providing city services to managerial-professional families for city services is relatively modest (only $750 per family, per year). When growth peaks in the city, managerial-professionals comprise about 12% of the work force.

Labor class members comprise the major portion of the work force in all enterprises. They live preponderantly in *worker housing*. They have slightly larger families (average size 6) and higher birth rates (average 10 per 1000 families per year). The cost of providing city services to these families is nearly double the cost for managerial-professional families ($1,200 per family per year). When growth peaks in the city, labor-class members comprise nearly 60% of the work force.

Underemployed class members comprise about 30% of the work force at the peak period and live preponderantly in underemployed housing (assessed value $5,000). They have larger families (average size 8) and higher birth rates (average 15 per 1000 families per year). Because of this

[7] These circumstances are represented in the model as "normal" constants influencing inflow and outflow rates to the model's level (stock) variables. The city's stocks of industry, housing and population in different categories are represented as levels. See our discussion of the model's enterprise, housing and demographic sectors, below.

demographic profile and their lower incomes,[8] the cost of providing city services to underemployed families is twice that of worker families ($2,400 per family per year) and more than three times that of managerial-professional families.

The structures of the enterprise and housing sectors are, as noted, somewhat less rich in detail. Their primary function is to provide jobs for the city's population, places for families to live and tax revenues to support city services. Forrester's city does not have an economy in any conventional sense. Enterprises do not produce goods and services. Jobs available depend on the number of industry units in the city. The enterprise sector is divided into *new enterprises* (assessed value $500,000 per unit), *mature businesses* (assessed value $300,000 per unit) and *declining industries* (assessed value $100,000). In addition to paying higher taxes, newer industries benefit the city more by employing more members of all classes. In particular, new enterprise units employ 4 managerial-professionals. Declining industries employ only one.

Just as the process of growth produces a vibrant city, generously populated with managerial-professionals, the aging of housing and enterprise units contributes to stagnation and decay. Alfeld describes this process as a "filter-down" mechanism (1995, p. 203). Each year, under "normal" conditions, 8% of new enterprises decline and become mature businesses, 5% of mature businesses become declining industries and 3% of declining industries are demolished. Similarly, 3% of the premium housing stock obsolesces and becomes worker housing, 2% of worker housing becomes underemployed housing and 2% of underemployed housing succumbs to "slum housing demolition." (Forrester, 1969, Appendix A, pp. 133, ff.) The rates of decline and obsolescence vary depending on the city's economic vitality, including employment opportunities, and especially its demographic mix.

Growth, stagnation and policy experiments in Professor Forrester's city

Urban Dynamics described results from three sets of simulation runs. In the first, the model was run for a 250-year period, generating reference mode graphs that picture growth and stagnation. Growth begins slowly but accelerates exponentially, as confidence in the city and its future rises. It peaks at about 100 years. New industries move in, attracted by available land. The economy is vibrant and a magnet for managerial professional class members and workers. Housing is constructed to meet their needs. City revenues are plentiful and tax rates are relatively low. It reaches a peak after about 100 years.

The growth period is followed by one in which available land for new construction is nearly filled. Industry ages, the quality of the housing stock declines and the city's tax base erodes as the needs of its burgeoning underemployed population grow. A shortage of high quality housing and job opportunities cause some of the more mobile and productive residents to move elsewhere. High land costs, high taxes and declining quality of life within the city deter new industries from considering the city as a place of opportunity. But underemployed families continue to move in, attracted by cheap housing and generous city services, including welfare. The growing political clout of the underemployed ensures that services for the poor continue to receive high priority even though high taxes and deteriorating services make the city less and less attractive for new enterprises and managerial-professionals. Eventually the social/political economy of the city settles into a period of stagnant equilibrium with little new enterprise, few

[8] Again, family income is not explicit in the model. It is assumed to be low based on the housing that lower class families can afford.

amenities, and a large politically influential underemployed population, living in overcrowded, substandard housing. It was the widespread prevalence of such conditions in US cities that motivated Forrester's and Collins' collaboration to create the urban dynamics model.

Using the stagnant equilibrium conditions as a point of departure, Forrester then simulated remedial programs, in model runs spanning an additional fifty years. These were typical of those being implemented by many cities. Mostly, such programs targeted poor people (underemployed workers and their families in the model). Most programs had failed to produce the results intended. Forrester hoped that the model-generated scenarios would help to explain why. Programs included creating jobs, job training, an external subsidy to provide higher quality city services and low-cost housing construction. To forestall possible criticism by program proponents (though this strategy failed), he made unrealistically generous assumptions about the effectiveness of such programs and their costs.

Without exception, results of the simulated programs mimicked the results of the real ones. They did not improve matters; they made things worse. In a later reflection, Forrester summarized the bottom line conclusion to which all the scenarios generated by these programs pointed. "*Urban Dynamics* showed that all of the major urban policies that the United States was following lay somewhere between neutral and detrimental, from the viewpoint either of the city as an institution or from the viewpoint of the low-income, unemployed residents (2007, p. 249)." This led to one of his most profound insights about complex systems: ***counterintuitive behavior***. He wrote: "From all normal personal experience, one learns that cause and effect are closely related in time and space. A difficulty or failure of the simple system is observed at once. The cause is obvious and immediately precedes the consequence.

> "But in complex systems, all of these facts become fallacies. Cause and effect are not related in either time or space… the complex system is far more devious and diabolical than merely being different from the simple systems with which we have experience. Though it is truly different, it appears to be the same. In a situation where coincident symptoms appear to be causes, a person acts to dispel the symptoms. But the underlying causes remain. The treatment is either ineffective or actually detrimental. With a high degree of confidence we can say that the intuitive solutions to the problems of complex social systems will be wrong most of the time. Here lies much of the explanation for the problems of faltering companies, disappointments in developing nations, foreign exchange crises and the troubles of urban areas." (p. 110).

Forrester's third set of simulations experimented with programs that seemed, in the light of the previous failed experiments, to be more promising candidates for catalyzing urban renewal. Among the most successful were those that made more land available for the development of new industry – declining industry demolition and slum housing demolition. When programs to discourage the construction of worker housing were added to the mix (for example, through zoning restrictions), there were further improvements in economic vitality. Paradoxically, the amount of worker housing available actually increased because of increased demand due to more favorable economic conditions and job opportunity. Ensuring that land for industrial development is available, ensuring a high quality housing stock and reducing housing availability for underemployed families that have few jobs or job prospects, were demonstrated to be areas of particularly high leverage.

