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MEASURING THE EFFECTIVENESS OF REGIONAL POLICIES USING MULTI-REGIONAL ECONOMIC MODELS

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May 1982
CP-82-26

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PREFACE

This paper was presented at the IIASA conference on the Practice and Prospect of Multiregional Economic Modeling, held in Laxenburg, Austria, on November 25-27, 1981. The conference marked the close of a project aimed at providing a world-wide survey of the current practice of multiregional economic model-building and a review of the major development trends.

A more detailed description of the models discussed in this paper is to be found in an IIASA Collaborative Paper 'A Review of Multiregional Economic Models', CP-82-7. Shortened versions of both papers will appear in a book entitled 'Practice and Prospect of Multiregional Economic Modeling' to be published in the summer of 1982.

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ABSTRACT

This paper discusses the contribution of multiregional models to the study of the effectiveness of regional policies. A survey of the instruments and objectives included in multiregional models is presented. Special attention is paid to the effectiveness of public expenditures, investment subsidies, and investment in infrastructure.

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1. INTRODUCTION

In recent years, policy analysis has been increasingly focussed on assessing the impacts of public policies (see, among others, Pleeter 1980). This development has also taken place in a regional and multiregional context.

Multiregional economic models have been developed in many countries during the last decades. These models contain a more or less comprehensive description of the economic structure of regions, the interrelationships among regions, and/or the interrelationships between regions and the national economy. Some multiregional economic models also contain links to other sectors such as energy, pollution, and demographic developments.

Regional policies deal with problems of interregional equity, efficiency, and the unintended or undesirable side-effects of spatial developments; consequently, multiregional models are a potentially useful tool for preparing these policies. This paper will be devoted to an analysis of the use of multiregional models in regional policy making. For an analysis of the effectiveness of policies in a purely regional context, see Folmer (1980) and Moore and Rhodes (1974) among others. The extent to which these models have been used to study the effectiveness of regional policies is discussed and this naturally requires a closer examination of the concept of effectiveness in a spatial context, which is the subject of section 2.

The information on the multiregional models is based on the results of a comparative study carried out at IIASA (Laxenburg) and the Free University (Amsterdam). In addition to the general information on this study contained in Nijkamp and Rietveld (1980) and Rietveld (1980), we refer to the brief survey of these models contained in Rietveld (1982). It is assumed that the reader is familiar with the information provided in this survey.

Given this set of multiregional models, the extent to which these models include policy instruments designed to resolve certain policy issues is considered. The choice of instruments and objectives is based on information provided by the model-builders themselves.

The organization of this paper is as follows.

-- In section 2 the effectiveness concept is discussed from a methodological viewpoint.
-- Section 3 is devoted to a survey of policy objectives and instruments included in multiregional models.
-- In sections 4-6 the effectiveness of some policy instruments (in particular, public expenditures, investment subsidies, and investments in infrastructure) is discussed.
-- Section 7 is devoted to the conclusions.

2. MEASURING THE EFFECTIVENESS OF POLICY INSTRUMENTS USING MODELS

This section will be devoted to an operationalization of the concept of effectiveness of instruments (based on the ideas of Kirschen et al. 1964, and Tinbergen 1956). The idea underlying this concept is that one should distinguish between the effects of policy instruments and of autonomous developments upon policy objectives. This requires a comprehensive representation of an economic system in which a distinction is made between objectives, instruments, and so-called data. Only in this way is it possible to indicate whether a change in policy objectives can be attributed to a certain policy or to autonomous processes.

Consider an economic system that is described by a model containing the following types of variables:

$\underline{w} = (w_1,\ldots,w_J)'$: objectives (or goal variables to be maximized),

$\underline{x} = (x_1,\ldots,x_I)'$: intermediary variables (endogenous economic variables, but no objectives),

$\underline{y} = (y_1,\ldots,y_M)'$: instruments,

$\underline{z} = (z_1,\ldots,z_N)'$: autonomous variables (data),

$\underline{v} = (v_1,\ldots,v_H)'$: non-economic side-effects (pollution, e.g.).

The relationships between objectives, intermediary variables, instruments, data, and side-effects can be represented by means of the simple stimulus-response approach shown in Figure 1.

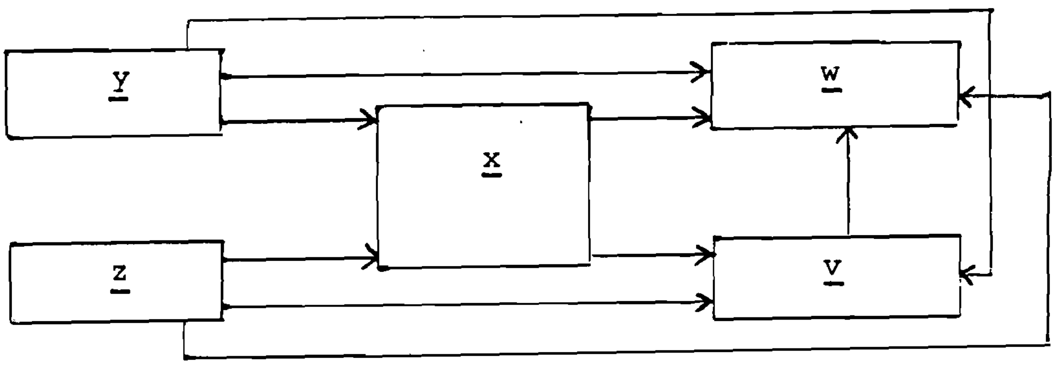

Figure 1. A stimulus-response model for policy analysis.

Clearly, in a dynamic context this system might contain several feedback relationships. It should also be noted that in a spatial setting this system should be extended with spatial spillover effects and spatial interaction linkages.

Assume that the model concerned consists of a series of K independent equations:

$$f_k(\underline{w}, \underline{x}, \underline{y}, \underline{z}) = 0 \quad , \qquad k = 1,\ldots,K \quad . \tag{2.1}$$

These equations describe various types of relationships between the variables, such as technical relationships, balance equations, behavioral patterns of various actors, definitions, etc. Non-economic side-effects are omitted for ease of presentation.

It is assumed that a clear distinction between objectives, instruments, and intermediary variables can be made. However, it should be noted that in certain cases policy instruments may also have the character of an objective, or vice versa (see also section 3). This holds especially true in models with various policy levels or with several policy-making institutions.

