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Evolutionary urban transportation planning? An exploration

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Abstract

For urban transportation planners these are challenging times. Mounting practical concerns are mirrored by more fundamental critiques. The latter come together in the observation that conventional approaches do not adequately account for the irreducible uncertainty of future developments. The central aim of this paper is to explore if and how an evolutionary approach can help overcome this limit. Two core-hypotheses are formulated. The first is that the urban transportation system behaves in an evolutionary fashion. The second hypothesis is that because of this, urban transportation planning needs also to focus on enhancing the resilience and adaptability of the system. Changes in transport and land use development patterns and policies and in the broader context in the post-war period in the Amsterdam region are analysed in order to illustrate the two core-hypotheses. In the conclusions more general implications are drawn.

1. Introduction

For urban transportation planners these are challenging times. On one side, and in spite of all the hype about dematerialization of society, physical mobility systems appear ever more crucial in granting individuals and organizations the access to the spatially and temporally disjointed resources they need to thrive or even just to survive. On the other side, because of a heterogeneous mix of mounting financial and fiscal constraints to infrastructure expansion, and growing awareness of and social resistance to the negative impacts of mobility, the traditional 'predict and provide' approach to planning is no longer an option.

Practical concerns are echoed by more fundamental critiques (see for instance Dimitriou, 1992; Gifford, 2003). Central to this more fundamental criticism is the contention that conventional planning methods do not adequately account for the *irreducible uncertainty* of developments affecting transport and its relationship with the broader context. Uncertainty is, of course, inherent to any future oriented activity. There are, however, different forms of uncertainty. As discussed by Van der Heijden (1996), a first form of uncertainty is *risk*, where there is enough historical precedent in terms of similar events to allow the estimation of probabilities for various outcomes (this is the core realm of forecasting); a second from are *structural uncertainties*, where the event, while still conceivable in terms of chains of cause and effect, is unique enough not to provide any indication of likelihood (think at the complex interplay of rising wealth, social emancipation, mass motorization and urban decentralization, as it unfolded in industrialized nations in the post-war period); a third form are *unknowables*, where the event cannot even be imagined (think at the 1973 oil crisis). While all three forms of uncertainty may apply at any time, the likelihood of uncertainties of type two and three increases as the time horizon gets longer and the system gets more complex (that is, with more components and more relationships), up to a point where prediction is no longer possible. As a discipline that also deals with the long term and with highly complex systems urban transportation planning should also be able to come to terms with fundamentally unpredictable events, that is, irreducible forms of uncertainty (the second and the third form).

Yet, a convincing response is still lacking. In the words of Meyer and Miller (2001, p. 519): "No aspect … is as pervasive to the [transport planning] process, and yet as often ignored, as uncertainty". In response, Meyer and Miller stress the need to improve present land use and transportation models. More adequate forecasting models would need to explore the full range of system responses (short and long run) to a broad variety of policy combinations (transportation, land use and other), and do this at the level of individual responses (by means of disaggregated behavioural models). However, and crucially, they also recognize that "Even with 'ideal' … models, uncertainty will still exist with respect to the exact nature of future activity systems" (p. 340). Banister (2002, p. 141) strikes a similar note by remarking: "Some of the limitations of the TPM [Transport planning model] have been met by the ILUTM [Integrated land use transport models]. But the complexity of the land development process, travel decisions and the rapidly changing forms of industry, of population structure, of lifestyles, and of the use of time all contrive to make progress difficult, if not impossible".

This paper attempts to take this more fundamental level of criticism to its consequences. In particular, its aim is to explore if and how an *evolutionary approach* to urban transportation planning can help overcome some of the limits mentioned above, and help develop planning methods that can usefully complement forecasting based ones. The inspiration is drawn from much more advanced conceptualisations in other disciplines, and most notably evolutionary economics and the application of complexity theory to the understanding of cities. Evolutionary and complexity approaches seem especially appropriate because they both recognize the high level of interdependency between the different components of the system and the limits to dealing with such interdependency by means of prediction, because of irreducible uncertainty. Building upon this line of reasoning, two core-hypotheses are formulated with respect to the object and the scope of urban transportation planning. The first hypothesis is that the urban transportation system indeed behaves in an evolutionary, complex fashion. The second, related hypothesis is that because of this, urban transportation policies need to also focus on enhancing the resilience and the adaptability of the system. Changes in transport and land use development patterns and policies and in the broader context in the post-war period in the Amsterdam region are analysed in order to illustrate the two core-hypotheses. In the conclusions more general implications are drawn.

2. An evolutionary approach

Evolutionary thinking originated in the natural sciences but is increasingly being applied in the social sciences and most explicitly in economics (Nelson & Winter, 1982; Dosi & Nelson, 1994; van den Bergh & Fetchenhauer, 2001; Boschma et al., 2002). Intriguing parallels can be also found in works adopting theories and methods of the emerging science of complexity - and particularly the concept of self-organization –most notably including applications to the analysis of cities (Allen, 1997; Portugali, 1999; Batten, 2001; but see already Jacobs, 1961). Characteristically of all these streams of work, the assumption of (a single) equilibrium as 'natural' state of the system is questioned, and attention is rather directed to far-from-equilibrium processes of change. It is acknowledged that different social actors can react differently to similar system-wide perturbations, depending on the specificities of the local context and on their personal features. Individual decisions and actions eventually cumulate into development processes that are both path-dependent – as earlier experiences largely determine the response to new stimuli – and unpredictable – as even small, local differences can have – due to self-reinforcing mechanisms - big, global consequences. Underlying this thinking is the recognition that social systems are *complex* systems, that is, that they are systems characterized by a high degree of interdependency between a wide range of

components and processes. Such complexity fundamentally bounds the rationality of social actors.

A focus on evolutionary economics can help further develop the argument. While there are different interpretations within the field, some basic principles are aptly captured by the notion of microevolution introduced by Nelson & Winter (1982). According to Nelson & Winter, because of irreducible uncertainty, the existence of transaction costs and the difficulty of change in the short-term, firms tend to follow *organizational routines*, or proven ways of conducting business, rather than consider each time all possible alternative courses of action. On the other hand, the evaluation of current routines can lead firms to their adjustments and even substitution. The results of such *searching process* are, however, also uncertain. Furthermore, because past experiences influence both existing routines and the search for new ones, different firms will typically have different routines and try different alternatives, resulting in a variety of economic behaviour. Eventually, the actual performance of a firm will constitute the major incentive to maintaining or changing a routine. Such performance is largely determined by the characteristics of the *selection environment*, that is, the interplay of demand and supply in the marketplace. The selection environment is not a static entity either, as it will also change as a result of the accumulation of firm-specific processes. In this sense, there is *co-evolution* between the market and individual firms.

The resulting economic reality is one characterized by continuous successions of disturbances and adaptations, which preclude the attainment of a stable equilibrium. Continuous change means that initially successful routines can become less efficient or effective, or even have unexpected consequences. There is no once-and-for-all optimal routine. Furthermore, the nature of the process underlies the incremental nature of change, and the difficulty of more than marginally altering an existing routine. The risk that firms be *locked-in* in a non-optimal routine is therefore always present. The implication is that beyond a certain threshold, marginal change will not suffice and coordinated change will be required. However, because it is uncertain which routine will be able to break the impasse, diversity of and competition among alternatives should be stimulated. It is precisely such redundancy of routines that makes the economic system resilient, that is, capable of continuous performance in the face of changing, uncertain circumstances.