Urban dynamics was subject to harsh criticism because of policies that were interpreted as discriminating against the poor, many of whom, in the United States, were African American. But in Chapter 7 of *Urban Dynamics*, Forrester makes it clear this is not the case. An implicit goal, he emphasizes must be to "restore economic vitality [to cities] and absorb the present underemployed groups into the mainstream of productive activity …The policies for controlling population balance that the city must establish are not antisocial. No purpose is served by operating a city so that it is a drain on the economy of the country and a disappointment and frustration to its occupants." (pp. 115-116)

Urban Dynamics was published more than forty years ago. But the ensuing years have not altered the truth or importance of its central message. In an "Afterword" for a forthcoming book (Seetharam and Yuen, 2010), Forrester writes:

> "…A city is a complex system that must remain in balance with its environment. Policies that are intended to improve the quality of urban life in the short term will disrupt the balance in ways that are counteracted by population inflows. As my book *Urban Dynamics* makes clear, many well-intended urban renewal policies implemented during the 1950s and 1960s actually created poverty and urban stagnation. The alternative approach is to decide what mix of desirable and undesirable characteristics a city is to have and still remain in balance with its environment. There can be many different kinds of cities. But every realistically possible city must have undesirable characteristics that are sufficiently strong to balance the attractiveness of the desirable characteristics. The most important step in arriving at a feasible plan is to decide what negative counterbalancing forces are to be activated."

Nine lessons that *Urban Dynamics* teaches

What basic lessons can be gained from Urban Dynamics that may be of benefit to cities elsewhere and especially cities in Asia? Most are implicit in our discussion. However, a summary will be useful.

1. A major goal of a city's leaders and the policies they implement should be the well-being of its people; rich and poor alike. This is the fundamental value that underlies Forrester's policy experiments. Cities that are "a source of disappointment and frustration to its inhabitants" should not be an option.
2. What is meant by "well-being"? This can be a subject of endless debate, but the value system underlying the simple social/political economy *Urban Dynamics* portrays is fairly straightforward. It is implicit in the notion of relative attractiveness. A city that is characterized by high levels of well-being is one that – at a minimum - provides decent jobs, decent housing, and opportunities for upward mobility. It is a city where the number of wealth-generating managerial-professionals is significant, where worker class members are predominant and the number of underemployed is relatively small.[9]

[9] Obviously the urban dynamics model omits many possible dimensions of well-being or what is often called 'livability' in rankings of cities. See for example the listing given in the Bloomberg-Mercer 2007 ranking. Our purpose in this paper is not to enter into that debate but only to suggest how a scenario outcome for a hypothetical city might be judged better or worse in the context of values that to us seem implicit in the urban dynamics model. We do acknowledge that this may be controversial as, indeed, was *Urban Dynamics* itself.

3. A city is master of its own destiny. It is the responsibility of city leaders to sustain a symbiotic relationship with its environment. Over time, the environment will change in ways that are both favorable and unfavorable to the city. To sustain the well-being and vibrancy of its people, the city must be adaptable and resilient.
4. An important requisite for sustaining the city's well-being (not the only requisite) is wealth. Given that Forrester's city has no oil reserves, diamonds or any other natural resource, its only source of wealth is the productivity of its enterprises and the tax base its stock of housing provides. These depend, in turn on the productivity of its people.
5. Individuals differ in their capacity to produce wealth. Forrester offers no theory why this is so; he simply incorporates this reality into his model. One might assume that differences are partly innate, partly determined by motivation and partly determined by favorable or unfavorable circumstances. The model assumes that educational opportunities and the opportunities created by a vibrant economy can increase upward mobility, which will in turn be manifest in increased productive capacities. Wealth creation, properly managed in an urban context, is a positive feedback loop.
6. In designing the tax structure of a city, and providing amenities to its residents, one must strike a balance between incentivizing those capable of producing wealth with low taxes and providing amenities that meet the needs of all. If the gap between rich and poor is too wide, the result can be social instability. If too narrow, the result can be an exodus of the city's most productive residents and stagnation.
7. The greater an individual's productive capacity, the greater his or her discretion in choosing a place to live. New enterprises too, have discretion in determining in which cities they will or will not locate. City leaders must take this into account. Forrester gives little attention to the mobility of mature and declining industries. However, we have seen that these, too, are making location decisions based on relative attractiveness. Forrester would probably argue that an exodus of mature and declining enterprises, creating opportunities for new enterprises to move in and encouraging city leaders to find them, benefits the city.
8. Long-term planning is important. This is because the nature of complex systems, programs and plans that seem promising in the short term are often counterproductive in the longer-term. Similarly, the objectives of long-term plans often seem counterproductive in the short term. One can derive immediate satisfactions by charging goods and entertainment to one's credit card but eventually "the bills fall due".[10] It is the responsibility of political leaders to make tough decisions that give priority to the long-term over the short term.
9. Most important is the relative attractiveness principle. This is the fundamental principle of *Urban Dynamics*, emphasized once again in Professor Forrester's "Afterword". It is so central and, in our view, so important, that it merits a reiteration, in somewhat different language, from a Donella Meadows Global Citizen Column. She was writing about the decision of community leaders in Woodstock, Vermont (USA), not to expand the two-lane highway leading to their town, despite pressure from commercial developers to do so. (1991; 2002, p. 137)

[10] This a common metaphor used to make the point. We believe we first heard it used system dynamics context during a personal conversation with Professor Forrester, but can't remember the specifics.

> "The attractiveness of a place is a complex combination of climate, economy, amenities and scenery. No one can define attractiveness exactly, but people make up their minds about it every day by deciding to move from Hartford or Boston or Westchester County to Vermont (that's the direction they are moving now). Millions of human judgments weigh Vermont's clean air against Boston's job market and Manhattan's cost of living. The very different mixes of attractiveness and unattractiveness in those places may seem incommensurable, but people make their comparisons and move around until attractiveness evens out everywhere."