Another assumption is that the model is closed, which means that once $\underline{y}$ and $\underline{z}$ are known, the values of $\underline{w}$ can be uniquely determined. A necessary condition for such a calculation is that the number of endogenous variables (I + J) is equal to the number of equations (K) (see Tinbergen 1956).

When the model is linear, (2.1) can be written as:

$$A_1 \begin{pmatrix} \underline{w} \\ \underline{x} \end{pmatrix} + A_2 \begin{pmatrix} \underline{y} \\ \underline{z} \end{pmatrix} + \underline{c} = \underline{0} \quad , \qquad (2.2)$$

where A_1 and A_2 are matrices of order (K x K) and (K x (M + N)), respectively; $\underline{c}$ is a vector with K elements. In this case the solution of the model can be explicitly written in the reduced form (provided A_1 is non-singular):

$$\begin{pmatrix} \underline{w} \\ \underline{x} \end{pmatrix} = -A_1^{-1} A_2 \begin{pmatrix} \underline{y} \\ \underline{z} \end{pmatrix} - A_1^{-1} \underline{c} \quad . \qquad (2.3)$$

The effectiveness of an instrument m with regard to an objective j, γ_{mj}, is defined as the marginal change in instrument m, holding the other instruments and the exogenous variables constant.*

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*For non-linear models, it may be more appropriate to define effectiveness in terms of elasticities. Another advantage of using elasticities is that it makes the effectiveness measures comparable for all instruments and objectives, as well as for all regions.

Note also that an implicit assumption underlying (2.1) is that the ceteris paribus condition holds. In some cases, however, this may not be a reasonable assumption, for example, when the effects of a policy package consisting of a mix of several instruments have to be studied (synergetic effects).

$$\gamma_{mj} = \frac{\Delta w_j}{\Delta y_m} \quad . \tag{2.4}$$

Of course the effectiveness can also be defined in terms of infinitesimal small changes (partial derivatives) in instruments and variables. It is also clear that the effectiveness of an instrument variable is equally determined by the structure and characteristics of the model concerned. When a model is linear, such as in (2.3), γ_{mj} can directly be found when A_1^{-1} and the relevant columns of A_2 are known. Obviously, in the linear case, the value of γ_{mj} does not depend on the values of the instruments and autonomous variables.

When a model is not linear, a straightforward reduced form can only be found in exceptional cases, so that another approach has to be adopted. A widely accepted approach is:

(1) Determine <u>reference values</u> for the instruments and autonomous variables ($\overset{o}{\underline{y}}$, $\overset{o}{\underline{z}}$) and find by means of some numerical procedure the resulting values of the objectives ($\overset{o}{\underline{w}}$).

(2) Formulate a <u>policy variant</u> in the following way. Let $\underline{\varepsilon}_m$ denote a unit vector of which the m-th element is equal to 1 and the other elements are 0. Repeat (1) for the values ($\overset{o}{\underline{y}} + \Delta y_m \, \underline{\varepsilon}_m$, $\overset{o}{\underline{z}}$). The resulting value of the objectives is $\underline{w}_m$.

(3) Determine γ_{mj}, the effectiveness of y_m with respect to w_j, as $(w_{mj} - \overset{o}{w}_j)/\Delta y_m$.

When this procedure has been repeated for all j and m, we arrive at the impact matrix described in Table 1, which can be considered as the central concept of this paper.

Attention is now given to some subjects that deserve further clarification:

1. the role of effectiveness measures in <u>programming</u> models;
2. <u>statistical aspects</u> of effectiveness measures;

Table 1. Impact matrix for M instruments and J objectives.

instruments \ objectives	$w_1 \; . \; . \; . \; w_J$
y_1	$\gamma_{11} \; . \; . \; . \; \gamma_{1J}$
.	. .
.	. .
.	. .
y_M	$\gamma_{M1} \; . \; . \; . \; \gamma_{MJ}$

3. the way in which reference values for $\underline{y}$ and $\underline{z}$ can be determined;
4. spatial aspects of effectiveness analysis.

ad 1. When model (2.1) is used for programming purposes, it has to be extended with a maximand, and with political and other constraints : $\underline{y} \in Y$. Hence:

$$\begin{cases} \max\limits_{\underline{x},\,\underline{y}}! \; \underline{w} \\ \text{s.t. } f_k(\underline{w}, \underline{x}, \underline{z}) = 0 \;, \qquad k = 1, \ldots, K \;. \\ \quad\; \underline{y} \in Y \end{cases} \tag{2.5}$$

This programming problem has been formulated here as a (multiobjective) vector maximization problem (see Rietveld 1980) to indicate that the solution depends on the weights to be attached to the w_j's. It is evident that such political priorities also determine the use of instruments for the achievement of certain goals. The latter problem, however, is more related to policy analysis in general than to effectiveness analysis.

From (2.5), it is clear that the problem of evaluating a policy (e.g. by means of social cost-benefit analysis, strategic choice analysis, or multicriteria analysis) is broader than the problem of measuring the effectiveness of a policy. The former problem presupposes the latter one, but also includes the problem of attaching appropriate weights to the policy objectives (including the costs of policy instruments). Consequently, in that case definite conclusions about the attractiveness of policy instruments may only be drawn when information about the weights of all policy objectives is available. This broader approach, however, falls outside the scope of this paper.

Another observation regarding (2.5) is that many programming models do not focus so much on the effectiveness of instruments (which is taken for granted),* but more on the optimal solution as well as on the sensitivity of this solution to changes in the exogenous variables, the parameters of the functions f_k, and the weights of the objectives.

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*An alternative formulation that is often used in programming models is:

$$\max_{\underline{y}}! \quad \underline{w} \, , \qquad \text{(a)}$$

$$\text{s.t.} \quad \underline{w}_j = w_j \, (y, z) \; , \qquad j = 1,\ldots,J \; , \qquad \text{(b)}$$

$$g_1 \, (\underline{y}, \underline{z}) \le 0 \; , \qquad 1 = 1,\ldots,L \; . \qquad \text{(c)}$$

In this formulation, intermediary variables do not play a role. The inequalities (c) refer to resource constraints, input-output relationships, political constraints, etc. Note that by means of (b) the effectiveness of $\underline{y}$ with respect to $\underline{w}$ can directly be determined.