The above conceptualisation of economic reality can be also usefully applied to the object of this paper. Existing transport and land use policies can be seen as *organizational routines*. The broader, changing urban socio-demographic and economic context can be seen as the *selection environment* in which existing policies must continuously prove their worth and the *searching process* for better policies takes place. As also policies, in their turn, affect the selection environment, there is *co-evolution* between environment and policies. The analogy further suggests that there is no universally valid, optimal policy. Accordingly, while learning from practical experiences elsewhere and from theoretical models is important, the value of a solution can only be appreciated in a specific, continuously evolving situation. Understanding the unique set of opportunities and constraints determined by a given historical development path and local configuration of factors is thus crucial. However, because of limits to predictability, only real-life 'policy experiments' (Szejnwald Brown et al. 2004), that is, actual engagement with the selection environment, can give full understanding of these. At the same time, recognition of the unpredictability of the outcome – particularly when the long term is concerned – should also result in recognition of the need to look for ways of improving the ability of the system to react and perform in the face of unforeseen (and unforeseeable) change. More specifically, an urban transport and land use system capable of

performing in the face of unpredictable change would be, in the first place, one capable of continuing to function in the face of change, that is, it must be a *resilient* system. This seems particularly important for system components that cannot change rapidly, or easily (such as a transportation network morphology). Secondly, it would be a system capable of changing itself in response to change in the socio-economic environment, that is, it must also be an *adaptable* system. This would especially apply to system components that, given their nature, can change relatively swiftly (think at a road pricing regime). As the requirements of resilience and adaptability might be contradictory, finding a workable balance between them lies at the heart of the task.

Building upon this line of reasoning, two core-hypotheses can be formulated with respect to the object and goals of urban transportation planning. The first hypothesis is that the urban transport system indeed behaves in an evolutionary, complex fashion. The second, related hypothesis is that because of this, urban transportation policies need to also focus on enhancing the resilience and the adaptability of the system. Changes in the transport and land use development patterns and policies and in the economic and socio-demographic context in the Amsterdam region in the post-war period are analysed in the following sections to illustrate the two core-hypotheses. The goal of this exercise is not so much that of providing an interpretation, let alone a conclusive one, of these events, but rather that of exploring to which degree they can be characterized as evolutionary and complex. For this purpose, the two core-hypotheses are further articulated in the following sub-hypotheses:

- The behaviour of the urban transport system can be characterized as evolutionary and complex because:
  - The system alternates periods of incremental, quantitative change and periods of radical, qualitative change, or system transition phases
  - In all periods, change in the system is path-dependent, that is, existing patterns of transportation networks, land uses and transport and land use policies limit the scope for change
  - However, during transition phases both the scope for policies to influence the outcome and the unpredictability of such outcome are greatest

- Because of path dependency, policies need to:
  - Build upon the unique set of opportunities and constraints for change determined by a specific historical development path and local combination of factors
- Because of unpredictability, policies need to:
  - Increase the resilience of the system, that is, its ability to keep functioning in the face of unexpected change. This seems especially important for the shape of transportation networks, as this is relatively difficult/slow to change
  - Increase the adaptability of the system, that is, its ability to react to unexpected change. This seems especially important for land use regulations and mobility management measures, as these are relatively easy/fast to change

Developments in the Amsterdam region are summarized in Tab. 1, Box 1, Box 2 and Fig. 1. In the following section, they will be used to illustrate the two sets of hypotheses.

TABLE 1, BOX 1, BOX 2 AND FIGURE 1 ABOUT HERE

3. Illustrating the hypotheses

3.1 The nature of change

Behaviour of the urban transport system in the Amsterdam case can be characterized as evolutionary and complex because:

- ***The system alternates periods of incremental, quantitative change and periods of radical, qualitative change, or system transition phases***

The alternating of periods of (more predictable) quantitative change and periods of (less predictable) qualitative change, or transition phases can be observed in all the domains of change described in Tab. 1. This pattern of development is best shown by the existence of trend-breaking points. Trend breaking points are defined here as changes in the nature of development rather than in the amount of development (for instance a shift from an industry-based to a service-based economy as opposed to a change in the rate of growth of an economy). For clarity, in the following transitions the different streams of change will be discussed sequentially. This should not conceal the fact that they are in reality strongly interrelated. Some feel for these interdependencies can be obtained from Box 1 and Box 2, where two major transport and land use policy transitions are discussed in some detail.

Socio-demographic transitions

There are two trend-breaking points in the population development of Amsterdam: in 1959, when the population in the central city starts to decline in absolute terms, and in 1985, when it starts to grow again. Contributing to this, are other demographic trend-breaking points (Wintershoven, 2000): 1973, when the national migration balance first starts improving; 1975, when the birth rate in the city first starts to rise again; the 1970s, when the international migration balance becomes positive (albeit strongly fluctuating since). Crucially, change is not just of a quantitative nature. Particularly the 1960s and 1970s were also a period of radical, and fairly abrupt cultural change, including far-reaching phenomena as the emergence of mass-consumption, women emancipation, a youth culture, etc. While many of the new lifestyles thrived in the city, the more traditional, middle-class family households started a massive migration to the suburbs. Later on, and further enriching the picture, the 1980s and 1990s saw the emergence of a new, extensive multicultural dimension in the city fuelled by national and international migration trends, but also – and perhaps more surprisingly - a comeback of urban living by choice.

Economic transitions

As far as economic trends are concerned there is a first major trend-breaking point in the 1970s, where following global developments epitomized by the first oil crisis of 1973, and after a long period of sustained growth, the urban, regional and national economy all fall in a decline that will last until the second half of the 1980s. Older centres in the region, such as Amsterdam and Haarlem are the worst hit. The 1990s were, on the contrary, growth years, with the Dutch economy consistently performing above the European average and the Amsterdam economy performing above the national average. The economic upheaval of the 1990s is of a decisively qualitative nature: growth has taken place within the context of a radical shift from an industry-based, nationally coordinated economy to a service-based, rapidly globalising economy, and has been spurred by the emergence of new leading sectors and locations as business and financial services in the southern urban fringe, tourism, leisure and new media in the historic city centre, logistics in the airport area. The emergence of

Schiphol airport as one of a few major European passenger and freight hubs is tightly linked to all this.

Land use policy transitions

The 1970s are also a major transition phase in land use policies. These are years of extreme policy turbulence, resulting in a radical change of course. This is particularly the case in the dominating attitude towards the historic city centre, where a shift from transformation to conservation occurs (see Box 1). This shift will have a long-standing impact also on land use policy elsewhere (think at the emergence and consolidation of the notion of complementary sub centres in the urban periphery, where office growth rejected from the historic city centre has been increasingly accommodated). A second period of land use policy instability can be observed at the beginning of the 1990s, with the failed attempt at a large-scale, CBD-like redevelopment of the IJ-banks, adjoining the historic city centre (see Box 2). In contrast to these recurring 'city centre turbulences' policies concerned with expansions in Amsterdam's urban periphery and in the suburbs show much less debate and a remarkable stability (essentially the acceptance of decentralization, albeit in concentrated form).