Urban Dynamics is about the way cities could be, but more important, it is about the *realities* of cities whose attributes are shaped by human decisions but also the dynamic properties of cities as complex systems. Acknowledging realities may be difficult, whether these be the realities of limited urban land or a finite planet. By way of illustration, Forrester describes a conversation with an MIT colleague, a social scientist, shortly after *Urban Dynamics* was published. "It doesn't make any difference whether you are right or wrong," the colleague opined, "the results are unacceptable." (2007, p. 348)

Forrester's view of realities, even "unacceptable" ones, is different, perhaps reflecting a childhood growing up on a Nebraska cattle ranch. "A ranch is a crossroads of economic forces," he writes. Supply and demand, changing prices and costs, and economic pressure of agriculture became a very personal, powerful and dominating part of life. Furthermore, in an agricultural setting, life must be very practical. It is not theoretical, nor is it conceptual without a purpose. It is a full time immersion in the real world." (2007)

For many, especially many in academic settings and in national leadership roles, the realities of relative attractiveness, physical limits and overshoot Forrester described in *Urban Dynamics* and *World Dynamics* 40 years ago remain abstractions to be debated rather than realities that must be faced. For Singapore's leaders, the challenges they faced in August 1965, when irreconcilable differences with Malaysian Federation leaders thrust independence upon them, made things different.

Singapore's Success[11] and Urban Dynamics

Singapore's independence day did not herald a success story

Reading Lee Kuan Yew's description of events surrounding independence and the immediate problems he faced, one is reminded of Dennis Meadows's descriptions of challenges leaders and peoples might face during a period when one or more major global systems collapsed due to overshoot. The problems were unanticipated, multifaceted, immediately threatening and without precedent. Singapore was cut off from its economic hinterland and from the role she had played as a regional entrepot since Sir Stamford Raffles founded the colony in 1819. Trade had dwindled to a trickle as Malaysia and Indonesia sought alternatives to an independent Singapore and threatened military intervention. Unemployment was 14% and rising, creating stresses in Singapore's multi-communal society that threatened law and order (Lee Kuan Yew, 2000, p. 23).

[11] We have borrowed from the title of Henri Ghesquiere's fine book (2007) for this section's heading, though our brief discussion omits many important issues he raises. Richardson also had the opportunity to sit in on his class, 'Singapore's Development: A Comparative Perspective.' Our understanding of Singapore was greatly enriched by the experience.

Singapore's water supply came across a causeway from Malaysia. Lee had youthful memories of how Japanese soldiers had cut off Singapore's water supply, demoralizing British defenders and forcing them to surrender (Lee Kuan Yew, 1998, p. 22). Three years earlier, in speeches supporting a vote favoring independence, Lee had argued that Singapore could not be viable on its own; that its future lay with Malaysia. Now, newspapers in Australia and London echoed his views (2000, pp. 19-20). The challenge Singapore's leaders and her people faced, as independence was announced, was survival. Lee writes:

> "We had to create a new kind of economy, try new methods and schemes never tried before anywhere else in the world because there was no other country like Singapore… We had to make extraordinary efforts to become a tightly knit, rugged and adaptable people who could do things better and cheaper than our neighbors… We had to be different." (2000, pp. 23-24)

While Singapore faced daunting challenges, she was not entirely devoid of advantages, as Henri Ghesquiere has noted. Most inhabitants were recent immigrants and while the society lacked cohesiveness, it was not weighed down by a historical legacy of "internal divisiveness that comes from old injustices." A predominantly immigrant population might be prepared to abandon old habits and seize new opportunities. Its traditional role as an entrepot center for the British Empire (though hostile neighbors were committed to supplanting this role) bequeathed financial and communications institutions supporting trade to the new nation. Ghesquiere also notes British legacies such as English as the working language (though mostly among the elite), a functioning civil service, strong educational institutions and 'rule of law' of traditions (2007, p. 41-42). Of course, many British colonies began life as new independent states with comparable or far greater advantages, and many fewer disadvantages. Putting those advantages to good use was the challenge.

Singapore succeeded. It now ranks as one of the richest countries in the world, in terms of per-capita purchasing power parity (Ghesquiere, 2007, p. 13) and one of the most livable cities in Asia (Business Week Interactive, 2007). Its top rankings in many categories – attractiveness for business, community health, public safety, freedom from corruption, rule of law, best international airline and airport, are almost accepted as routine (though used by Singapore's political leaders to motivate her people to continue striving for excellence). Today, many dismiss Singapore as a special case from which little can be learned. We disagree. In 1965, no one would have pointed to Singapore as a success story from which lessons could be drawn.

The Singapore story viewed through a lens of literature and personal experience

This section emphasizes facets of that success story that are relevant to the issues raised above. Our goal is to highlight aspects for readers who are unfamiliar with Singapore's post-independence history or only know it as a caricature, perhaps from one or two critical newspaper articles or even a short visit as a tourist. A brief reflection on why we chose Singapore and how we have chosen to portray it may be in order. We believe Singapore's rags-to-riches transformation embodies principles and practices that can be applied in other settings. Many correspond to principles emphasized by Jay Forrester, based on an analysis of his generic city, the *Urban Dynamics* model. For other cities whose leaders face daunting challenges, though some different than those Singapore faced, this offers hope.

We also chose Singapore because we live there. One author is a lifetime resident, the other a very recent arrival who is viewing Singapore with new eyes, albeit eyes sensitized by field research in other Asian cities with very different development experiences. In our description, scholarly accounts and personal reflections are intermingled.

The terrain we briefly survey has, of course been surveyed by others in greater depth than this paper allows. Lee Kuan Yew's remarkable two-volume autobiography (1998, 2000) provides a rich chronicle by one of the world's remarkable political leaders. Henri Ghesquiere's volume, *Singapore's Success* (2007) provides a refreshingly clear and succinct account of Singapore's economic development. Kenneth Paul Tan's edited volume, *Renaissance Singapore?: Economy, Culture and Politic*s (2007) demonstrates that criticism of Singapore from within the country is not out of bounds, especially when pursued with civility and good humor. Neo Boon Siong's and Geraldine Chen's *Dynamic Governance* offers a unique 'insider' perspective on Singapore's successes. Obviously we cannot give full justice to these works, and many others. We are also aware that Singapore has its critics. For those interested, Rodney King's *The Singapore Miracle: Myth and Reality* catalogues critics' major concerns. Responding to them is not our purpose here.

Promoting economic development

Those describing Singapore's success most commonly highlight economic development. From 1965 through 2005, economic growth averaged at 8.5%. (Ghesquiere, 2007, p. 13) Most noteworthy during this period was the implementation of a planning process that was sensitive to changes in global economic circumstances and flexible in seeking out ways to capitalize on them that would work to Singapore's advantage.