A problem arising in many applications of such programming formulations is that $\underline{z}$ includes instruments that cannot directly be controlled by the policy unit concerned. For example, in many market or mixed economies, policy units have no direct control of private investments. The obvious consequence is that programming models often yield overoptimistic conclusions concerning options for alternative policies.

In this respect, the side-conditions $\underline{y} \in Y$ from (2.5) may also include policy instruments (e.g. a system of environmental standards). The consequences (i.e. effectiveness) of imposing such constraints for the objectives can be studied by means of dual variables.

ad 2. Statistical aspects of effectiveness measures have in general received little attention in the theory and practice of modeling. Obviously, this is an unsatisfactory situation, since several sources of uncertainty are present in economic modeling: measurement errors in variables, the stochastic nature of parameter values, omitted and latent variables, specification errors, and uncertainties about the future development of autonomous variables. Only recently, the problems of the level of measurement of variables has received more attention in so-called soft or qualitative econometrics (see Nijkamp and Rietveld 1982).

Even in the case of linear models, it is extremely difficult to draw conclusions in a formal analytical way about the statistical properties of the γ_{mj}. Therefore, Monte Carlo simulations are an obvious alternative (cf. Openshaw 1979), although one should be aware of their disadvantages, such as the costs of running a model several times.

From a comparison of ex post with ex ante effectiveness analyses, it is clear that in the latter more uncertainties are involved than in the former. The additional uncertainties relate to (1) the future values of the autonomous variables and (2) the validity of the model for periods that have not been taken into account during the estimation phase. For instance, one may question the relevance of asymmetric economic behavior in a period of economic growth and of economic decline, especially when these models have been assessed during an economic 'upswing' (see Nijkamp 1981). Both uncertainties may be relevant in multiregional models. For example, Courbis (1977) concludes that the effectiveness of certain investment stimulation policies in the REGINA model depends heavily on the values of the autonomous variables. As an example of the second uncertainty, it should be noted that most models have been estimated for a period with steady growth (say the period from 1958 to 1973), so that they may be less useful for policy analysis in periods of stagnation or fluctuation; the behavior of multiregional economic models in a period of economic recession or sudden disturbances is not guaranteed to be consistent (cf. also the notions of stability in catastrophe and bifurcation theory). In this respect, the spatiotemporal structure of an interregional model is extremely important.

ad 3. The determination of reference values for instruments and autonomous variables is in many cases not straightforward, especially with respect to dynamic models when several periods are involved. Reference values for autonomous variables can be obtained by using other models, extrapolating time series, subjective guesses, or a combination of these. Reference values for instruments are based on the notion of no policy alterations. Such a notion of a reference alternative is not an unambiguous term, however (see, for example, Table 2).

Table 2. Government revenues and expenditures measured in real terms.

period	t - 2	t - 1	t	t + 1 forecast	t + 1 policy 1	t + 1 policy 2
public expenditures	17.0	20.0	23.0		26.0	25.3
tax rate	0.15	0.16	0.17		0.18	0.18
tax base	100.0	110.0	110.0	110.0	110.0	110.0
tax revenues	15.0	17.6	18.7		19.8	19.8
budget deficit	2.0	2.4	4.3		6.2	5.5

Table 2 contains (synthetic) data on public expenditures and taxes in previous periods as well as a forecast for the tax base in the next period. Policy 1 is based on extrapolating the trends in the expenditure and the tax rate, while the budget deficit follows as a result. Policy 2 is based on a norm for the deficit/tax base ratio (5%) and an extrapolation of the tax rate. In this case the expenditures follows as a result. We conclude that in many cases the term 'unaltered policy' can be interpreted in several ways (see also de Falleux et al. 1975).

ad 4. The spatial aspects (such as interregional spillover and interaction effects) of an effectiveness analysis of policy instruments in a multiregional model can further be analyzed by employing the notion of decomposability as a formal way of characterizing a complex system (see also Kuenne 1963, and Paelinck and Nijkamp 1976). Suppose that a spatial system is composed of R regions. Each region can be represented by means of a model of type (2.1). If the implementation of policy instruments in a certain region $r (r = 1,...,R)$ has no effects on the endogenous variables and policy objectives in another region $r' (r' = 1,...,R; r' \neq r)$, the spatial system is said to be strongly decomposable. This means essentially that all regions of the spatial system at hand are independent entities with no spatial spillover effects. Strong decomposability implies in formal terms:

$$\gamma_{mj}^{rr'} = 0 \quad , \qquad \forall r,r' \quad , \tag{2.6}$$

where $\gamma_{mj}^{rr'}$ represents the effectiveness of the m-th instrument in region r with regard to the j-th objective in region r' (see also Table 5).

Similarly, one may define indecomposability as follows:

$$\gamma_{mj}^{rr'} \neq 0 \quad , \qquad \forall r,r' \quad , \tag{2.7}$$

which means that the multiregional model at hand is either an interregional model with links among all regions of that (interdependent) system, or a national-regional model with links between the national system and the regions. In this respect, an input-output framework may provide a consistent approach.

If the instruments of one region affect only in one direction the objectives of another region (or a set of other regions), which in turn may affect other regions, a (block-) triangular system can be created (this is a situation of a weak decomposability). For an analysis of such recursive systems, see also Malinvaud (1968) and Wold (1954). For a discussion of national-regional interdependencies the reader is referred to section 3. The obvious conclusion is that in an interdependent multiregional model, the effectiveness of instruments can only be studied in a satisfactory way if the indecomposability of the spatial system is taken into account.

It should also be mentioned that an effectiveness analysis in a geographical setting should take into account the scale of regions and sectors employed in the model, since the results may differ according to the size of regions and the number of sectors at hand.

3. OBJECTIVES AND INSTRUMENTS IN MULTIREGIONAL ECONOMIC MODELS

A comparative study of the effectiveness of instruments of multiregional models may be based on two different approaches: (1) a uniform approach in which for all models the same instruments and objectives are assumed, or (2) an individual approach in which for each model different instruments and objectives are allowed. The latter approach has been chosen here because there appears to be considerable variation in the choice of instruments and objectives across all models. This is evidently determined by the fact that the regional problems may be entirely different in many countries, so that many models have their own specific scope and aim. This would not permit a uniform approach, so that the individual approach appears to be a reasonable strategy. However, no specific critical comments on each individual model can be made, since this would require a detailed long-term study of each model, which is impossible in a comparative study covering approximately 45 models.