Land use transitions

Changes in land use policies appear to have been both a consequence and a factor of actual land use changes (see land use column in Tab.1). In both Amsterdam and the Netherlands land use policies in the post-war period can be seen as a reaction to wider urbanization trends first and suburbanization trends later. On the other hand, the conservative policies for the city centre adopted at the end of the 1970s have been a factor in determining the unique land use mix that has developed there in the subsequent, partial reurbanization phase. (see "City centre trends, 1975-1999" in Tab. 1). More indirectly, they have also had a role in the emergence of alternative centres in the periphery and in the suburbs, which has assumed a systematic rather than incidental character following the disappearance of expansion opportunities in the historic city centre. There are sharp discontinuities in both broader trends and local policies: the shift from urban expansion to suburbanization as dominating force in the early post-war years, the partial counterweight provided by reurbanization trends since restructuring of the economy in the late 1980s, and the transitions in land use policy discussed in Box 1 and Box 2.

Transport policy transitions

The land use policy debate in the 1960s and 1970s has been mirrored by intense transport policy debate in the same period (see Box 1). Also in this case the focus was the historic city centre, here in the form of contestation of urban motorway and, particularly, railway plans. The resulting shift in transport policy was perhaps even more pronounced than that in land use policy, with an effective halt to both urban motorway and urban railway expansion and a shift to an approach dominated by mobility management and marginal infrastructure interventions (see the traffic plans of the 1970s in Tab. 1). Only during the 1990s, and at the condition of no-harm to the existing urban fabric will new urban infrastructure proposals be allowed to re-enter the political arena (see the local transport policies in the 1985-1999 period in Tab. 1). Even then, the no-harm condition appears to have been a main rationale determining which links were going to be given priority, at least in terms of implementation (compare the relatively short time span from plan to realization of the elevated light rail ring line that opened in 1997 with the much longer and contested planning and development process of the underground north south line, which is set to open in 2011).

Transport transitions

Finally, continuities and discontinuities characterize also actual infrastructure and mobility developments. During the whole period, and particularly since the second half of the 1960s, the motorway system has been dramatically expanded. The same can be said of the interregional railway network. The change was far from quantitative alone, as the superimposition of motorway and railway tangents on the existing radial systems profoundly affected the relative accessibility of locations in the region. These developments, illustrated in Fig. 1, have had profound, largely unanticipated impacts on mobility and activity patterns in the region. The implications of the new structure (the emergence of a new, polycentric and unstable set of activity centres and mobility flows) seem to have been fully appreciated only in the 1990s, when perception of the need to address issues at the urban regional scale has become ubiquitous.

As far as mobility is concerned the main radical change in the period under examination is the advent of mass motorization. Even in this case, policy-makers were at first caught off guard, if not by the phenomenon in itself, certainly by its pervasiveness. However, the reaction as matured through the transport policy transition phase mentioned above and discussed in Box 1 produced, at least within the historic city centre, a set of measures that has long been able to manage mobility (see in Tab. 1 the local transport plans of the 1970s and 1980s). The impact of this policy shift on actual behaviour is perhaps best epitomized by the reversal in the decline in bike use since the 1970s, (see trends in "Bike share in the city" in Tab.1), which has fundamentally contributed to give Amsterdam an exceptional share of non-motorized traffic (at 51% of all trips in 1995 it is by far the highest in the industrialized world in a large sample of cities analyzed by Kenworthy & Laube, 2005).

- ***Change in the system is path-dependent, that is, existing patterns of transportation networks, land uses and transport and land use policies limit the scope for change***

The issue of path-dependency is a wide-ranging one, cutting across multiple aspects and different layers of economic, social and cultural trends. There is path-dependency in facts, but also in ideas, and the two are intertwined. Adequate treatment would require much more than a couple of paragraphs. Its consideration in this paper will have to limited and will only refer to land use and transport morphological aspects. The existence of opportunities for and constraints to policy change determined by the existing urban and network morphology is seen here as evidence of path-dependency.

The pre-existing shape of land uses and transport infrastructure has conditioned subsequent developments in the Amsterdam region in many ways. The pre-war modernization of the Amsterdam city centre was comparatively late and limited in nature. This can be related to the comparatively late and limited industrialization of the Netherlands, but also to the sheer size of the city centre itself, in its turn a legacy of the global role of Amsterdam in the XVII century (Terhorst & van De Ven, 2003). The existence of such large, preserved city centre was a factor that first hampered large-scale urban renewal and later favoured the policy shift from transformation to conservation as described in Box 1. While there have since been attempts to somewhat turn away from this decision (see Box 2), the halt to large scale, downtown like restructuring of the city centre has up to now proven irreversible, even if reasons have shifted (first especially because of social resistance, later especially because of market preferences: compare Box 1 and Box 2).

On the infrastructure side there is also a long line connecting the radial road and railway structure in place before the war, infrastructure plans and land reservations dating from as early as the first half of the XX century, and actual transport and land use developments in the period under discussion. Just focusing on the road and rail tangents that have proven so crucial for successive developments, the most important decisions and actions contributing to the final result include: land reservations for a railway freight line around the city made at the beginning of the XX century; land reservations for local roads made in the 1932 Amsterdam 'general expansion plan'; the opening – starting in the 1970s and profiting of those rights of way – of railway links to connect the airport of Schiphol to the rest of the country (a national government-led process); the realization since the 1970s of a motorway ring as part of the national motorway plan of 1966 – partly using the reservations for the freight line and partly those for the local roads; the realization in the 1990s of a light rail line following the route of the airport railway links.

The transport systems that were eventually put in place are of a totally different nature of anything just even thinkable prior to the war (not roads but motorways, , not freight but passenger rail.). Analogously, the national motorway and railway planners of the 1960s and 1970s were not anticipating on (if at all concerned with) significant impacts on urban form. However, previous decisions largely determined *where* new infrastructure developments, and thus indirectly also land use developments, were to occur. The unique network morphology that eventually emerged, with a combination of radial and tangential connections, both road and rail, intersecting well inside the existing urban fabric, and since providing the infrastructure backbone to urban and regional development (see Fig. 1), would have never emerged in this form without such early land reservations and national infrastructure plans.