Ghesquiere describes the strength of this process as an ability to reframe objectives in order to overcome a succession of "binding constraints*"* that threatened to curb economic growth. (pp. 82-86; Palmade, 2005) Thus, "during 1967-73 Singapore opted for *export-oriented industrialization*, focused on the production of labor-intensive, low value-added items" while investing in petroleum refining and chemicals. "The 1973-84 period targeted *economic restructuring with technological catch up."* [12] The binding constraint of "insufficient indigenous entrepreneurship" was overcome by providing conditions that would persuade multinational corporations to locate in Singapore. Among these were creation of the Economic Development Board that provided high-quality one-stop service to potential investors (Lee Kuan Yew, 2000, pp. 77, ff.) and ~~a~~ the National Trade Unions Congress, which, with the backing of new legislation, ensured strike-free labor relations (Ibid, p. 108, ff.). Few stones were left unturned that would attract profitable new enterprises and skilled managerial-professionals to staff them.

When the 1985 recession revealed "the danger of excessive concentration of exports in a few sectors," Singapore embarked on a new 12-year strategy emphasizing *economic diversification*, sector wise and geographically. …The focus turned to leveraging the city's locational advantage and trade expertise to successfully develop air transportation, telecommunications, logistics, shipping and cargo-handling facilities." Conference facilities and business centers were also emphasized (Ghesquiere 2007, p. 84). Between 1985 and 1997, tourist arrivals increased from about 3 million to more than 7 million. (Singapore Tourist Board 2000, p. 24)

[12] The italics for emphasis in this section are the author's.

Singapore weathered the 1997-1998 Asian financial crisis with no major dislocations (Lee Kuan Yew, 2000, pp. 101, 202). However, this motivated another reassessment and new priorities, emphasizing the strengthening of Singapore an "advanced and globally competitive *knowledge intensive economy*. Ongoing restructuring (aimed) to ensure long-term competitiveness…" Singapore sought to become "a key node in a global network of people and ideas" with emphasis placed on "marketing and design services and on making Singapore a choice location for international events." (Ghesquiere 2007, p. 84-85)

Free market principles have been at the heart of Singapore's economic development strategy since Lee Kuan Yew first sought advice from former UNDP consultant Albert Wisenmius on industrialization, fiscal and monetary policies.[13] Success in implementing these principles is confirmed by international rankings. Singapore was ranked no. 2 on the Heritage Foundation Index of Economic Freedom for 2010 (Heritage Foundation, 2010), no. 1 on the World Economic Forum's Global Enabling Trade Report for 2009 (World Economic Forum, 2009), and no. 2 in the Economic Integration Index of the Pacific Economic Council. (Chen Bo and Woo, 2008)

These rankings must not, however, obscure the disciplined role played by Singapore's government in ensuring the stability and predictability that its "clients", top executives of multinational corporations, required. (Lee Kuan Yew, 2000, pp. 73-88; Ghesquiere, pp. 87-97) Moreover, the government did not shrink from establishing publicly-held corporations, where attractive niches beckoned, and managing them profitably. The term "profitable public corporation" is not an oxymoron in Singapore. Singapore Airlines, regularly ranked by international travelers as #1, is the best-known example, but by no means the only one.

A not-unrelated factor setting Singapore apart is the high salaries, probably the highest in the world, paid to senior public officials. These are intended to ensure that the government can compete with the private sector for top talent and that 'revolving door' practices such as in the US, where officials use government jobs as stepping-stones to high salaried private-sector positions in the private sector are avoided. Salaries are set at two-thirds of the amount paid to occupants of comparable positions in the private sector as determined by income tax returns. (Lee Kuan Yew, 2000, p. 195). The high salaries are coupled with draconian, effective measures to ensure "clean government", administered by an independent public commission. (Ibid., p. 188, ff.)

The government's role in ensuring non-confrontational labor relations has already been emphasized. This was one element in a set of pragmatic policies that also included free trade and monetary policy that sustained a stable currency. Fiscal, discipline, with strong safeguards against deficit spending, contributed to low inflation. Ghesquiere terms this approach 'pragmatic policy adaptation', noting that it was not so much the framing of development plans as their consistent implementation that set Singapore apart. He concludes: "Singapore's development experience by contrast (with those of other developing countries) shows many instances of policies that were highly predictable. They were carefully engineered to be mutually reinforcing, creating virtuous cycles". (p. 90)

[13] Wisenmius advised Singapore's government, serving in a in a pro-bono capacity, for 23 years.

Ensuring the well-being of Singapore's people

We began our discussion of Singapore's success with economic growth because it is as a leading free market economy (and one of the world's best tourist and shopping destinations) that Singapore is best known. But we do not believe Singapore's leaders ever viewed economic development as an end in itself. Rather, it has always been seen as a prerequisite to realizing two strategic priorities, which were viewed as interrelated. The first was securing the well-being of all Singaporeans in their daily lives. The second was securing national survival in a world viewed as economically and politically turbulent and in a region populated by neighbors with hegemonic aspirations that viewed Singapore, with its majority Chinese population, as an alien presence.[14]

Economic growth provided the resources that made policies intended to enhance well-being possible. Because this paper focuses primarily on lessons to be learned from Singapore's development *as a city*, minimal attention will be given to the geopolitical considerations impacting on Singapore's development, though successful management of geopolitical challenges was obviously essential to Singapore's success. For those interested, a good place to begin is with Lee Kuan Yew's masterful treatment of the subject in Part II of the second volume of his autobiography. (Lee Kuan Yew, 2000)

Academics and development practitioners have debated the meaning of human well-being for decades. The goals of PAP leaders were practical and concrete. Priority was given to public security, housing, water and sanitation, health care, education and job opportunities. Later, public transport and creating physically appealing public spaces ("Clean and Green Singapore") were added to the list.

Singapore's achievements on these dimensions of human well-being are comparable to its economic development achievements. The 2008 Mercer Survey ranked Singapore 9th among the World's safest cities (Best City Reviews, 2008). On Transparency International's *Corruption Perceptions Index* (2009), Singapore ranks #3.[15] Clean water and sanitary facilities are available to every Singaporean. The estimated infant mortality rate in 2009 was 2.3, one of the lowest in the world. Life expectancy for both males and females is over eighty years. Adult literacy is over 92%, up from less than 65% in 1960. Nearly 90% of Singaporeans have secondary or higher educational qualifications.[16] This year, television reports are describing Singapore's current unemployment rate at just slightly higher than 2%.

