TRAFFIC CONGESTION, THE URBAN BUSINESS SECTOR AND THE SUSTAINABLE CITY: A PROPOSED FRAMEWORK FOR ANALYSIS

VINCENZO LI DONNI
Istituto di Scienze Finanziare
Facoltà di economia, University of Palermo
PALERMO, ITALY

ANGELA S. BERGANTINO
Istituto di Scienze Finanziare
Facoltà di economia, University of Palermo
PALERMO, ITALY

BILL GERRARD
Leeds University Business School
University of Leeds
LEEDS LS2 9JT, UK

Abstract

Starting from the assumption that a city can be considered as a closed spatial system with a limited capacity for hosting production and consumption activities, we present a model that allows the calculation of the direct and indirect mobility generated by each additional unit of income. An urban accounting equation is used to derive various income and mobility multipliers. The limit to sustainability is encountered whenever the multipliers become negative. Finally, we identify the propagation paths of expenditure impulses to highlight the structural characteristics of the urban economic space and, consequently, determine the frontiers of the sustainable city.

THE RELATIONSHIP BETWEEN URBAN TRANSPORT AND SUSTAINABILITY FRONTIERS

This study seeks to develop a methodology that allows the issue of "sustainability frontiers" to be incorporated in the evaluation of urban policies directed at the problems of urban traffic congestion. The sustainability frontier for any city can be defined as the point beyond which any further increase in physical or human capital within the urban area generate net negative indirect effects that exceed the positive direct effects. These effects consist of both economic effects (i.e. income and employment effects) and environmental effects. The specific focus of this study is the economic and environmental effects of urban traffic congestion. Traffic congestion can be defined as the situation in which an increase in mobility (i.e. the demand to travel) leads to external costs greater than the private benefits to individuals from the additional mobility.

The World Commission on Environment and Development has defined sustainability as 'a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional changes are made consistent with future as well as present needs' (1987). However the existing literature on the sustainable city suggests a number of definitions of sustainability linked to the environmental impact and the effects on the "irreproducible" factors (see, for example, Alberti et al, 1994; Breheney, 1994; Camagni, 1996; Van Den Bergh et al, 1994). In part the multiplicity of definitions derives from the multidisciplinary nature of the subject. Sustainability is an object of study for economists, sociologists, geographers and environmentalists amongst others. The concept of sustainability adopted in this study is adopted with special reference to traffic congestion problems. It is assumed that the city is a closed "container" with a maximum capacity to absorb further increases in population and production. The optimal level of sustainability can be identified as lying between a maximum and minimum level of capacity defined for each specific form of activity within the urban area. The city can be considered to be a specific territorial entity containing a stock of social, human, physical and natural capital. Changes in activity in the city will impact directly and indirectly on one or more of the component forms of the urban capital stock. The sum of direct and indirect effects determines the position of the city with respect to its sustainability frontier. If the development of a new activity (or the expansion of an existing activity) has a net positive effect, then the city lies inside its sustainability frontier. If the net effect is zero, the city has reached its sustainability frontiers. A net negative effect indicates that the city has moved beyond its sustainability frontier such that in aggregate the urban capital stock has declined.

Mobility is a crucial dimension for the determination of the sustainability frontier of an urban area (and hereafter will be the sole focus of the discussion). Increases in the resident population and the stock of physical productive capital (either the opening of new units of production or the expansion of existing units) generate direct and indirect changes in the level of mobility. Since the city is a closed territorial entity, it has only a limited capacity to contain further increases in the demand for mobility given its existing infrastructure. It is possible to determine this limit to the capacity of the urban area to accommodate the marginal unit of physical or human capital (i.e. the sustainability frontier for mobility) by considering the marginal costs and benefits. The determination of this sustainability frontier is presented graphically in Figure 1 below.