- ***During transition phases both the scope for policies to influence the outcome and the unpredictability of such outcome are greatest***

Proof for the first part of this hypothesis (scope) is the occurrence of qualitative (rather than quantitative) change consistent with policy goals. Evidence for the second part (unpredictability) is the concomitant occurrence of qualitative change that was not aimed at. Let us focus on the main policy transition phase, the late 1960s and early 1970s (see Box 1). This was a unique period because instability in different domains connected (just think at the central role of the emerging youth culture in the contestation of urban renewal plans), resulting in radical policy change. It can be argued (even if it should be tested in more detail) that it is precisely because of this diffused turbulence that such radical, deliberate change was possible. In other periods policy seems rather a reaction to broader, stable (and thus difficult to reverse) trends, having at best the effect of marginally conditioning the outcome (as with the relative concentration of suburbanization). On the contrary, qualitative policy change in the 1970s resulted in qualitative actual change, as documented above. The final outcome proved, however, unpredicted for a significant part. The conservative land use and transport policies in the city centre not just helped preserve, as desired and expected, its residential function. They were also, unexpectedly and unwillingly, a factor in its later gentrification and the development of a burgeoning tourist and leisure industry there (Terhorst & van De Ven, 2003). Furthermore, constraints on city centre development indirectly helped shift the focus of economic activity in the region towards the emerging centres in the periphery and the suburbs, not an entirely unforeseen but certainly at the time not even a deliberate policy goal. As far as mobility is concerned, while the outcome of the policy turn in the 1970s within the city (less cars, more bikes, and a more liveable public space) was by an large an explicit goal,

the related development of a diffused, multi-centred urban region were the car dominates and adequate public transport is lagging behind was not.

3.2 Policy implications

While still exploratory and necessarily limited in scope, the analysis above does provide some evidence that the Amsterdam land use and transport system has changed in an evolutionary, complex fashion, in the sense defined by the first set of hypotheses. Periods of incremental change have been followed by periods of radical change, path-dependency has played a decisive (in this paper just superficially explored) role, and transition phases have been characterized by both possibilities to affect the outcome and inability to predict it. Let us now move to the second set of hypotheses. These posit that because the systems behaved in an evolutionary, complex fashion, successful policies needed to:

- ***Build upon the unique set of opportunities and constraints for change determined by a specific historical development path and local combination of factors***

The fact that successful policies (that is, policies that have achieved their declared goals) have such characteristic is seen as verification of this hypothesis.
Successful policies in Amsterdam in the period under examination have explicitly or implicitly recognized the specificity of the city, that is, the existence of path-dependency. This seems true both in phases of incremental and in phases of radical change. Again, the discussion will be limited here to the morphological aspects. The repeated failure of attempts at radical transformation of Amsterdam city centre and the success of more conservative land use and transport policies there are the clearest example (see Box 1 and Box 2).

It is important, however, to underline here also that the acknowledgement of path-dependency does by no means imply that radical change is by definition impossible, or should not be striven for. The urban and regional structure that has ultimately emerged in Amsterdam is profoundly different from the pre-existing one (see Fig. 1). In the case of the conservative policies for the city centre, Terhorst & van de Ven (2003) even contend that it is has been precisely this 'freezing' of the built environment there that, by limiting the scope for large scale, coordinated transformation, has paradoxically given the market unprecedented freedom to re-shape land uses on the micro-level, in often surprising ways. The system-wide effects of the implementation of relatively undisruptive, but still very far-reaching infrastructure developments as the expansion of the motorway system and interregional railway links on the urban fringe and in the region are another case in point.

In both examples above the actual impacts – and particularly the emergence of a strongly polycentric urban system - differed greatly from anything most were able to imagine at the time. Actually applying policies - that is, experimenting – seems to have been necessary to realize the full implications. The crucial question for change-minded policy-makers seems then to be the following. How to identify interventions that are able to disrupt the present functioning of the system as little as possible while affecting its future development as much as possible? At the same time, the limits to the predictability of the outcome should make aware of the need of also increasing the resilience and adaptability of the system, which leads us to the next two hypotheses.

- ***Increase the resilience of the system, that is, its ability to keep functioning in the face of unexpected change. This seems especially important for the shape of transportation networks, as this is relatively difficult/slow to change***

The fact that successful policies were policies that have proven effective in qualitatively different contexts (that is, both before and after trend breaking points) is seen as evidence for this hypothesis. There are several examples of resilient interventions in the Amsterdam case. It is especially the shape of the infrastructure networks (*not* their function!) that seems to have had this characteristic. The combination of motorway and railway radials and tangents has proved able to support a wide variety of developments across the whole period, including shifting foci of economic and social activity, different transport technologies, and the two major policy transitions described in Box 1 and Box 2. The necessity of robust choices with respect to network morphology seems all the more crucial as the Amsterdam case also shows how alterations in its basic shape are extremely difficult to implement (think at the failed attempts at infrastructure penetration into the historic city centre, and conversely at the positive role of long standing land reservations in its expansion). An intriguing policy question follows. Is it possible to identify in advance such resilient interventions, and – if so - how? I will get back on this in the conclusions.

- ***Increase the adaptability of the system, that is, its ability to react to unexpected change. This seems especially important for land use regulations and mobility management measures, as these are relatively easy/fast to change***

The fact that, in order to be effective, policies that were not resilient in the sense discussed in the previous section needed to be adapted, is seen as proof for this hypothesis. The Amsterdam case also shows several examples of policy adaptation, particularly as far as land use policy and the mobility management side of transport policy are concerned. The most poignant example seems, once again, the radical change of course of transport and land use policies in the 1970s (see Box 1). Such adaptation has been an essential condition for the development of the new, quite successful policy mix that – at least as far as the historic city is concerned - has shown viable up to the present day (if this will also hold for the future is, of course, a different matter). Policy change proved, however, all but a natural process. A decade of intense conflict including violent riots and a 'policy-trauma' that is still felt in the city was needed to achieve it. In many ways, the existing plans and planning institutions appear to have been, at least initially, hampering rather than promoting adaptation. A somewhat different picture is offered by the land use policy transition of the early 1990s (see Box 2). Also here the capability to adapt has been an essential condition for the development of what most now see as a much more effective strategy for dealing with the reality of a multi-modal, multi-centred urban region. However, differently than in the 1970s, the transition seems to have happened in a much less traumatic manner (perhaps a sign that the planning system has become more adaptable?). The policy question is thus if and how such policy transitions could be made easier, or how the adaptability of policies could be increased. In other words: how can policies be made more responsive to (unexpected) reactions from the society at large? But also: how can this be done without reducing too much the just as necessary stability of the policy context, that is, its resilience? Also this issue will be addressed in the conclusions.

4. Discussion and conclusions

The central contention of this paper is that an urban transport and land use system capable of supporting economic and socio-demographic change is also one capable of continuing to function in the face of change, that is, it must be a *resilient* system. Secondly, an urban transport and land use system capable of supporting economic and social change must be able of changing itself in response to change in the socio-economic environment, that is, it must be also an *adaptable* system. The Amsterdam case shows both the workings of resilience and adaptability, and specific ways (that is, ways that take account of path-dependency of achieving them. The resilience of the system is perhaps best shown by a transport network morphology (the combination of radial and tangential links, both road and rail) that has provided a relatively stable base for the radical shift from a monocentric to a polycentric urban structure. The adaptability of the system is perhaps best shown by the (ultimately) successful re-shaping of the policy course, particularly in terms of land use and mobility management, in response to systemic crises. There is a link between the two. The resilience of the transport network morphology has been a condition for the adaptability of land use and mobility management strategies, because it has allowed choosing at all times between *different* land use and mobility management strategies.