Singapore's higher education policies provide a good example of how government planners linked programs to improve human well-being with national economic development objectives. Ghesquiere describes how in the 1960s, the national educational goal was to produce skilled artisans and technicians and avoid turning out unemployable white-collar graduates (2007, p. 77). When expanding higher education became a priority, entering classes were kept small to ensure high quality. Admission requirements were rigorous. Generous scholarships were awarded, but quickly withdrawn from students who did not perform at a high standard. Emphasis

[14] This view was reaffirmed by journalist Tom Plate in a recent book that reports on two lengthy days of interviews he held with former Prime Minister Lee Kuan Yew (2010).

[15] Rankings of other Asian countries are Hong Kong #12, Japan #17, Taiwan #37, South Korea #39, Malaysia #56, India #84, and Indonesia #111. The United Kingdom ranked #17; the United States #18.

[16] These data are from a database we have compiled using data from the Singapore Department of Statistics (Singstat online) and the World Bank World Development Indicators, online.

was given to curricula in science, engineering, information technology and management to meet the needs of Singapore's expanding high-technology economy (Ghesquiere, 2007, p. 78).

The PAP leadership's commitment to human well-being reflected its origins as a socialist party.[17] But its philosophy differed radically from that of the OECD countries, which in 2001 expended more than 13% of GDP on welfare, while Singapore expended less than 1%. Its approach more closely reflected Jay Forrester's hotly criticized recommendations that welfare programs for the underemployed be limited. Lee Kuan Yew writes (2000, p 126): "We noted by the 1970s that when governments took primary responsibility for the basic duties of the head of the family, the drive in the people weakened. Welfare undermined self-reliance. The handout became a way of life."

Singapore's alternative was the Central Provident Fund (CPF), a program of government-mandated savings over which workers had control and which was intended for retirement and home ownership. Like Singapore's health care system (see Ghesquiere, 2007, pp. 67, ff.) the CPF system places maximum emphasis on individual discretion, individual responsibility and the operation of market mechanisms to influence user choices. These principles are illustrated particularly well in an innovation that is distinctively Singaporean and, once again, consistent with *Urban Dynamics*. We refer to programs that have resulted in widespread home ownership of government constructed and managed "public housing".

Balancing commercial and housing demands on the land

As a small island state, Singapore has severe physical constraints to contend with. Leaders have had to set aside sufficient land for businesses, financial centers and industries while at the same time making sure that the needs of the population for housing, open space and recreation are met.

Despite a population density of 7,022 per sq km, one of the world's highest, only 15% of Singapore's land has been allocated to housing and only 17% to recreational and community needs. The rest is used for commerce (4%) and industry (10%), infrastructure, utilities and transport (17%) and reservoirs, defense facilities, and cemeteries and undeveloped land (37%). Plans are underway to set aside an ample proportion of the latter to support high-technology commercial development (Economic Strategies Committee (ESC) Subcommittee Report, 2009).

How has Singapore overcome the obstacle that Forrester targeted as one of the major impediments to sustaining a vital economy: the preponderance of substandard housing attracting the *underemployed?* In 1960, only 9% of Singapore's population occupied public housing and much of the city's housing stock resembled the overcrowded deteriorating stock of *underemployed housing* described in Forrester's hypothetical city. Today, an astonishing 82% of Singaporeans live in "Housing Development Board" apartments (HDB flats) clustered in high-density public residential estates. HDB flats are ubiquitous in Singapore's landscape (though less so in areas most commonly frequented by short-term visitors). A second statistic is equally astonishing to those familiar with the failed public housing projects in large US cities and on the outskirts of cities in Russia and former Communist bloc countries: *virtually all of the HDB flat residents are homeowners*.

[17] The PAP was a member of the Socialist International until 1976 when it withdrew to avoid expulsion on the grounds of suppressing independent labor unions and freedom of the press (Ghesquiere, 2007, p. 79).

For Lee Kuan Yew, the opportunity for near universal home ownership was a key element in his plans to build a stable society based on shared responsibilities and shared commitments. He writes:

> "My primary preoccupation was to give every citizen a stake in the country and its future. I wanted a home-owning society. I had seen the contrast between blocks of low-cost rental flats, badly misused and poorly maintained and those of house-proud owners, and was convinced that if every family owned their own home, the country would be more stable. …If a soldier's family did not own their own home, he would soon conclude that he would be fighting to protect the properties of the wealthy. I believed this sense of ownership was vital for our new society with no deep roots or common historical experiences." (2000, p. 117)

When the program was created, HDB flats were targeted for lower and middle-income residents with means-tested subsidies provided to those who could not otherwise afford home ownership. This practice has continued, though as Singapore has become wealthier, the value of flats has appreciated. Housing Development Board staff are continually adjusting rules and procedures to strike a balance between allowing for the operation of market forces and keeping the program true to its objectives, though in a very different Singapore than when it was created.

Flats are located in public housing estates, each of which is equipped with amenities such as markets and food centers, schools, community or regional libraries, places of worship, shopping and entertainment complexes and parks. They seek to achieve the ambience of small communities – often there are also government-sponsored community centers. High quality maintenance is also a priority. Upgrading of these flats and estates is ongoing. Singapore's efficient public transport system provides easy and affordable access for residents to commute and travel to other parts of the city.

Land use planning has been greatly facilitated by another distinctive Singapore characteristic. Passage of the 1966 Land Acquisition Act began a process through which Singapore's government now owns about 90% of the total land area (Ghesquiere, 2007, p. 80). Balancing the limited supply of land with competing demands has only been possible through combining officials' integrated, long-term approach to land use and infrastructure planning with major demolitions. But commercial development has by no means been the only priority.[18] For instance, park connectors have been built to allow the public to travel between parks on foot, bicycles and rollerblades. New integrated activity hubs are being developed to spatially distribute economic activities. Government planners have now initiated plans to measure land productivity in terms of its yield, using indicators such as jobs, spillover and value capture per hectare. (ESC Subcommittee Report, 2009)

Ensuring public confidence and stability through strong and sustained leadership

Prime Minister Lee Kuan Yew set the tone for self-confident, decisive leadership, asserting authority and helping to develop the country in tangible ways that improved citizens' lives. He resisted external pressures to adopt the liberal democracy of the West, which he felt was inappropriate to Singapore's culture and level of development. He believed that what the people

[18] See Lee Kuan Yew, 2000, p. 231. Lee writes that to construct Changhi Airport (rated in 2010 as the world's best by international travelers), "we demolished hundreds of buildings [and] exhumed thousands of graves… For an airport of that size, the normal construction time was 10 years. We completed it in six."