The vertical axis measures the marginal costs and revenues of mobility in monetary units. The horizontal axis indicates the economic size of the appropriately defined urban space as measured by the population or the physical productive capital stock. The marginal revenue of mobility curve (MR) assumes that the private benefits from mobility increase in the initial phases of urban growth representing the benefits from spatial concentration. The growth in the marginal revenue of mobility is assumed to diminish and eventually, as the city expands further, marginal revenue declines but

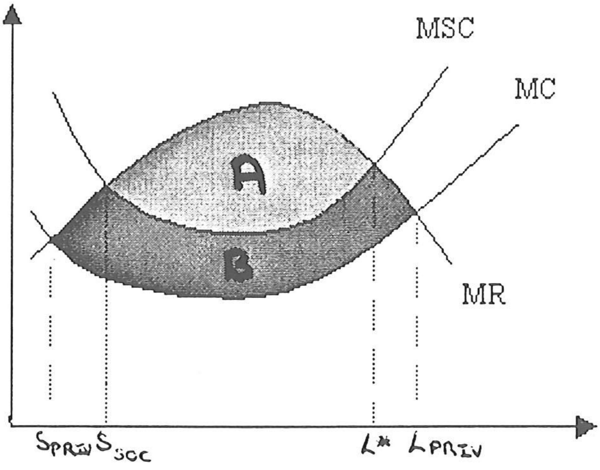

Figure 1 – The Sustainability Frontier for Mobility in an Urban Area

remains positive. The marginal (private) cost of mobility (MC) represents to the direct cost to individual of increases in their own mobility. The marginal social cost of mobility (MSC) represents the total direct and indirect costs (including net externality costs). It is assumed that marginal private and social costs both initially decline but then increase with urban growth. The shaded area A represents the net social gains of mobility accruing from urban expansion whereas the shaded areas A and B jointly represent the net private gains of mobility.

The first-order optimising condition of the equality of marginal costs and revenues implies that the city faces a multiple equilibria problem. There are defines potential equilibria for the optimal economic size of the urban area. The point S_{PRIV} at which MR = MC represents the minimum private threshold size for the city above which there are net positive private gains of mobility. However, if there are net externality costs of mobility, then the marginal social costs exceed the marginal (private) costs. This implies that the minimum social threshold size is S_{SOC} above which the net marginal social gains of mobility are positive.

S_{PRIV} and S_{SOC} are both small-city equilibria but neither is stable in the sense that there are net marginal gains from further urban expansion. The net marginal social gains of mobility are only exhausted if the economic size of the urban area expands to the large-city equilibrium, L*. This represents the sustainability frontier for the urban area with respect to mobility. There are no additional net social gains to be realised from the increased mobility consequent on further urban growth. Hence L* represents the point beyond which there exists urban traffic congestion (as defined above).

However, the sustainability frontier for mobility is not stable from the point of view of individual private decisions. At L* there still exists further net private gains of mobility from further urban growth (represented graphically by the shaded area B extending beyond L*). Indeed private incentives imply that the optimal size of the urban area is L_{PRIV}. The difference (L_{PRIV} - L*) represents the "sustainability gap" for mobility. Private incentives create a tendency for urban traffic congestion. The sustainable city (i.e. an urban area operating on or within its sustainable frontier) is a social good that can only be obtained through collective action e.g. appropriate taxation policies. From this perspective, the role of urban policy is to eliminate the sustainability gap.

It follows from the discussion above that, in order to determine the sustainability of an increase in economic activity in the urban area, it is necessary to develop a methodology that incorporates not only the direct effects of the specific activity (e.g. space utilisation, income and employment generation), but also its indirect effects. A starting point for such a methodology is the concept of the "export base" that classifies production activities with respect to some specified space and the rest of the world. In the current context the specified space is an urban area. Two sets of activities can be distinguished (Derycke, 1972):

(a) export (or base) activities that produce goods and services for external consumption/production; and
(b) induced (or non-base) activities that produce goods and services for consumption within the urban area.

This distinction between export and induced activities can be linked directly to the decomposition of income into autonomous and induced components. This decomposition provides the basis for the determination of the multiplier relationship between autonomous income and total income. Hence, by using the concept of the export base and the associated decomposition of income, it is possible to quantify the total impact of new economic activity in an urban area as a multiplier relationship.