However, the Amsterdam case also shows the limits of a purely rational approach (in the sense of 'rational choice', as in Simon, 1957; March & Simon, 1958; Simon, 1969) to achieving resilience and adaptability. The present network morphology is the result of a very long chain of decisions and actions, often unconsciously or unwillingly contributing to the final result. The land use and mobility management policy mix also emerged after a protracted period of conflicts and contradictions, and many effects were not anticipated. These limits to predictability are by no means specific of the Amsterdam context. In Britain for instance, the expectation that, following the development of new radial and tangential roads, growth would still take place in the city centre was long undisputed, while no model had anticipated inner-city decline or massive decentralization (Banister, 2002).

In terms of decision-making, the approach emerging from the Amsterdam case seems to contain elements of both the incremental model (Lindblom, 1959; Lindblom, 1968; Braybrooke and Lindblom, 1970) and the rational model (Simon, 1957; March & Simon, 1958; Simon, 1969). It is incremental in that it points at the role of the existing, historically grown situation in shaping the discussion around problems and solutions. It is rational in its attempts at drawing implications from the awareness of the long-term implications of decisions, particularly as they might affect the very scope for choice at a later stage. This characterization does by no means imply that such decision-making model was deliberately pursued in Amsterdam. Rather, it emerged through an often-painful process of trial and error. The interesting question is, of course, what more conscious efforts in this direction would deliver, in Amsterdam and elsewhere.

This preliminary, exploratory analysis points at both research and policy challenges. As far as research is concerned, there is a need to gain both more depth and breadth. More depth is most notably needed in order to more fully capture the dynamics of transition phases. In particular, the complex interplay of path-dependency (of both facts and ideas) and unpredictability, and of possibilities of and limits to influencing the outcome need to be understood better. More breadth is most notably needed in order to test the applicability to other geographical contexts of the proposed characterization of developments and of ways of achieving resilience and adaptability. As far as policy is concerned, the practical implications

of an urban transportation planning also geared at increasing resilience and adaptability of the system should be further elaborated upon. Furthermore, the complementarities with other, forecasting based approaches should be explored.

What sort of urban transportation planning would this lead to? A reference to Christensen's (1985; see also Gifford, 2003) classic characterization of uncertainty in planning can help make a first step. According to Christensen (Fig. 2a) planning problems and approaches can be characterized in terms of the uncertainty about goals and the means to achieve them (or 'technology'). The term 'technology' is used here in the broad sense of 'means to achieve goals'. In this respect a transportation system is a technology, but also a parking regime, or a marketing campaign. Furthermore, the term is inclusive of the economic, social and cultural institutions that identify the context in which a technology is developed and applied. Different sorts of uncertainty require different planning approaches. When goals are not agreed and the technology is unknown there is "chaos". In Christensen's interpretation these are untreatable planning issues, and uncertainty needs somehow to be reduced in order to proceed. When feasible, this should certainly be the preferred option. However, in many (even if by no means all) situations uncertainty seems *not* reducible. What to do then? Abstracting from the discussion of the Amsterdam case Fig. 2b sketches a possible approach. The starting point is the observation that even when goals are not agreed a distinction can be made between goals that are independent of the future technological context (as "promoting the growth of the urban economy") and goals that are not (as "promoting the growth of a specific economic sector in a specific location"). Analogously, even when the technology is unknown a distinction can be made between a technology that only has the potential to serve limited goals (as a transportation system connecting a limited number of places in a limited number of ways) and a technology that has the potential to serve more goals (as a transportation system connecting more places in more ways). When goals are both not agreed and dependent on a specific future technological context and technologies are both unknown and can only serve limited goals options should be kept open, thus preserving the *adaptability* of the system. On the contrary, not agreed goals that are independent of the technological context and unknown technologies that can serve many goals are, at least potentially, robust goals and technologies and should, with reference to Christensen's characterization, be bargained over and/or experimented with. Because of the limits to predictability, only actual bargaining and experimentation – or 'policy experiments' - will tell how true this potential is. If it is, policies should be brought further towards implementation, as they are likely to improve the resilience of the system. If this does not prove to be the case, the need to keep options open will be reintroduced. It is through such a recursive, exploratory process, that the system can gain both resilience (by means of robust measures) and adaptability (by means of keeping options open).

There is, however, a caveat. The above suggests that in cases of irreducible uncertainty and insufficient robustness, options should be always left open. However, it is easy to think of situations where action might still be desirable (think at the development of an innovative transportation system with highly uncertain, but potentially highly rewarding impacts). The approach sketched above could still be useful. First, it will point at the need to keep exploring ways of increasing the resilience and adaptability of the action (perhaps the innovative transportation system can be broken down into smaller components and realized in a more incremental, experimental way?). Second, when further redesign is not deemed possible, it will make explicit that decision-makers are taking a risk with an unpredictable outcome. In political (rather than technical) terms this can still be acceptable (or even desirable, as taking risks has been always considered a hallmark of leadership). Even in this last case however,

allowance should be made for learning, that is, to treat implementation as much as possible as a 'policy experiment'.

FIGURE 2 ABOUT HERE

Economic and socio-demographic change shape urban transport and land uses, but the latter provide in their turn a still essential physical support to the former. In the face of rising complexity and persisting uncertainty about the future, planners should devote more energy to understanding the evolutionary, complex nature of change in urban land use and transport systems, and, accordingly, to finding ways of promoting their resilience and adaptability. This would complement other, forecasting based approaches, and allow transport providers to develop and transport users to choose between different ways of moving around, both in the shorter and, most importantly, the longer term. The latter appears all the more urgent in the face of real uncertainty about the future viability of the presently dominating transport solutions and a tendency not to recognize this by those taking decisions. In this respect, the classic definition of sustainability proposed in the Bruntlandt report (World Commission on Environment and Development, 1987) still provides a poignant evaluation criterion. How does a particular transport and land use policy affect the possibility of future generations of making their own mobility choices? An exploratory attitude seems essential, as the answer will be different in different contexts, and contexts will keep changing, unpredictably.

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Table 1: Overview of different domains of change in the Amsterdam urban region in the 1946-1999 period[1].
Sources: Brand, 2002; Bruhèze & Veraart, 1999; Centraal Bureau voor de Statistiek (www.cbs.nl); le Clercq, 2002; Dienst Ruimtelijke Ordening Amsterdam, 2003a, 2003b; Dijkstra et al., 1999; Honig, 1996; Poelstra, 2003; Regionaal Orgaan Amsterdam, 2000, 2004; Rommerts, 1997; Terhorst & van de Ven, 2003; Wintershoven, 2000.