want is good government, not a particular form of democracy that had evolved in a very different context. (Han et. al., 1998, p. 376) He pointed to the failures of democracy in most post-colonial states, especially multi-ethnic ones. A good government, he asserted, is one "which is honest, effective and efficient in protecting its people, and allowing opportunities for all to advance themselves in a stable and orderly society, where they can live a good life and raise their children to do better than themselves." (Ibid. p. 380 and also see Lee Kuan Yew, 2000, Chapts. 9 & 14)

The People's Action Party (PAP) has ruled Singapore since self-rule was granted in 1959. Its world ranking of 81 (just below Albania) on the Economist Intelligence Unit's 2008 *Index of Democracy* and comparably low rankings on other similar scales contrasts with its high rankings in other areas. However, PAP leaders take pride in this continuity in office. They believe it has been a key factor in sustaining the coherent policies and long-term planning that have been keys to Singapore's success. They argue that this achievement, which has been ratified in successive elections, affirms their approach to promoting Singaporean's well-being and retaining public trust. (Lee Kuan Yew, 2000, 143, ff.)

Further, they maintain that even with one party, the political succession in the nation is systematically and painstakingly planned, with peaceful handovers and ex-Prime Ministers remaining in the cabinet as influential members. This protects Singapore from the destabilizing and unpredictable leadership changes that have damaged other developing countries. New leaders are untiringly sought, rigorously tested and groomed; the criteria for their selection are their powers of analysis, sense of reality, imagination, quality of leadership and dynamism. Most important of all are their character and motivation, "because the smarter a man is, the more harm he will do society". (Han et. al. p. 338; also see Lee Kuan Yew, 2000, Chapts. 15 & 41)

Engaging the people's hearts and minds

Singapore's stability and success would not have been possible without strong support from her citizenry. Government leaders invest considerable time and effort in communicating goals, priorities, values and policy rationales to the public. Feedback from the public is invited through multiple channels, though civil society organizations common in the US and Europe are not major players. The mass media is expected to play a supportive role in doing this, as well as in reinforcing, not undermining the cultural values and social attitudes being inculcated in schools and universities. Its potential to raise the standards of living in the nation by cultivating a quest by the people for the attainment of knowledge, skills and disciplines of advanced countries is also tapped. (Han, et. al., p. 427)

To engage the hearts and minds of the citizenry, and in particular to share with the post-independence generation the history and struggles of the nation, the present threats and opportunities and her hopes for the future, the National Education (N.E.) program was launched in schools in 1997 as a government-led initiative. The N.E. messages are discussed in class, and lessons and applications are drawn from a wide range of contexts within the academic and co-curricular programs of the schools. The messages are: (Ministry of Defence Nexus website, accessed 19th March 2010)

1. Singapore is our homeland; this is where we belong.
2. We must preserve racial and religious harmony.
3. We must uphold meritocracy and incorruptibility.

4. No one owes Singapore a living.
5. We must ourselves defend Singapore.
6. We have confidence in our future.

Not long ago, The Institute of Policy Studies, a research institute of The Lee Kuan Yew School of Public Policy, sponsored a day-long conference on strengthening Singapore through long-term planning, with wide public involvement. The emphasis was on building community as an essential ingredient of development. The conference was sponsored by 20 organizations, mostly corporations, attended by nearly 300 business and civic leaders and held at a downtown five-star hotel. The Prime Minister spoke for 40 minutes and answered questions for another 30. Seated next to us was the head of the Sony Corporation for Southeast Asia. Community building is taken seriously in Singapore.

Cultivating and maintaining social cohesion in a multi-communal society

One of the most oft-repeated messages from political leaders to the people emphasizes the issue of fostering social cohesion, which is seen as the bedrock for Singapore's future as a nation. Communalism was the issue that broke apart the Malaysian Federation. In other Asian nations, most notably Sri Lanka, it has fostered divisiveness and sapped promising economic development initiatives. In Singapore, political appeals based on communalism are forbidden. In Malaysia, preferential treatment for Malay citizens is government policy. At the time of the breakup, Prime Minister Lee highlighted the problem by noting that a statement of government policy on communal issues in Singapore would be viewed as treason in Malaysia and that a statement of government policy on communal issues in Kuala Lumpur would be viewed as treason in Singapore.

Singapore's population is a melting pot of immigrants from different racial, cultural and religious affiliations and backgrounds. Singapore's leaders were mindful of the dangers communal conflict posed from the outset. (Lee Kuan Yew 2000, Chapts 1 and 6). S. Rajaratnam, Singapore's first Minister for Foreign Affairs and the author of the nation's citizen pledge said, "the communal problem…must be and will always remain one of the major problems which, if we do not resolve intelligently, could break our society, especially of an independent Singapore." (Kwa, 2006, p. 155)

The stakes are high: situated in the Malay Archipelago, and the only Asian nation outside of China (including Taiwan) with a predominantly Chinese population, Singapore has been described as a "juicy Chinese nut in a Malay nutcracker". This is apt, as the city-state is sandwiched between two much larger neighbors who have at various periods in history been openly antagonistic in their policies and stances towards her. Perceived injustice towards Singapore's small Malay population might well trigger hostility and aggression from these quarters. (Singh, 2007, pp. 9-10)

Courting and controlling immigration

This goal of sustainable social cohesion has been extended to foreigners working in Singapore and permanent residents in the city-state. This matter is especially critical to a country like Singapore, which has one of the highest percentages of foreigners in the world. A third of Singapore's total population of 4.99 million is foreigners working in Singapore. Of the remaining 3.73 million, 14.3% are permanent residents and 85.7% are citizens. (Singapore Statistics Online, accessed 19th March 2010)

Immigration policies are regarded by Singapore's leaders to be of critical importance to the nation's survival. The city-state faces an impending working population decline due to a very low total fertility rate of 1.23, further aggravated by having one of the fastest ageing populations in the world. In tandem with efforts to promote marriage and parenthood to boost her distressingly low fertility rate, Singapore's leaders have chosen to recruit foreign talent using the job opportunities created by its high-performing economy and high quality of life as recruiting tools. These policies have so far engineered a doubling of Singapore's immigration rate from 7.98 per thousand in 2002 to 14.3 per thousand in 2008. There was an average of 48,300 new permanent residents over a five-year period from 2003 to 2007. A target of 20,000 new citizens has been set, in anticipation of the shrinking of the resident population from 2025 when deaths outstrip births. (Hussain, 2010)

The rationale Singapore's leaders have given for this aggressive intake of foreigners is that immigrants make up for the children that Singaporeans are not having, address the threat of a declining economy with a shrinking labor force and reduce the future burden of young Singaporeans. (Oon and Goh, 2009) This is the unequivocal message that has been continually communicated to the citizenry in a bid to help them understand the intents of their leaders and to address their concerns about the impact that newcomers may have on their lives and those of their children.