The starting point for the derivation of the multiplier relationship for the urban economy is the decomposition of urban production (Y) into its export activities and induced activities.

$$Y = L + G \qquad (1)$$

L represents autonomous income derived from export activities. G represents induced income derived from induced activities. Assuming that the level of induced income depends linearly on total urban income, it follows that

$$G = \alpha Y, \quad 0 < \alpha < 1 \qquad (2)$$

Substituting eqn (2) into eqn (1) and rearranging yields

$$Y = [1/(1 - \alpha)]L \qquad (3)$$

$1/(1 - \alpha)$ represents the urban income multiplier. A one-unit increase in export income will generate an increase of $1/(1 - \alpha)$ in total income in the urban area.

The urban multiplier methodology allows the investigation of two types of phenomena: the internal effects, both direct and induced, of an additional investment; and the links between the urban economy and other neighbouring economies.

It is possible to extend the analysis from income effects to mobility effects by assigning coefficients of "mobility generation" to incremental units of activity in the urban economy. The total mobility generated by an increase in export activity comprises the mobility directly generated by the export activity as well as the mobility indirectly generated from the increase in induced activities. Let β represent the average mobility generation coefficient for the urban economy as a whole. Total urban mobility (M) measured in passenger-kilometres is given by

$$M = \beta Y, \quad \beta > 0 \qquad (4)$$

Hence it follows that the urban mobility multiplier relationship is

$$M = [\beta/(1 - \alpha)]L \qquad (5)$$

Eqn (5) implies that a one-unit increase in total export activity will generate an increase in total mobility of $\beta/(1 - \alpha)$ passenger-kilometres.

The two-sector model of the urban economy is a useful simplification for theoretical exposition. However, for practical policy purposes, it is necessary to measure the likely impact on total mobility of individual investment projects in specific sectors. This requires a more disaggregated approach that (i) identifies the propagation paths through which an initial impulse in one sector generates increased mobility in other sectors; and (ii) estimates the coefficients of mobility generation for each sector. A fundamental proposition of this study is that mobility effects are closely related to income effects. The propagation paths for income effects are well understood and quantified in urban input-output tables. Combining these urban input-output tables with estimates of the mobility generation coefficients for each sector to create a mobility accounting matrix that provides a means of determining the urban mobility multiplier for new individual investment projects.

The urban mobility multiplier method is simple, easily implemented and capable of being adapted to incorporate environmental effects. In particular, the urban mobility multiplier can be used to determine the sustainability frontier for mobility in an urban area. The mobility accounting matrix can be used to determine the likely direct and indirect effects on urban mobility as new investment projects generate additional income. For example, an increase in household income will lead to increased expenditure on various consumption goods and services that, in turn, will generate additional demands for mobility. Having used the mobility accounting matrix to estimate the total increase in mobility, it is then possible to incorporate these mobility effects into an environmental model to calculate the externality costs of increased mobility. These externality costs can be compared with the (private) income effects of the new investment to evaluate whether the new investment takes the urban area beyond its sustainability frontier.

Returning to the two-sector model of the urban economy, let γ represent the externality cost per unit of mobility. The total externality cost of mobility in the urban area (X) is given by

$$X = \gamma M, \gamma > 0 \qquad (6)$$

Assuming that X can be measured in monetary terms (i.e. weak sustainability) and defining the net social benefit of economic activity as Y – X, it follows from eqns (3), (5) and (6) that

$$Y - X = [(1 - \gamma\beta)/(1 - \alpha)]L \qquad (7)$$

Eqn (7) gives the urban social multiplier relationship with respect to mobility. The multiplier effect for the incremental investment project can be calculated by using the respective marginal parameters. Provided that the (marginal) multiplier exceeds zero, the urban area is inside the sustainability frontier for mobility. This implies that the condition for sustainability is $\gamma\beta < 1$. If $\gamma\beta > 1$, the urban area has gone beyond its sustainability frontier for mobility.