Period	Socio-demographic	Economic	Land use policy	Land use	Transport policy	Transport
Pre-1946		Relative economic stagnation	1935: Amsterdam 'general expansion plan' (AUP); concentrated, star-like urban expansion as alternative to suburbanization	Limited CBD-forming in the city centre; extensive public housing developments in the rest of the city; train/tram supported suburbanization elsewhere in the region	1901: first plan for a freight railway ring around Amsterdam 1935: (AUP) 'bicyclable distance' from the city centre defines the outer limit of urban expansion, provincial roads and tram lines connect city and surroundings, accessibility of the harbour is a central concern, land reservations for future tangential roads, canals and freight railways are made	1876: Amsterdam-North Sea Canal opens (shifting the focus of harbour activity from East to West) 1889: Central Station opens (separating harbour from city) 1917: Schiphol opens as military airport
1946-1958	Amsterdam from 770.000 to 870.000 inhabitants ***(post war maximum)*** Demographic trends: first positive, later negative migration balance (towards suburbs and abroad)		**National** 1958: national report introduces Randstad ('rim city') and Groene Hart ('green heart') concepts, which are to guide land-use planning in the West of the Netherlands for the rest of the century **Local** 1955: first city centre report, envisaging its radical transformation (will not be adopted) 1958-1965: plans for peripheral residential expansions	In the city centre: 'CBD-forming' and 'slum clearance'. In the periphery: new residential neighbourhoods (West); expansion of industrial and harbour sites	1955: (first city centre report) the study of an underground railway system is proposed, discussions and alternative plans follow	**Infrastructure** 1958: Schiphol becomes the national airport **Mobility** Growth of commuting towards Amsterdam and other regional centres Modal split region (home to work): 1947: Public tr. 75% Car 5% Bike 20% 1960:

						Public tr. 67% Car 16% Bike 18%
1959-1984	Amsterdam from 870.000 to 675.000 inhabitants ***(post war minimum)*** Demographic trends: negative national migration balance, positive international migration balance National migration: traditional households (families) to the suburbs, smaller households to the city International migration: Turks and Moroccan guest workers in the 1960s, bringing over their families in the 1970s; growing share from Dutch Antilles and Suriname (following independence in 1975) Cultural trends: emergence of mass-consumption, new lifestyles, emancipation of women, youth culture	General trends: sustained growth of the economy until the early 1970s; long period of decline following the first oil-crisis (1973) and continuing into the 1980s Spatial tends: firms move to the urban periphery and the suburban centres, in search of cheap space and/or labour; the harbour declines and the airport grows strongly	**National** In the second half of the 1960s and up to the end of the 1970s 'concentrated decentralization' policy = growth-centres at around 30 km from the major cities From the beginning of the 1980s 'compact city' policy = densification of existing centres and suburban growth close (at 15-30 km) to the major cities **Local** Urban renewal debates: ***See box 1: 'The late 1960s and early 1970s, a transport and land use policy transition dissected'*** 1974-1981: structure plan parts A, B and C; shift of focus from urban design to planning process, preservation of the residential function in old neighbourhoods, identification of sub-centres on the urban fringe, studies for a residential conversion of the eastern harbour	In the city centre: first urban renewal and later neighbourhood regeneration In the periphery: new residential neighbourhoods; further expansion of industrial and harbour sites; increasingly also office developments In the suburbs: development of growth centres (Purmerend, Almere, Hoofddorp)	**National** 1966: national motorway plan (in the region often following existing historical routes, as the A2 towards Utrecht, but also including new tangents, as the A10 motorway ring) **Local** Underground railway debates: ***See box 1: 'The late 1960s and early 1970s, a transport and land use policy transition dissected'*** 1975/1976/1978: first "traffic circulation plan"; a balance between accessibility and liveability is needed, the means are public transport (most notably the tram), a limited, coarse primary road network, a restrictive parking policy in the city centre, and new bike routes 1982: draft transport structure plan; the focus is on improving the existing situation and on an incremental approach	**Infrastructure** Expansion of the motorway network, little investment in the railways, plans for new canals are abandoned 1966-1991: realization of the motorway ring A10, largely using existing rights of way During the 1960s: runway expansion of Schiphol airport 1972: Amsterdam-North Sea canal broadened and deepened 1978-1997: Schiphol railway connections open 1977-1982: east line underground railway opens **Mobility** Longer and more car-based trips; congestion, especially in the centre. Growth of

						commuting towards Amsterdam and, more notably, other regional centres <u>Modal split region (home to work):</u> 1960: Public tr. 67% Car 16% Bike 18% 1971: Public tr. 41% Car 46% Bike 13% <u>Bike share in the city (all trips):</u> 1950: ca. 80% 1975: ca. 25%
1985-1999	Amsterdam from 675.000 to 725.000 inhabitants <u>Demographic trends:</u> less suburbanization, more births, more immigrants than in the preceding period <u>Cultural trends:</u> growing appreciation of urban living; older urban neighbourhoods increasingly popular; continuous growth of ethnic minorities (up to 36% in 1999); emergence of ethnic	<u>General trends</u>: structural change and strong recovery of the economy since the second half of the 1980s/in the 1990s; growth concentrated in business services, logistics, ICT and new media, leisure and tourism. <u>Spatial trends</u>: continuing de-concentration but also geographical specialization of economic activity	**National** Since 1988: 'urban nodes' policy; development to be concentrated in the major cities Since 1991: 'VINEX-neighbourhoods' policy; residential expansion to be realized within or adjacent to the existing city **Local** 1980s: while existing plans (growth centres, new motorways and railways) are implemented in the rest of the region, Amsterdam adopts a compact city policy	<u>In the city centre:</u> new housing and cultural and leisure facilities <u>In the periphery:</u> new residential neighbourhoods; residential conversion of older harbour sites (East); further expansion of younger industrial and harbour sites (West, South-east) <u>In the suburbs:</u> housing developments diffused (but strongly constrained by noise-boundaries around Schiphol airport	**National** 1988: "Second transport structure plan"; 'double goal' of improving both accessibility and liveability, to be achieved by reducing mobility by car, through a mix of pricing and location policies, and selective infrastructure improvements **Local** 1985: (structure plan) the metro has become a *no-no*, focus on expansion of the tram network, enforcement, small improvements, coordination and maintenance (also because of	**Infrastructure** 1978-1997: Schiphol railway connections open 1987-1988: Almere and Flevoland railway connections open 1990: Amstelveen surface light rail line opens 1991: Zeeburgertunnel opens (completion of the motorway ring A10) 1997: surface metro ring line opens 1997: Piet

	neighbourhoods in the periphery	(new media, leisure and tourism in the city centre, business services and ICT in the peripheral sub-centres, logistics around the airport, harbour and motorways)	1985: structure plan "The city central"; compact city, high densities and functional mix, housing-led, consolidation of the historical centre 1991: structure plan "Amsterdam"; downsizing of the peripheral expansions; ambitious redevelopment plan for the IJ-banks <u>IJ-banks debates:</u> ***See box 2: 'The late 1980s and early 1990s, a land use policy transition dissected'*** 1996: structure plan "Open city"; definitive abandonment of plans for western expansions, focus on the green structure, the South Axis will become the main business centre, the IJ-banks will develop a live-work-leisure mix, a new sub-centre in Amsterdam North is indicated	and nature preservation areas); office and industry developments (concentrated around airport and motorway corridors) <u>City centre trends, 1975-1999:</u> Inhabitants + 11% Dwellings + 39% Jobs – 24% Offices – 10% Restaurants/cafes + 53% Shops + 40%	financial problems) 1986: following recurring congestion of the Coentunnel and strong growth of the airport, construction of a new western motorway tangent (the A5) is decided Late 1980s: a study of the Chamber of Commerce shows the new possibilities of tunnelling without disruption of the existing urban fabric 1991: (structure plan) several new infrastructure is envisaged, including the new western motorway tangent and railway freight line, a new north-south metro line, a light rail ring line, and a light rail line to connect the reconverted eastern dockland area 1993: regional transport plan (RVVP); the goal is improving accessibility while preserving liveability, the most important means are reduction of the growth in car-kilometres and a modal shift to public transport and bike	Heintunnel opens (road link connecting reconverted eastern docklands to motorway ring) <u>Modal split region (home to work):</u> 1971: Public tr. 41% Car 46% Bike 13% 1991: Public tr. 22% Car 60% Bike 18% <u>Bike share in the city (all trips):</u> 1975: ca. 25% 1996: ca. 35%