For the purpose of this international comparative study, it is important to indicate first the scope of multiregional economic models. Which kinds of policy objectives and instruments are covered by them? The responses of approximately 45 model builders to a questionnaire concerning multiregional economic models were used to answer this question.

One of the questions included in the questionnaire was: 'Which policy goals/objectives are endogenous in the model (at the regional and/or national level)?'. In approximately 31 cases the response contained useful information. In several other models, policy instruments and/or objectives were not dealt with in an identifiable way, they were therefore not considered. The frequency distribution of these responses is represented in Table 3.

The most important socio-economic objectives are present in Table 3, although the frequencies of economic growth and labor market variables are clearly higher than those of the other socio-economic objectives. Policy objectives from related fields are only present to a moderate extent. It may therefore be concluded that in a strict sense multiregional economic models can only be used to a very limited extent to analyze the effects of policy instruments on energy, environmental, or physical planning objectives. Only when these models are linked with other models (e.g. environmental models) is an analysis of effectiveness in this sense feasible.

With respect to the instruments, the following question has been posed: 'For which policy instruments or policy measures can the effects on the policy objectives be determined (at the regional and/or national level)?'. In 25 cases the response contained useful information. The frequency distribution is represented in Table 4.

The main instruments in multiregional models can be found in the fields of government consumption expenditures, public investments, and subsidies of private investments. Other instruments receiving some attention are taxes and employment in government services. Relatively little attention is paid to pricing policies

Table 3. Frequency distribution of objectives in 31 multiregional economic models.

socio-economic objectives	
income, production, consumption	22
employment	19
unemployment	9
prices, inflation	7
balance of payments	2
income distribution	2
budgetary objectives	
tax revenues, investment costs, budget deficit	4
facilities	
infrastructure, utilities	3
energy and environment	
energy consumption	3
pollution	2
physical planning objectives	
land use	1
population distribution	4
land prices	1
trip distribution	1

Table 4. Frequency distribution of instruments in 25 multiregional economic models.

<u>government revenues and expenditures</u>	
consumption expenditures	10
employment in government services	3
public investments	15
flows between national and regional governments	3
social security payments	1
taxes	6
<u>prices</u>	
subsidies of private investments	10
wage subsidies	1
average or minimum wage	2
interest rate	2
public prices	1
transportation costs	1
fuel prices	1
<u>physical planning</u>	
housing	2
<u>environment</u>	
pollution standards	3
<u>other instruments</u>	
limits on productive age	1
agricultural policies	1
national immigration policies	2

(apart from investment subsidies) and to instruments from related policy fields such as physical and environmental planning. These results also show the focus of model-building to be on the demand side (for instance, input-output export base and Keynesian demand theories). There is a serious lack of attention for supply policies.

It is important to note that in many multiregional models it is far from easy to model in a straightforward way a certain policy measure. Many models lack appropriate policy handles (cf. Bolton 1980). For example, in several models, private investments are treated as exogenous variables without any indication of how these investments react to subsidies. Yet if one wishes to study the effectiveness of these subsidies, either one has to link the multiregional model with a model dealing with investment behavior or one has to use the model in connection with some subjective guesses about the sensitivity of investments for subsidies. In this respect, there is a serious lack of information about the internal mechanism of a spatial system.

This lack of policy handles in multiregional models is a clear indication that the language and concepts of regional policies cannot always easily be translated into the language and concepts of multiregional models (cf. Bogaert et al. 1979). De Falleur et al. (1975, p. 278), therefore claim that much attention should be paid to a consistent formulation of policy variants: '...the time spent in formulating a variant can be broken down as follows: 90 percent preparing and formulating the assumptions, 1 percent formulating the simulation, and 9 percent analyzing the results'.

Note that no <u>distinction between national and regional</u> objectives and instruments has been made. Instruments may be used at both a national and a regional level, while objectives may also be specified at both a national and a regional level, leading to complex linkages in a spatial system. So the majority of the objectives may function at both levels (exceptions are the balance-of-payments, inflation, and budgetary objectives of the national government), while the same holds true for the instruments (for example, an investment subsidy may be specified for an individual region, but it may also be uniformly applicable to all regions).

Consequently, the impacts shown in Table 5 can in principle be covered by multiregional models.

Table 5. Impact matrix for region-specific and uniform regional instruments and objectives.

	region-specific objectives	national objectives
region-specific instruments	Λ^{rr}	Λ^{rn}
uniform regional instruments	Λ^{nr}	Λ^{nn}

The matrix Λ^{rr} indicates the effects of regional policies on regional objectives. The matrix Λ^{rn} indicates the (perhaps unintended) effects of regional policies on national objectives. The matrix Λ^{nr} is the main interest of national policies, while Λ^{nr} describes the (perhaps unintended) effects of national policies on specific regions. When dealing with the performance of a specific region, there is often a tendency to focus on Λ^{rr}, but this is not always justifiable. There are several policy fields without an explicit regional orientation that may have strong differential impacts Λ^{nr} (e.g. education, infrastructure, environmental standards, income and labor market policies). The same holds true for national capacity limits or national price policies.

Top-down models are based on the assumption that the main national variables are given, or at least not determined as endogenous variables in a multiregional framework. They provide a feasible area within which regional trade-offs and allocations take place, although the regional distribution of activity will not affect the national totals. Hence, these models can only be used to study Λ^{rr} and Λ^{nr}.

One might argue that Λ^{nn} is already covered by national models, so that it can be deleted in the context of multiregional models; this, however, is not necessarily true. Multiregional models with a bottom-up structure or with national-regional interactions are in principle also suitable for this purpose and may even be more appropriate than national models in certain cases.

The following conclusions can be drawn from this section:

1. Multiregional economic models are in most cases not sufficiently integrated to be used for analyzing the effects <u>on</u> or <u>of</u> policy fields related to regional economic policy (such as physical or environmental planning). In these cases multiregional economic models can only be used for analyzing such effects if they are extended in that direction, linked with other models, or supplemented with expert information.