THE DIFFERENT ROLES OF INTERNAL AND EXTERNAL MOBILITY

The distinction between mobility generated by internal activities and mobility generated by external activities is of crucial importance. In general, changes in the internal component of total mobility constitute largely a reallocation between different types of mobility. In contrast changes in the external component of mobility represent a net increase in mobility and, hence, are the primary cause of congestion and non-sustainability. Consider the following two examples by way of illustration. Suppose that on average the existing residents of a city decide to spend more of their leisure time and income on sport activities rather than attending the theatre. This would imply a shift of mobility from one sector to the other. Ultimately the overall coefficient of mobility generation for the urban area may be affected by this reallocation of activity if there are changes in the frequency and average distance of trips and the mode of transport. The net effect of these changes on total mobility is likely to be small. Suppose, however, that a large new supermarket locates in the urban area and is accessible to consumers from neighbouring areas. The additional trips of non-residents top the city could have a significant impact on total mobility. In addition the increased importance of external mobility implies that total mobility in the urban area will become more sensitive to changes in external income.

The distinction between internal and external mobility highlights the importance of understanding the "territorial interdependence" between the urban economy and local neighbouring economies. This interdependence can lead to conflicts between local economies. Urban authorities may attempt to minimise external costs by "dumping" some economic activities at the edge of the city boundaries. Such behaviour merely shifts the externality costs onto local neighbouring economies.

One response to traffic congestion has been to restrict access to central urban areas to traffic originating externally. This type of local transport policy shows the practical importance of distinguishing between internal and external mobility. However, such policies must be developed in full recognition of the complexities of territorial interdependence. In some instances, there is a synergistic relationship the urban economy and local neighbouring economies that creates added value in the production process.

A METHODOLOGY TO HIGHLIGHT THE TERRITORIAL INTERDEPENDENCE OF MOBILITY

In order to evaluate fully the effects of territorial interdependence between the urban economy and the external economy, it is appropriate to use the Social Accounting Matrix (SAM). The SAM is based on the Leontief's original input-output model. The SAM is a method of analysis widely applied in the study of phenomena in which the effects propagate both in the economic and the social areas (see, Defourny et al, 1984; Round, 1985). In recent years the SAM have been increasingly used to represent interdependence relationships between economic variables with a territorial specificity.

The mobility accounting matrix, outlined above, represents the adaptation of the SAM for the specific purpose of investigating the problem of traffic congestion. In the initial stage of the analysis, it is necessary to collect the inter-sector accounting information in a double-entry table (with the unit of measurement chosen) to represent the relationship between the operators of the economic system. The system can be disaggregated according to the needs of the particular investigation. The SAM shows the operation of the economic process, identifying the propagation paths by which the impact of an initial impulse in one sector is diffused throughout the whole economic system.

As a first approximation the accounting matrix represents the flows between three sectors defined by type of agent: (i) households; (ii) firms; and (iii) government and other public institutions. The specific application to territorial interdependencies requires that the matrix be segmented into spatial sectors. Following the discussion above of the application of the export base to the urban economy, two spatial sectors are defined: the endogenous sector representing the local economy and the exogenous sector representing the external economy. The endogenous sector constitutes the set of activities that produce goods and services for the internal market, while the exogenous sector includes all the remaining activities that produce goods and services on the external market.

Once the interdependencies between operators in the different territorial sectors of the economy are defined in the matrix, the analysis can proceed to the consequences of an expenditure (or other form of) impulse originating in the exogenous sector and feeding through to the local economy and *vice versa*. In particular, the effects of impulses, be these either exogenous or endogenous in nature, can be explored through the analysis of the expenditure multipliers calculated from the matrix. The expenditure multipliers measure the direct and indirect effects of an exogenous expenditure impulse on the endogenous sector and *vice versa*. From the analysis of the expenditure multipliers it is possible to infer the degree of interdependence with the local economy and between the local economy and the external economy. Furthermore, by associating the relevant coefficient of mobility generation to each expenditure multiplier, it is possible to estimate the traffic generated by an exogenous expenditure impulse.

The territorial interdependencies are represented explicitly by the distinction between the urban area (i.e. the endogenous sector) and its external area (i.e. the exogenous sector). The territorial interdependencies also appear indirectly in the mobility generation coefficients associated with expenditure multipliers for each sector of the local and external economies.

THE ANALYSIS OF THE INTER-TERRITORIAL EFFECTS

A schematic representation of a SAM can illustrate the relation between the endogenous and exogenous sectors. The matrix in Table 1 is divided into four quadrants representing the flow of transactions between and within the two spatial sectors. Each quadrant contains the expenditures originating in the column sector and flowing to the row sector. The matrix contains the data necessary to calculate the matrix of multipliers in order to determine the degree of interdependence between the local economy and the external economy.