1) The two demographic trend-breaking points of 1959 (from population growth to population decline in Amsterdam) and 1985 (from decline to growth) are used to distinguish three main phases. This is just done for convenience and does not imply that these are relevant dates also for other streams of change, including more qualitative aspects of demographic development.

Box 1: The late 1960s and early 1970s, a transport and land use policy transition dissected.

Sources: le Clercq, 2002; Dienst Ruimtelijke Ordening Amsterdam, 2003a; Dijkstra et al., 1999; Honig, 1996; Poelstra, 2003.

The 1960s are the theatre of an extensive production of far-reaching urban renewal and infrastructure plans for Amsterdam's historic city, following a first city centre report in 1955. The underlying philosophy seems straightforward: population growth is to be accommodated in new expansions on the urban periphery and in growth centres in the region (in line with national policy), service growth is to be concentrated in an enlarged and restructured city centre, and a new underground urban railway network is to be developed to link the new concentrations of population, jobs and services. The new transportation system is seen as a tool to reinforce the position of the city centre in the region, and as a way to fight mounting congestion there (by both providing an alternative to the car and giving the car more space above ground). From 1963 to 1966 an urban railway office is installed to work out the plans. Conclusion of the study is to start with the construction of an east line - connecting the central railway station to urban renewal areas in the centre and the newly planned South-eastern urban expansion - and to follow later with a north-south line. However, and signalling expert disagreement, also an alternative, incremental plan is developed, envisioning a first phase with a north-south line only and expansion of the bus and tram network as a substitute – at least for the time being - for an extensive underground railway network. Other plans follow, including in 1967 one by the American professor D.A.Jokinen who proposes a system of radial urban motorways to connect a drastically restructured city centre. Particularly this plan has a shock effect on a public opinion increasingly concerned with the fate of the historic city. In 1968 however, conflicting plans and ongoing discussions notwithstanding, the city council decides 'in principle' to build the underground railway. The decade of urban renewal debates seems also to reach its resolution point with the publication in 1969 of rigorous plans envisaging the demolition of as much as 75.000 dwellings in the historic city.

While there is still enough consensus on the policy course within the city council, the railway and urban renewal proposals meet unexpected, strenuous resistance from the population. Leading the contestation is an unorthodox coalition of local inhabitants fearing displacement and emerging urban youth movements wanting to affirm their alternative visions of urban life. The planning machinery seems, however, unstoppable. In 1970 an agreement is reached with the national state on financing the east line and in the same year the city council decides to start its construction as well as preparations for a north-south line. Shortly thereafter construction starts. The contestation, however, explodes and takes the streets, seamlessly merging with protest against urban renewal. Popular pressure mounts up to the point that the city council has to come back on its decisions. The first change is on the land use side. In 1972 the council decides to build houses instead of a throughway on top of the inner-city section of the underground railway tunnel. Amendments on the transport side follow: in 1974 the council decides to complete the east line but to halt indefinitely further implementation of the rest of the plan. The decision does not immediately calm the spirits, and in 1975 there are violent riots against the underground railway.

The first stretch of the east line opens in 1977, but a year later the policy change of course is made official. On the land use side a local government report sanctions the shift by trading 'urban renewal' with 'building for the neighbourhood', that is, incremental, housing-led adaptation of the historic city, without displacement of the existing inhabitants. A 'traffic circulation plan' does the same on the transport side, by stressing the need to strike a balance between accessibility and liveability, and to do this by means of improvement of the existing tram system, development of a coarse primary road network, a restrictive parking policy in the city centre, and new bike routes.

The contrast between the vision of the city and its transport system before and after these turbulent years can be still appreciated at a glance in the Mr. Visser square, where the underground railway east line enters the medieval city centre. Looking towards the periphery of the city one sees a large traffic thoroughfare flanked by modern, tall office buildings. Looking towards the centre one sees a much smaller street with plenty of space for bicycles and pedestrians and a mix of preserved and new residential buildings, with mostly small-scale retail on the ground floor. In between the two is the mouth of a never completed road tunnel, since converted in an indoor playground. In the Nieuwmarkt underground railway station underneath pictures of the 1975 riots still remind how this all came about.

Box 2: The late 1980s and early 1990s, a land use policy transition dissected.
Sources: ARCAM, 1988; Bertolini & Spit 1998; Gemeente Amsterdam 1996; Van Nierop, 1993.

In the late '80s, while the municipality is struggling to attract office developments to the IJ-banks area next to Amsterdam Central Station, an intense, spontaneous market dynamics is taking place at peripheral locations along the southern and western motorway rings (see Fig. 1). The traditional orientation of the city on its port on the north side, which the IJ-banks project tries to continue, is thus being subverted by an orientation of new developments towards the south side, better connected with the airport and the rest of the Randstad. In 1988 an exhibition and publication (ARCAM, 1988) first gives a synthetic, and to many shocking, impression of the new spatial reality taking shape. Putting together information on plans and projects until then only fragmentarily available to the general public, the independent ARCAM foundation shows how peripheral developments are throwing Amsterdam 'inside out'.

The answer of the municipality to this evidence remains ambiguous. The official policy is that the IJ-banks is the most important location to develop, in order to reinforce the economic base of the city centre and that developments along the motorway ring are not to be allowed. But risk that firms leave or bypass the city - which desperately needs both the jobs and the land rents they carry with them - altogether is too great to adopt a hard stance. Thus, one after the other, exceptions to the policy are made to allow companies to remain or locate at least within the city boundaries. Nothing more, though: in 1993, an officer of the municipality still declares:

An integral vision [for peripheral developments] has no priority. You just have to allow sometimes something in order to avoid that firms escape to competing locations. (Van Nierop 1993, p. 95).

However, this approach is meeting growing criticism. Market actors lament that an urban design framework and coordination of development would boost property demand and values in the southern urban fringe. Also, concerned local district authorities (these are the lower-level municipal governments installed in 1990) protest that transformations are happening without reference to each other and to the context, making local impacts difficult to identify and to manage. Quite strikingly, the big transport infrastructure providers and operators - the department of public works, the national railway company (NS) and the local transport company (GVB) - are not participating in the debate at this point. However, ambitious interventions and plans that will boost the accessibility of the southern urban fringe are, quite independently from the urban development debate, following each other. These include a light rail ring line, a north south underground railway line, capacity and connection improvements in the national and regional railway networks, and High Speed Train links to France and Germany.