2. In multiregional economic models relatively little attention is paid to pricing policies (apart from investment subsidies). The same holds true for the supply side (capacity limits on the labor or capital market, e.g.). Neglecting these elements may evidently lead to biased results in the effectiveness analysis, or to lack of insight into equilibrium tendencies in multiregional models.

In section 4 some numerical results of effectiveness analyses using 14 multiregional models from various countries are presented. For a description of these models, see the summary descriptions in Rietveld (1981). A selection of specific policy areas will be made. Sections 4-6 will be devoted to three main fields of regional policy: government expenditures, stimulation of private investments, and investments in infrastructure. The main emphasis is on the effects of these instruments on economic growth, income, and employment. Some models also yield effects of other objectives, but - for the ease of presentation - these effects will not be reported here.

4. GOVERNMENT REVENUES AND EXPENDITURES

Some conclusions of model results and simulations are preserved in this section. The main focus is on the effectiveness of policies in which government revenues and expenditures play an important role. In general, it turns out to be almost impossible to draw inferences about the statistical validity of the results, since no model provides information on these aspects. For ease of presentation, a representative sample of models will be treated here. The presentation is based on the results of NRIES, MAG, IDIOM, a version of MRIO, and MEPA. All information has been provided by the model-builders.

NRIES has been used to analyze the effects of a revision of the financial flows between the national (federal) and regional (state and local) authorities (see Ballard et al. 1980). The revised system assumes grants that are proportional to the population of the regions. The sum of the grants remains the same in the reference case and the policy variant. The redistribution of grants may give rise to a considerable increase or decrease in grants (for many regions a change of 10 to 20 percent). The long-run effects of the redistribution on per-capita income in the regions are relatively small (in most cases a change of less than 1%). The interregional inequality in per-capita incomes, measured by means of the coefficient of variation, decreases from 0.1374 to 0.1359. Since NRIES is not a top-down model, it also yields results for the effects on the national economy. The redistribution gives rise to an increase of 112,000 man-years in the long-run, which indicates that high multiplier states gain more than low multiplier states.

Another application of NRIES concerns the effects of a uniform increase in federal expenditures (partially covered by some uniform tax increases) on the regional economies (see Ballard and Wendling 1980). The national effect is an average employment growth of 1 percent per year. The regional variations in the effects of the policy package are substantial: when the USA is partitioned into 8 clusters of states, the yearly regional employment growth can be calculated by means of the abovementioned effectiveness analysis and it varies between 0.2 percent and 2.8 percent.

The second model discussed here is the MAG model. The MAG model has been used for an impact analysis of a spatial redistribution of government activity (see Milne et al. 1980). In the reference solution, the share of the northern tier of the USA in government production declines from 37.1 percent to 36.9 percent in a ten-year period. In the policy variant, an increase of this share to 39.8 percent has been formulated. The implications of these policies for gross regional production are represented in Table 6.

Table 6. Regional impacts of a redistribution of government activity.

	yearly growth rate of gross regional product		
	northern tier	rest of the nation	national
reference solution	2.5	3.3	2.9
policy variant	2.7	3.0	2.9

We may conclude from Table 6 that a redistribution in favor of the northern tier gives rise to a reduction of differences in regional growth rates. The model does not allow an analysis of the impacts on national efficiency, since the sum of the regional variables is made to coincide with forecasts of the national values from the driving national model.

The next model discussed in this section is IDIOM. One of the policy simulations with IDIOM concerns the direct, indirect, and induced effects of a cut in military exports (see Dresch and Updegrove 1980). The national decrease in employment is 0.7 percent. When the USA is partitioned into 13 clusters of states, the regional decrease varies from 0.2 to 1.0 percent. Two compensatory programs have been devised: a public works program with emphasis on the mostly heavily affected regions and a uniform reduction in the labor tax rate. In both cases the decrease in employment can be offset at the national level. When the second compensatory program is employed, regional variations persist, however (the change in regional employment varies from -0.3 to + 0.3 percent).

Not surprisingly, it appears that the main industries to suffer from the reduction in exports are not the industries benefiting from the compensatory measures. Therefore, the outcomes of the simulations rely heavily on the assumption of a flexible labor market (large occupational mobility and elastic supply). This is obviously due to the fact that IDIOM is a demand-oriented model.

Now a specific version of MRIO will be discussed. This version has been used to study the effects of various tax and income redistribution measures (see Golladay and Haveman 1977). It is the version developed at the Institute for Research on Poverty (IRP). In the IRP version, much attention is paid to income distribution aspects; for example, consumption functions have been specified for 7 income classes; labor requirements for 114 occupational categories are included.

The model has been used to identify the impacts of a redistribution of incomes by means of a family assistance plan and a negative income tax. In a regional perspective, this means that the southern part of the USA receives large net transfers at the expense of other parts of the USA. One of the main conclusions of the study is that the transfers lead to a certain reduction in interregional income inequalities, but the production shifts resulting from the transfers are substantially less equalizing, since, as a result of the interregional trade pattern, a substantial part of consumption in the South is produced in other regions. Another conclusion of the study is that the income transfers give rise to an increase in aggregate demand in the national economy (due to differences in the propensity to consume between income classes). In some policy variants an increase of 120,000 jobs has been shown.

In this section some attention is given to policy studies with the MEPA model. MEPA was originally designed as a single-region model for Massachusetts (USA), but at present the model is supplemented by a partitioning into 5 sub-regions (cf. Treyz 1980; Treyz et al. 1980; and Treyz and Duguay 1980). Although our presentation is based on the single-region version of MEPA, the model is included here because it sheds light on important points that are not covered by the other policy studies reported.

In MEPA a crucial element of the policy simulations concerns the effects on wages and prices. For example, in a study of the effects of an increase in defense-related contracts in Massachusetts, the model gives rise to the conclusion that the total direct and indirect employment effect in the first year is approximately 2.8 times the direct employment effect. In the fourth year, this number has decreased to 1.7.

The reason for the decrease is that the direct effect leads to a tighter labor market and hence to higher wages. This gives rise to substitutions between labor and capital and to a reduction of investment in the pertaining region. In another application of MEPA the effects of an increase in welfare payments of 400 million dollars in Massachusetts have been analyzed (see Treyz and Duguay 1980). Fifty percent of the increase is covered by an increase in personal income tax, the other fifty percent comes from federal resources. The short-run effect of the policy is an increase in employment of 16,790 jobs in Massachusetts. The long-run effect (after 10 years) is a <u>decrease</u> of 3,170 jobs, the reason being the above-mentioned substitution and spatial re-allocation effects.