Table 1: Simplified scheme of a SAM

SECTORS	ENDOGENOUS	$\sum$	EXOGENOUS	$\sum$	Total
ENDOGENOUS	T_{nn}	p	T_{nx}	r	y_n
EXOGENOUS	T_{xn}	q	T_{xx}	s	y_x
Total		z_n		Z_x	

In Table 1 the column vector y_n represents the total of the incomes received by the endogenous sector. It has two components:

(i) the expenditures within the endogenous sector represented by the transactions matrix T_{nn}; and

(ii) the expenditures of the exogenous sector that flow into the endogenous sector represented by the matrix T_{nx}.

The total of the incomes received by the endogenous sector is given by

$$y_n = p + r \quad (8)$$

where p and r are the respective summations of the component expenditures.

The total of the incomes received by the exogenous sector, y_x, is given by

$$y_x = q + s \quad (9)$$

Using the transaction matrix, the matrix of average expenditure propensities, A_n, can be constructed showing expenditures as a proportion of the total incomes. Thus, the elements of the matrix of the endogenous transactions T_{nn} in Table 1 can be expressed as a function of the average expenditure propensities

$$T_{nn} = A_n \acute{Y}_n \quad (10)$$

where $\acute{Y}_n$ is the diagonal matrix with the elements y_i, with $i = 1,\ldots,n$.

Similarly

$$T_{xn} = A_l \acute{Y}_n \quad (11)$$

Using the matrices A_n and A_l the vectors p and q can be expressed as

$$p = A_n y_n \quad (12)$$

and

$$q = A_l y_n \quad (13)$$

Combining eqns (8) and (12) we can obtain the multipliers' matrix $\mathbf{M_a}$:

$$\mathbf{y_n = A_n y_n + r = (I - A_n)^{-1}\, r = M_a\, r} \qquad (14)$$

Eqn (14) shows the exogenous incomes, $\mathbf{y_n}$, as a function of the exogenous impulses, $\mathbf{r}$, and the matrix of income multipliers, $\mathbf{M_a}$.

Table 2 shows a schematic representation of the input-output relationships between sectors in a simplified territorial accounting matrix.

Table 2: Example of a simplified territorial matrix for an urban economy

		ENDOGENOUS OPERATORS			EXOGENOUS OPERATORS		
		Households	**Firms**	**Public Sector**	**Households**	**Firms**	**Public Sector**
ENDOG. OPERATORS	HOUSE-HOLDS		Labour.	Labour.		Exported labour.	Exported labour.
	FIRMS	Consumption goods and services.	Capital and semi-finished goods.	Goods and services.	Exports of goods and services.	Exports of capital and semi-finished products.	Exports of goods and services.
	PUBLIC SECTOR	Public services to the personal sector.	Public services to the business sector.		Public services to external personal sector.	Public services to External business sector.	
EXOG. OPERATORS	HOUSE-HOLDS		Imported Labour.	Imported labour.		External labour.	External labour.
	FIRMS	Imported onsumption goods and services.	Imported capital and semi-finished goods.	Imported goods and services.	External consumption goods and services.	External capital and semi-finished goods.	External goods and services.
	PUBLIC SECTOR	Imported public services to the personal sector.	Imported public services to the business sector.		External public services to the personal sector.	External public services to the business sector.	

By way of explanation of Table 2, consider the row representing the output of the productive activities of local (i.e. endogenous) firms. Local firms produce the following outputs:

- consumption goods and services for local households
- capital and semi-finished goods for local firms
- goods and services for the local public sector
- goods and services supplied to the external economy (consisting of external households, external firms and the external public sector)

Hence the row for local firms contains all of the added values produced by the local business sector and supplied to local households, other local firms, the local public sector and external operators. The column for local firms contains the inputs required for the production activities in the local economy:

- labour from local households
- capital and semi-finished goods from local households
- local public services
- production inputs from external operators