In the early 1990s, unfolding events are making the position of the municipality increasingly difficult. While little happens at the IJ-banks, exceptions continue to accumulate along the ring: in a later stadium, the municipality itself will estimate the amount of office space thus developed at around 300.000 m2! Also, the large bank concern ABN-AMRO demands the authorization to build its headquarters next to Zuid station, on the southern urban fringe, exacerbating tensions that are also maturing inside the municipality. Then comes the proverbial last straw: in February 1994, the private partner of the IJ-banks initiative withdraws, not believing in the financial feasibility of the operation. A policy U-turn appears inevitable.

In the spring of 1994, following the local elections, a programme agreement is voted by the new council, in which a new policy is indeed agreed. On the IJ-banks, rather than an office concentration, a mixed live-work area will be aimed at, anchored to activities in the cultural and tourist spheres, thus reinforcing the emerging character of the historic city centre. Along the Zuidas (South Axis), an office district of international standing will be promoted, bringing together in an integrated plan developments that are at the moment happening piecemeal. Contradicting what affirmed only a year earlier, the city council states that:

For the Zuidas, the area for large-scale offices, an integral plan will be prepared in order to avoid that the development continue to happen incidentally. (reported in Gemeente Amsterdam,1996).

Figure 1: Changes in the built-up area and the infrastructure in the Amsterdam region, 1967-2001. *Source*: adapted from Jansen, 2003.

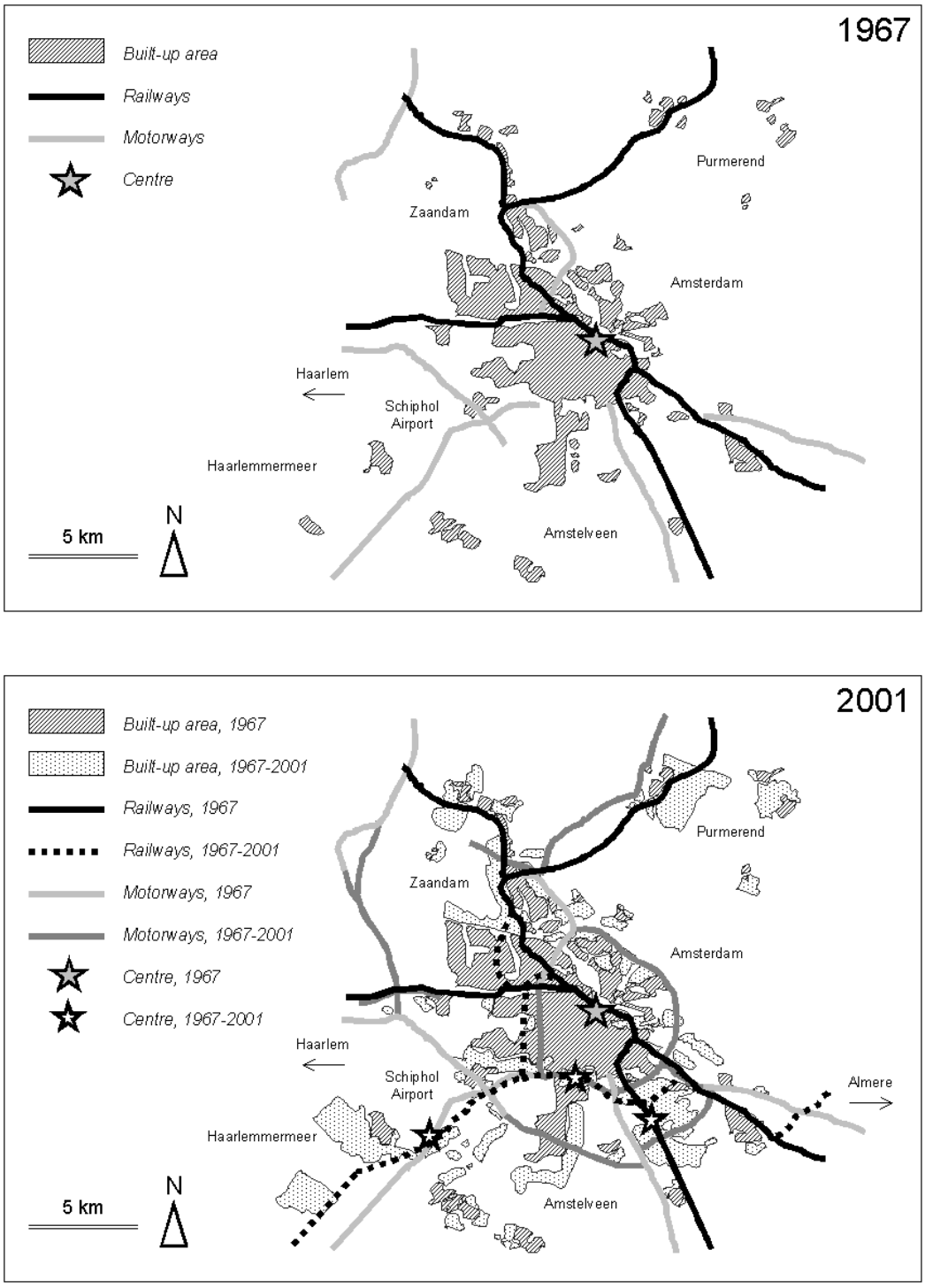

Figure 2a: Coping with uncertainty in planning (Christensen, 1985)

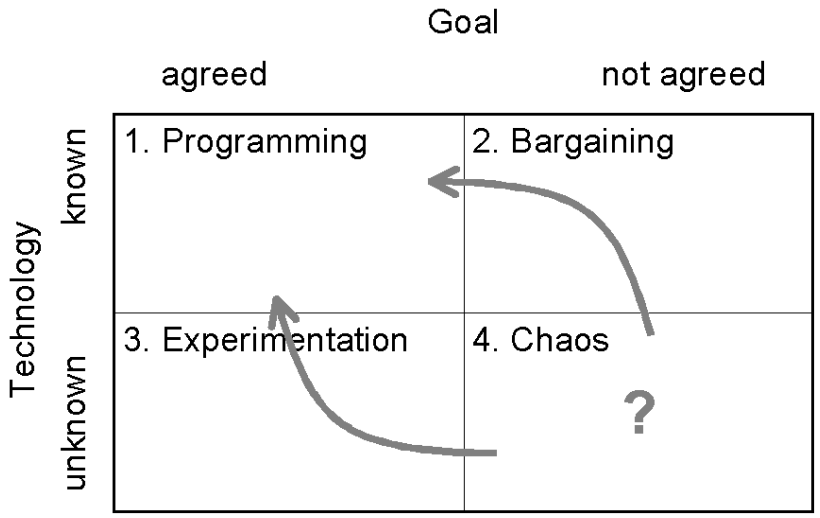

Figure 2b: Coping with *irreducible* uncertainty in planning (or 'chaos')