Nevertheless, measures have been put in place to control the size and nature of the immigrant pool. Only those who increase the average level of competence of Singaporeans are accepted; they must have skills and at least secondary, preferably tertiary education. (Oon and Goh, 2009) Care is taken to monitor the intake of immigrants so that the racial balance in the city-state is not upset. Housing regulations prevent enclaves of immigrants of the same race or nationality from forming, and newcomers are educated on social norms. In addition to such attempts to preserve the character and values of Singapore society, Singaporean's interests are protected with measures targeted at widening the gaps in benefits between those accorded to permanent residents and citizens in the areas of housing, education and healthcare. (Hussain, 2010)

This highlights an awareness of the social and physical limits faced by the city-state in receiving immigrants. The adverse impact that a dependence on foreign labor has on industrial operations and productivity levels has also been recognized. Levies were raised early this year to reduce industries' reliance on foreign labor, and 5.5 billion Singapore dollars has been earmarked for use over the next five years to upgrade the skills of Singaporean workers and raise their productivity. Notwithstanding this, the government leaders continue to uphold their stance: that the city needs people with entrepreneurial abilities and higher skills to grow the economy and create jobs and income growth for lower-skilled workers. (Shanmugaratnam, 2010)

Singapore's Finance Minister, Tharman Shanmugaratnam, made this clear in an article which he wrote for the national paper:

> "Slow growth will make everybody worse off, but it will have the harshest impact on those at the bottom.
>
> "Our basic approach therefore must be to maximize opportunities for all Singaporeans – opportunities to get a good education, to work or to start a business, to retrain and upgrade, to own a home and raise a family in a community they feel they belong in.

> "We should never reduce the incentive for people to work and to make the most of their skills and talents. That has to be the basis for our society, for how we keep our economy growing, and for how we must strive to raise living standards for all Singaporeans including those in our lower-income groups." (Shanmugaratnam, 2010)

Developing a strategy for sustainable development

Singapore's approach to the use of land exemplifies an overall sustainable development strategy. This strategy was developed over the past forty years and grew out of necessities dictated by limited land and no natural resources.

It is based on an integrated, long-term and comprehensive planning approach that involves technical agencies across ministries coming together to plan land use and infrastructure, and water and energy management and use. Secondly, this is supported by the use of a highly pragmatic approach to achieving environmental sustainability outcomes through the use of the most viable and cost-effective methods and breakthrough innovations in technology.

A third element in this strategy is the willingness to make difficult trade-offs. Singapore's Minister for National Development, Mr. Mah Bow Tan, explains it this way: (Ministry of National Development website, accessed 3 March, 2010)

> "Tough trade-offs between the needs of the economy and housing, between housing and conservation, and between development and preservation of nature areas must continue to be made, especially in a small and resource scarce city-state like ours. We want a virtuous cycle of economic growth and a higher quality of the living environment supporting each other, and not place one objective before or at the expense of the other."

Water management – an illustration of Singapore's sustainable development strategy

Singapore's management of water provides an apt illustration of this three-pronged sustainable development strategy. It may serve as a model, for cities and nations facing limited supplies that have been an issue for Singapore since Independence Day. To ensure a clean and reliable supply of potable water, Singapore has had to substantially increase the number and size of water catchment areas and prevent the collected water from leaking away or being polluted. Such an exercise was large-scale as it affected land use, transport planning, water treatment, sanitation and sewerage, and involved close collaboration between the Public Utilities Board (PUB) and other government agencies.

Earlier experiments with recycling water were abandoned because the process was expensive and unreliable. However, with breakthroughs in water technology, a new water reclamation study was set up in 1998, leading to the production of recycled water (NEWater). NEWater is produced using a purification process using dual-membrane and ultraviolet technologies to transform wastewater to high purity water suitable for human consumption and industrial use. As NEWater is purer than tap water, it is more cost-effective to use, as water fabrication and semiconductor plants no longer have to incur the costs of purifying tap water for their use.

Tough tradeoffs were involved in Singapore's water management policies. Currently, she has fifteen reservoirs (including Marina Barrage – the first reservoir in the city) which together occupy very substantial portions of the city-state's land (Lee, 2005). The view among Singaporeans is that a cutoff of the water supply from Malaysia would incur costs and require

adjustments but not jeopardize the nation's survival. Through technology, disciplined management and conservation, the threat to Singapore posed by the limited availability of water has been overcome.

Notwithstanding this, one of the targets that the Singapore government has set for 2030 is the reduction of domestic consumption to 140L per person per day. Other targets include achieving a 35% improvement in energy efficiency and attaining a recycling rate of 70%. In addition, 70% of all journeys will be made via public transport by 2030 (Sustainable Blueprint Report, 2009).

Singapore's success and *Urban Dynamics*

We have found no evidence that Lee Kuan Yew and his colleagues were aware of *Urban Dynamics* or *World Dynamics* in making the decisions that guided Singapore's development.[19] But they have coped with challenges of scarce water and scarce land. They have curbed population growth and avoided many of the pitfalls about which *Urban Dynamic*s warns. In the 45 years since independence, they have implemented policies that have secured the well-being of Singapore's people. They have been sensitive to the need for resiliency in the face of challenges that physical limits and the uncertainty of the wider world posed.

If one compares the lessons of *Urban Dynamics* with the policies of Singapore's leaders during the last 45 years, the correspondences are significant. Singapore's leaders have been foresighted about the need to balance short-and long-term priorities. They have been realistic in balancing the strengths and shortcomings of human nature. They have provided rewards for those talented individuals who could create value in public and private spheres, while not closing off opportunities for upwardly mobile members of the working and underemployed classes. They have achieved goals that are judged by many to be prerequisites for attaining well-being and development: a quality of life that is physically secure and a government that is free of corruption. Their planning encompasses a time horizon as long as fifty years and is taken seriously. Long-term plans are adjusted in response to changing conditions, but not in response to shifting ideological and political winds. For these reasons, Singapore's society and political economy may be more resilient than most in moving beyond the crisis. This will not necessarily involve a willingness to change programs and policies that have worked in the past. It will involve being alert to new global economic, ecological and political challenges. It will involve 'beating the competition' in order to ensure Singapore's survival and the well-being of its people.