Although the matrix distinguishes between exogenous and endogenous sectors and hence can easily assimilate the theory of the export base, the partitioning criteria adopted can be spatial or functional. Spatial partitioning assigns operators to the exogenous or endogenous sectors depending on their geographical location. In this case the exogenous activities are defined as the autonomous components of income originating from operators located outside the local economy and the endogenous activities as the components of income determined by the level of activity in the local economy. Functional partitioning distinguishes between the exogenous and endogenous sectors by activity, not the geographical location of the operators. Exogenous activities are defined as those that are sensitive to the level of income in the external economy whereas endogenous activities are sensitive to level of income in the local economy. The criteria used to assign any operator to the exogenous or endogenous sectors depend on the objectives of the particular study and the amount of available information.

Functional partitioning is better suited to the representation of a local economy. For example, functional partitioning is more able to deal with multinational operators whose total turnover is primarily determined by the level of external income and hence their activities are largely independent of conditions in the local economy. Similarly the activities of the public sector should be classified functionally rather than spatially, implying that only part of the public sector located in a local economy should be treated as endogenous. For example, if the central (national) government locates some of its functions in a local economy, it is likely that much of this government activity should be classified functionally as part of the exogenous sector. Only those activities that produce public services directly consumed by the local should be considered as endogenous. Hence a naval base located in a port city is part of the exogenous sector but the induced additional expenditures on locally produced goods and services are part of the endogenous sector.

One of the advantages of this matrix construction is that it can be easily extended to deal with the problem of mobility. This requires the estimation of the level of mobility both direct and indirect mobility related to changes in income in the territorial economy under investigation. Designating households as H, firms as F and the public sector as P, the basic accounting identity for an economy can be rewritten in disaggregated form as

$$\begin{bmatrix} T_H \\ T_F \\ T_P \end{bmatrix} = \begin{bmatrix} 0 & A_{FH} & A_{HP} \\ A_{FH} & A_{FF} & A_{FP} \\ A_{PH} & A_{PF} & 0 \end{bmatrix} \mathrm{x} \begin{bmatrix} T_H \\ T_F \\ T_P \end{bmatrix} + \begin{bmatrix} E_H \\ E_F \\ E_P \end{bmatrix} \tag{15}$$

where $\mathbf{T}_i$ and $\mathbf{E}_i$ are column vectors representing the components of the column vector of total incomes, **T**, and the column vector of autonomous expenditures, **E**, respectively. $\mathbf{A}_{ij}$ are the component blocks of the matrix of expenditure coefficients, **A**. The elements of the expenditure coefficients matrix, $A_{ij} = T_{ij}/T_i$ where T_{ij} is the income of the i^{th} operator received from the j^{th} operator and T_i is the total income of the i^{th} operator.

From eqn (15) it follows that

$$\begin{bmatrix} T_H \\ T_F \\ T_P \end{bmatrix} = \begin{bmatrix} M_{HH} & M_{FH} & M_{HP} \\ M_{FH} & M_{FF} & M_{FP} \\ M_{PH} & M_{PF} & M_{PP} \end{bmatrix} \mathrm{x} \begin{bmatrix} E_H \\ E_F \\ E_P \end{bmatrix} \tag{16}$$

where **M** = **INV(I-A)** is the matrix of the (global) income multipliers. The block $\mathbf{M}_{ij}$ contains the elements that measure the direct and indirect impact of an additional unit of exogenous expenditure by the i^{th}-type of operators on the incomes of the j^{th}-type of operators.

In the case of an urban economy disaggregated into exogenous and endogenous sectors, designated by X and D respectively, the multiplier relationship in eqn (16) becomes

$$\begin{bmatrix} T_X \\ T_D \end{bmatrix} = \begin{bmatrix} M_{XX} & M_{XD} \\ M_{DX} & M_{DD} \end{bmatrix} \mathrm{x} \begin{bmatrix} E_X \\ E_D \end{bmatrix} \tag{17}$$

The multiplier matrix **M** contains four income multipliers. $\mathbf{M}_{DD}$ is the internal multiplier for the endogenous sector showing the impact of autonomous expenditures in the endogenous sector on the level of endogenous income. $\mathbf{M}_{XX}$ is the exogenous multiplier showing the impact of autonomous expenditures in the exogenous sector on the level of exogenous income. $\mathbf{M}_{XD}$ is the export multiplier for the endogenous sector that captures the direct and indirect effects of autonomous expenditure in the exogenous sector on endogenous income. $\mathbf{M}_{DX}$ is the import multiplier representing the direct and indirect effects of autonomous expenditure in the endogenous sector on exogenous income.