In order to test the sensitivity of the outcomes for feed-back effects from the labor markets, MEPA has been rerun with fixed wage levels. In this case, a completely different effect is found, namely an increase in the long-run of 16,760 jobs in Massachusetts. This is a clear illustration of the sensitivity of the outcomes of policy analysis for the structure of the models. These results once more demonstrate the necessity of a careful effectiveness analysis in regional models.

These policy exercises and simulations give rise to the following observations:

1. Some models (NRIES and the IRP version of MRIO) allow one to study the effects of an interregional redistribution of income or government expenditures on national efficiency (cf. the matrices Λ^{rn} in Table 5). The common idea that there is a trade-off between national efficiency and interregional equity is not confirmed by these models. These models give rise to the conclusion that - given the present situation - it is possible to increase both national efficiency and interregional equity.

2. Uniform policies at the national level may give rise to substantially varying effects for the regions (see NRIES, IDIOM, and the IRP version of MRIO). This is a clear indication that the Λ^{nr} part of Table 5 should not be neglected in regional policy analysis.

3. In the policy analyses, little systematic attention is paid to the uncertainties in conclusions concerning policy effects. An exception is the experiment with the MEPA model in which the sensitivity for the assumptions of fixed wages is tested.

4. Some experiments (IDIOM, the IRP version of MRIO) are based on the method of comparative statics. The obvious disadvantage is that it is not possible to assess the magnitude of effects in the short and the longer run. As indicated by an experiment with the MEPA model, short- and long-run effects may differ significantly.

5. IDIOM and the IRP version of MRIO are pure demand-driven models. Hence, they are based on the assumption that there are no serious bottlenecks on the supply side (for example the labor market). In cases where this assumption is not realistic, one may question whether the outcomes of the simulations are meaningful.

6. In all cases, the experiments concern <u>ex ante</u> analyses of policy measures.

5. STIMULATION OF PRIVATE INVESTMENTS

The effects of stimulating private investments is the subject of the present section. Here again, a representative sample of models will be discussed. The results of REGAM, the Suzuku et al. model, RENA, MACEDOINE, and REGINA are presented.

REGAM has been used for an _ex post_ analysis of the effectiveness of regional investment subsidies in the Netherlands.* One important finding is that the effectiveness depends heavily on the macro-economic conditions. Consider, for example, the effect of a one percent reduction in the price of investments in a region compared to the average price reduction over the regions on the discrepancy between the regional and national growth rate of manufacturing employment. This effect declined from 0.40 percent a year in the fifties to about 0.15 percent a year in the seventies.

In another _ex post_ analysis, REGAM has been used to determine the extent to which investments for which a subsidy has been received would have been realized without the subsidy. In the period from 1973-1979, 20,000 jobs were created in connection with subsidized investments. REGAM indicates that approximately 9,500 jobs (40-50 percent) would not have been realized without subsidies. In the model no attention is paid to indirect and induced effects. Hence, a certain underestimation of the policy effect may have occurred.

REGAM is a top-down model. This means that the regional investment subsidies only influence the regional distribution of employment, but not the national volume. Consequently, the 9,500 jobs created in the stimulation regions have been realized at the expense of 9,500 jobs in regions without subsidies. In Table 7 the positive, negative, and net effects per region are represented.

The fourth row contains the actual development of industrial employment during the period considered. Clearly the net effects of the subsidies are small compared with the effects of autonomous

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*See the official government document: Nota Regionaal-Sociaal Economisch Beleid, 1981-1985 (1981); see also Van Delft and Suyker (1981).

Table 7. The development of industrial employment and effects of investment subsidies, measured in man-years in the Netherlands (1973-1979).

region	north	east	west	south	Netherlands
1. positive effects	3,000	2,000	500	4,000	9,500
2. negative effects	500	1,500	5,500	2,000	9,500
3. net effects	2,500	500	-5,000	2,000	-
4. total mutation	-15,500	-33,500	-71,500	-37,500	-158,000
5. mutation based on constant employment shares	-15,500	-31,500	-67,500	-43,500	-158,000
6. regional component	-	-2,000	-4,000	6,000	-

variables. The investment subsidies influenced only marginally the development of regional employment.

The fifth row indicates the development of regional industrial employment that would arise if the national rate of decline had been applied to all regions in a uniform way.

In the sixth row the regional component in the actual development has been presented (row 6 is defined as the difference between rows 4 and 5). When comparing rows 3 and 6, it is concluded that part of the relatively favorable development of the South may be ascribed to the investment subsidy.

For the North and the East, the inferrence is that the positive net effect of the subsidy is hardly sufficient or is insufficient to counterbalance the negative effects of other variables.

The next model discussed here has been designed by Suzuki et al. (1978), who have analyzed the effects of policies aiming at industrial decentralization by means of congestion taxes in highly industrialized regions and subsidies in less industrialized regions. The taxes are imposed on factory floor space in the industrial sector. The taxes and subsidies are included in the model by means of the variables determining regional investment. The effects of the policy measures are represented in Table 8, which indicates that the measures lead to a certain dispersion of industrial activity from the main industrial center (Kanto) to the rest of the country. The measures are not strong enough to prevent Kanto from increasing its share, when compared with the situation in 1970. This conclusion is striking when one knows that in the reference solution certain dispersion measures have already been taken into account (for example, a tax on environmental pollution).

Next, the RENA model is briefly discussed. According to the RENA model the short- and medium-term effects of an investment stimulus on regional employment are very small (see Bogaert et al. 1979). The model-users report that this can be attributed to the fact that, in the past, investment aid has been used predominantly for a rationalization of production, instead of for an extension of the production capacity. This behavior in the past

Table 8. Impacts of industrial decentralization policies in Japan.

region	industrial 1970	production in billions yen 1985(reference solution)	(and in percentages) 1985 (policy variant)
Kanto	64,500 (39.2)	160,600 (40.7)	156,400 (39.6)
Japan	164,400 (100.0)	394,900 (100.0)	395,000 (100.0)

has largely influenced the estimation results and hence the conclusions of the effects of investment aid on employment.