Conclusion: Messages for Singaporean Leaders and Singaporeans

A paper's conclusion should have an audience in mind and should be clear about what its authors wish audience members to learn or what actions they wish them to take. In the foreseeable future, we anticipate there will be opportunities to present the ideas described in this paper to groups in Singapore that are concerned with long-term planning. There may also be meetings with those holding similar positions in cities other than Singapore, but facing very different

[19] A conversation with a senior government official who worked closely with Prime Minister (now Minister Mentor) Lee confirmed this.

challenges. We also intend to communicate with members of the System Dynamics community, taking advantage of whatever venues and opportunities offer themselves. Since our Singapore meetings are coming first, we have chosen to target that audience with our conclusions. Messages for others are implicit in what we have written. However, we will direct more explicit messages toward them in later iterations.

Message 1. Warnings about impending global-scale problems should be taken seriously. Creating systems that will scan for early warnings of overshoot and collapse should be a priority.

Perhaps the most important message for Singapore audiences, both governmental and academic, is the one with which we began this paper. There is a global-scale crisis. The causes of the crisis, writ large, are the high probabilities of overshoot and collapse. Among the consequences about which we can be certain are rising energy prices and the consequences of global warming, including rising sea levels and more turbulent weather patterns whose character and impact cannot yet be fully anticipated. Most likely, by mid-century, there will also be significant political and economic turbulences to which Singapore must adapt.

Message 2. Singapore is as well positioned to deal with potential crises as any city or nation, but needs to further build upon its strengths of adaptability and resilience, as well as future scanning and planning institutions that emphasize the long term.

At the *Singapore Perspectives* conference alluded to earlier, Prime Minister Lee Hsien Leong offered a telling characterization of his nation's position. As an actor on the world stage, he said, "we are a bantamweight." Candidly acknowledging this reality has been another of Singapore's strengths. As a 'bantamweight' nation facing a future with strong elements of unpredictability, Singapore's leaders should continue to emphasize the fundamental goal of enhancing the well-being of her people. Policies should continue to be flexible in seeking an appropriate balance between incentivizing the most able in the society and ensuring that all Singaporeans feel they have a stake in their community. Leaders should be alert to pressures from more wealthy Singaporeans for changes that may lead to the inter-generational "systems-trap" of "success to the successful" (Donella Meadows, 2008. P. 150). An example would be creating circumstances in employment and especially education where children of the well-to-do were able to advance on the financial and influential coat-tails of their parents' achievements, rather than by their own merit. They should continue to ensure that the best and brightest are incentivized to join the government service. They should sustain Singapore's commitment to financial resilience and strengthen early warning systems to detect instabilities in the global financial system. They should sustain and strengthen mechanisms for environmental scanning and long-term planning that have served Singapore so well.

Message 3. System dynamics modeling can help and, in particular, should become an integral part of Singapore's primary and secondary education requirements.

Through the efforts of Daniel Kim (2002) and others, principles of organizational learning and systems thinking, grounded in Peter Senge's path-breaking work (2006), have made considerable headway in Singapore. System Dynamics modeling is less well known. Jay Forrester has questioned the utility of "systems thinking" that is not grounded in System Dynamics Modeling. We agree with Forrester that raising consciousness about properties of complex systems with

systems thinking approaches is useful, but believe that the full value of this will only be realized if more rigorous training in System Dynamics modeling is made available.

For a country like Singapore, with her emphasis on capitalizing on new opportunities, providing leadership and being better than the competition, the breakthroughs in teaching System Dynamics modeling at the primary and secondary level, exemplified by work of the Learning Exchange Network offer particularly exciting possibilities. The notion that System Dynamics modeling might be required in the curricula of every primary and second school student in Singapore is not out of the question. How would a city and nation be changed by an entire generation of young men and women for whom the lessons of system dynamics modeling were integral to their world view? This might be exactly what bantamweight Singapore will need to do to prosper as brilliantly in the 21st Century as it did in the 20th.

Message 4. Singapore's leaders and people should consider the challenge of creating and modeling a paradigm that offers a compelling alternative to humanity's current growth-oriented one.

Lastly, we believe there is a new opportunity that awaits Singapore. Having provided the world with a path-breaking model for moving "from third world to first", there is a possibility it could offer the world a similarly path-breaking model of an equilibrium society. From the early days of global modeling, proponents of sustainability have known that fundamental changes in attitudes would be essential if humanity was to move beyond the crisis. But we have failed utterly in our efforts to create and market a compelling paradigm emphasizing equilibrium that could compete effectively with dominant paradigms emphasizing consumption-based growth. "Paradigms are the sources of systems," Donella Meadows has emphasized. "From them, from shared social agreements about the nature of reality, come system goals and information flows, feedbacks, stocks, flows and everything else about systems." (Donella Meadows, 2008, p. 163).

While no paradigm of an equilibrium society has yet caught public attention, there is one that is more compelling than most. It is found in the conclusion of *Beyond the Limits,* the book describing the second iteration of *World3*. (Donella Meadows, et. al. 1991) Among the most important elements are these:

- Sustainability, efficiency, justice, equity and community as high social values.
- Leaders who are honest, respectful and more interested in doing their jobs than keeping their jobs.
- Material sufficiency and security for all, with low death and birth rates and stable populations.
- Work that dignifies people instead of demeaning them. Some way of providing incentives for people to give their best to society and be rewarded for doing so, while still ensuring that all people will be provided for sufficiently under any circumstances.
- An economy that is a means and not an end, one that serves the welfare of the human community and the environment rather than demanding that the community and the environment serve it.
- Political structures that permit a balance between short-term and long-term considerations. Some way of exerting political pressure on behalf of the grandchildren.
- High skills on the part of governments and citizens in the art of non-violent conflict resolution.

- Reasons for living and thinking well of oneself that do not require the accumulation of material things.

We have been familiar with this list for many years, but not until now had we considered it in the context of Singapore. While her commitment to a growth-oriented paradigm is still evident, on many elements of this list Singapore already scores well, better than most cities and nations. Moreover, we are not saying that the vision in *Beyond the Limits* of an equilibrium society will provide the needed basis for paradigm change. We are saying there is a need to create an alternative paradigm of an equilibrium society. Such a paradigm must demonstrate that sustaining high levels of human well-being that does not depend on exponentially growing consumption of material resources, in a turbulent world of overshoot and collapse, is possible. That is Singapore's next challenge – and opportunity.[20]

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