Assuming that there is a fixed linear relationship between the generation of mobility and variations in income, the income multipliers can be directly applied to data on mobility to calculate the effects that on mobility of an increase in exogenous activities on the urban economy. For example, this method would allow the calculation of the impact of an increase in tourism on a city on the demand for mobility, thereby allowing the development of a co-ordinated response that incorporates transport planning.

Conclusions

Using sector multipliers allows the investigator to follow the "itinerary" by which an initial change in expenditure affects different economic sectors in an economy. Such an analysis is particularly useful in studying the effects of changes in expenditure on an urban economy. The size of the income multipliers indicates the degree of territorial interdependency. If the multiplier effect for exogenous changes is small, this indicates a strongly localised economy that is relatively insensitive to external impulses. If the export and import multipliers are high, the local economy is highly integrated with the external economy.

In general previous analyses of mobility have typically focused only on direct mobility effects and, as a consequence, have tended to give downwardly biased assessments of the total mobility effects of a given project. Given the dynamic complexity of modern economies, it is important to include the indirect mobility effects of the secondary expenditures induced by the primary expenditure on the project. It is the basic thesis of this study that the most appropriate method of assessing mobility effects is to combine disaggregated income multipliers with a set of estimated mobility generation coefficients to yield mobility multipliers. These mobility multipliers show the total (direct and indirect) change in mobility caused by an additional unit of expenditure in any sector.

The advantage of this method is that in many cases the necessary input-output matrixes are already available since they are required for economic planning. It is relatively straightforward to adapt these existing matrices for the purposes of a mobility analysis. The key assumption of this method is that there is an identifiable and stable relationship between income and mobility in all of the significant sectors of the urban economy. An alternative approach is to investigate mobility on the basis of land-use. However this land-use approach is likely to require large amounts of information. The indirect method proposed here should be able to provide a good approximation at considerably less resource cost.

The multiplier approach highlights the importance of exogenous changes on the urban economy. From the perspective of the city as a "limited container" with a maximum capacity to host economic activities, the export multiplier effects of changes in the external economy on the urban economy are crucial in determining the sustainability of further increases in economic activity. The multiplier approach provides a convenient method of determining the sustainability frontiers. If the urban social multiplier becomes negative, the city has moved beyond its sustainability frontier for mobility with all of the consequent problems of traffic congestion. Hence the multiplier approach can provide an effective "early-warning system" to determine when an urban area is close to exceeding its optimal size.

ACKNOWLEDGEMENTS

This research has been funded by a grant from the British Council – MURST/CRUI Agreement (Grant No. ROM/889/96/51).

REFERENCES

Alberti M., Solera G., Tsetsi V. (1994) **La Città Sostenibile**. Legambiente, Milano.

Breheney, M. (1992) **Sustainable Development and Urban Form**. Pion, London.

Camagni, R. (1996), **Economia e Pianificazione della Città Sostenibile**. Il Mulino, Bologna.

Defourny, J. and Thorbecke, E. (1984) Structural path analysis and multiplier decomposition within a social accounting matrix framework. **Economic Journal 94**, 111-136.

Derycke, P. H., (1972) **Economia Urbana.** Il Mulino, Bologna.

Li Donni, V. (1993) **Dall'Europa delle Nazioni all'Europa delle Regioni**, Nuove prospettive Meridionali, Sicilcassa, Palermo.

Round J. I. (1985) Decomposing multipliers for economic systems involving regional and world trade. **Economic Journal 95**, 378-399.

Van Den Bergh, J. and Nijkamp, P. (1994) Sustainability, resources and regions. **Annals of Regional Science 28**, 256-273.

World Commission on Environment and Development (1987) **Our Common Future**. Oxford University Press, Oxford.