In MACEDOINE, gross investments as such are assumed to be exogenous. Therefore, in a strict sense an analysis of stimulation policies cannot be carried out. The model is interesting, however, since much attention is paid to investment multipliers in space and time (see Despontin 1980).

In short-term multiplier of gross regional investments on gross regional production varies considerably among the 8 regions: they range from 0.53 to 1.08. This may be due to large differences in the economic structure of these regions. The corresponding interim multipliers increase considerably over several years. Eventually, these multipliers decrease because of substitution processes induced by wage increases. Cumulative interim multipliers or total multipliers have not been computed. This is related to the fact that several eigenvalues of MACEDOINE are substantially higher than 1, giving rise to a divergent system. This result casts doubt on the relevance of the model in simulations for a long run.

The REGINA model has been used to find the impacts on the national economy of various regional investment strategies (see Courbis 1979). For each of the five REGINA regions, a gradual increase of two percentage points in the share of manufacturing investments that the region holds in the total manufacturing investment is considered for the period 1970-1980. This increase is compensated for by a decrease of investments in the other regions with an equal decrease in relative terms for each of these. This redistribution of investments would give rise to an increase of approximately 50,000 jobs in manufacturing in the stimulation region.

Since REGINA is not a top-down model, it can be used to assess the effects of the various alternatives on the national economy. It appears that these effects vary considerably (see Table 9). For example, a stimulation of the Paris region assuming rapid national economic growth gives rise to a decrease in 1980 of 132,000 jobs in the total employment pool, while a similar stimulus in Eastern and Northern France give rise to an increase in 1980 of 40,000 jobs. This difference is due to the tight labor market in Paris and the dependence of wage development in other regions on the wages in Paris.

Table 9. Effects of regional investment policy (1970-1980) on the national economy in 1980, given alternative assumptions concerning national economic growth.

	stimulation region	impact on national employment (measured in jobs)	impact on national price level (measured in percent points)
rapid national economic growth	Paris	-132,000	+ 1.3
	Western and South-Western France	- 31,000	+ 0.8
	Eastern and Northern France	+ 40,000	- 0.5
moderate national economic growth	Paris	-112,000	+ 1.2
	Western and South-Western France	+ 4,000	+ 0.2
	Eastern and Northern France	+ 31,000	- 0.4

An interesting result of REGINA is that the effects of regional policy depend considerably on the assumptions about autonomous variables. For example, when more moderate national economic growth is assumed, the effects also tend to be smaller and may sometimes show a change in sign. This is illustrated in Table 9 by the employment effect of an investment policy in favor of Western and South-Western France that is negative in the strong growth variant and positive in the moderate growth variant.

These policy experiments give rise to the following observations:

1. The simulation with REGAM is the only ex post experiment in this section. This experiment gives rise to the conclusion that a substantial part (40-50 percent of the jobs created in connection with investment subsidies in the Netherlands from 1973-1979 would not have been created without subsidies. Another conclusion from REGAM, which is also supported by Suzuki's model and the RENA model, is that the effects of subsidies are small compared with the effects of autonomous variables. This means that - given the level of subsidies considered - the spatial distribution of investments is only marginally influenced by the subsidies.

2. From the experiments with REGAM and REGINA, it appears that the effectiveness of investment subsidies depends considerably on national economic conditions. In periods of rapid economic growth, the effectiveness is, in general, greater.

3. In the simulation with REGINA, attention is paid to the effects of an interregional distribution of investments on the national economy (see matrix Λ^{rn} in Table 5). These effects may be substantial.

4. In three of the five simulations, investments are stimulated by means of subsidies, which are modeled via the user cost of capital. In the other two cases, no indication of how the investments are stimulated

is given; one simply assumes a given shift in regional investments. If one wants to study the effectiveness of subsidies in the last two cases, additional information about the influence of subsidies on investments would be required.

5. All models are based on the assumption that investments resulting from stimulation measures are - on the average - not different from other investments in a certain sector. This assumption may give rise to questionable results. For example, a common argument against investment subsidies is that they are on the average used by less efficient firms. This gives rise to a higher than average probability that these firms might close down within a fairly short period. Such an argument is not taken into account in the models. As far as the argument is real, the models give rise to an overestimation of the effectiveness of investment subsidies.

6. It is a well-known fact that modeling investment behavior is a difficult task and that statistical tests of estimated relationships in this field often give rise to less satisfactory results. Therefore, it is disappointing that in the simulations little attention is paid to the measure of uncertainty of the outcomes.

7. In two cases (MACEDOINE and RENA), the economy is treated as one uniform sector. Consequently, these models are less adequate for an analysis of subsidies to specific industries.

6. INVESTMENTS IN INFRASTRUCTURE

As a final example of effectiveness analysis, the impact of public infrastructure is examined. Investments in infrastructure are part of government expenditures, which have already been dealt with in section 4. A separate treatment of infrastructure investments is justified, however, since these instruments give rise to effects that are often absent in the case of consumptive expenditures (see Biehl et al. 1980, and Nijkamp 1981). They are not only a component of final demand, but may also add to regional productivity and the attractiveness and development potential of regions for productive or residential purposes. The latter effect will be called the attractiveness effect. In this section, the results of BALAMO, a model of Fukuchi, RENA, MRMI, and REGAL are presented.

In BALAMO, special attention is paid to investments in road infrastructure. The two production factors determining regional production are the regional labor force and the regional road stock (this is evidently a rather restricted production theory). The production function has been specified such that considerable substitution possibilities exist between these production factors.

In one of the simulations (see Kawashima 1977), a 100 percent growth rate per 5-year period of gross road investment in a particular region is assumed, while for the remaining regions a 50 percent growth rate is taken. Gross investments are devoted to the replacement or repair of the existing stock (depending on the intensity of use in the previous period) and the extension of the regional road network. In this simulation the share of the particular region in the total production of mineral resources increased from 6 percent to 20 percent after six periods.* The reliability of this result is questionable. The structure of the model is not very suitable for an analysis of 30 years or more, especially since no attention is paid to the formation of private capital stock.

In another Japanese model (built by Fukuchi 1978), considerable attention is paid to the role of infrastructure. Infrastructure plays a role in the equations explaining the regional

*Note that in this case reference values for the instruments have not been given (for example by assuming a uniform growth rate of instruments of 50 percent in all regions). The reported result for the share of regional production has been compared with the initial situation and not with the result of a reference policy. Consequently, in a strict sense, this experiment does not give any information about the effectiveness of the road investments.

population (social welfare capital) and regional production levels in various sectors (collective agricultural, industrial, and tertiary capital). The elasticities in the production functions are considerable. For example, an increase of 1 percent in collective capital for the tertiary sector in a certain region gives rise to an increase in the regional production in that sector of 0.3 percent in the same year.

In this model no attention is paid to the role of investments in infrastructure as a final demand component. Their only function is that they increase the regional production capacity. This treatment of infrastructure can also be found in BALAMO.

The impacts of public infrastructure can also be identified in RENA. A result of the RENA model is that a reallocation of public investments among regions has relatively small effects on regional growth and employment (see Bogaert et al. 1979). In this model, public investments are treated as an exogenous part of total investments. Hence, their effects on employment can be found in a way similar to the procedure applied to private investments (see section 5). Consequently, the same explanation of the small extent of the effects can be given here as in section 5.

The MRMI model has been used extensively for studies concerning the effects of changes in transportation networks on regional economies (see Harris 1980, and Hilewick et al. 1980). One study has focussed on the effects of building and upgrading highways and railroads in Pitt County, a county with approximately 75,000 inhabitants in North Carolina (USA). The short-run effects of the investemtns are clearly positive: during the years of construction, employment has increased by approximately 1,200 jobs. The long-run effects (10-15 years) of improved accessibility are small and <u>negative</u>: the model indicates a decrease of 40 jobs. This means that in this case other regions benefit more from increased accessibility than the region of investment itself. In a similar case study for other counties, a small but positive long-run effect is found for the region of investment. Obviously, the MRMI model allows for both a positive and a negative sign for the long-run effects of investments in transportation on the pertaining region. The sign of the effect depends partially on the level of congestion in the transportation system, the existing spatial distribution of activities, and the size of the investment relative to the regional product.

The effects of investments in transportation have been compared with the effects of investments in the communications sector (printing, computing machinery, broadcasting, etc.) in Pitt County. The conclusion is the investments in communications, aiming at regional self-sufficiency, give rise to a smaller investment sum, but a larger number of jobs in the medium and longer term. This is due in part to the relatively low capital intensity of the communications sector. No indication is given of the policy measures to be taken to realize these investments in the private sector (see the fourth observation of section 5).

Finally, the REGAL model is discussed. REGAL is based on the assumption that public capital is a necessary condition for production in the private sector (see Granholm 1981). Public capital is tied to the volume of private capital stock by the fixation of minimum requirement parameters. Thus, when the regional public capital stock is fixed, a limit is imposed on the extent to which the regional private stock can be used, and thus on regional production. Hence, when there is a shortage of public capital, public investments give rise to a proportional increase of production in the private sector. When there is no shortage of public capital, public investments have no direct effects on the level of production in the private sector. The following public sectors have been distinguished: child care and basic education, medical services, public administration (national and regional), transport and communications, housing stock, eletricity and water production, road capital. Regional public capital also plays a role in REGAL in the determination of the regional population. Given the level of regional public services, a constraint is imposed on the total population that can live in a region.

The policy simulations give rise to the following observations:

1. In two out of the five models (RENA and MRMI), attention is paid to both the demand and the attractiveness effects of public investments. In the other three models, only attractiveness effects are dealt with.

2. The atractiveness effects of public capital investments can be modeled in a direct and an indirect way. In MRMI the indirect approach is used. The effects of investments in transportation infrastructure on regional development are modeled by means of the ensuing reduction in transport costs. In this case, the question of how transport costs are influenced by the investments has to be solved outside the model. In the other models a direct approach is used. The public stock plays an explicit role in these models, for example, via production functions.

3. In the RENA, BALAMO, and Fukuchi models, substitutability between public capital and private production factors (labor or capital) is assumed. This is not the case with the REGAL model. In this model the notion of complementarity of private and public capital is fundamental.

4. The level of disaggregation of the public sector differs substantially among the models. In RENA disaggregation does not take place; BALAMO deals only with road stock, in Fukuchi's model four general classes of public capital are distinguished; in REGAL the public sector is divided into eight groups. Obviously, a low level of disaggregation hampers the analysis of the effects of specific public investment projects.

5. In all models, attention is paid to the role of public investments for the behavior of private enterprises. Obviously public capital may also influence household behavior. For example, in REGAL and Fukuchi's model attention is paid to the influence of infrastructure on migration.

6. The simulation with MRMI indicates that the short-run (demand) effects of investments in infrastructure may be completely different from longer-run (attractiveness) effects. This points to the importance of a dynamic analysis.

7. No uniform conclusions can be drawn about the size of the attractiveness effects of investments. MRMI and RENA indicate small effects, whereas the other models give rise to the conclusion that substantial effects will arise.

7. CONCLUSIONS

At the end of each of the preceding sections certain observations have been put forward. In this section some conclusions of a more general nature are presented.

1. In sections 4-6, the contributions of approximately one-third of the models included in the survey have been discussed with respect to the problem of instrumental effectiveness. There are various reasons why the other models have not been discussed: some models are not yet fully operational, some are not intended for policy studies, in some cases insufficient documentation is available, etc.

2. As a consequence of conclusion (1), multiregional economic models do not allow definite conclusions with regard to policy debates concerning labor versus capital subsidies, work-to-workers or workers-to-work policies, the role of direct controls, etc.

3. In some cases, more definite conclusions can be derived from model simulations:

    a. Given the present level of investment subsidies considered, the effects of subsidies are small compared with the effects of autonomous variables (observation 5-1).

    b. The notion that there is a general trade-off between national efficiency and regional equity is not confirmed by the models. In various experiments it appears possible to increase efficiency and equity simultaneously (observations 4-1 and 5-3).

c. In various model experiments, uniform policies at the national level give rise to substantially varying effects for the regions (observation 4-2).

4. In the experiments, insufficient attention is paid to uncertainties concerning instrumental effectiveness. Uncertainties may arise from sources such as the stochastic nature of parameters, specification errors, and uncertainties about the future development of autonomous variables. In some experiments the last source of uncertainties is treated (observation 5-2), but the other sources remain almost unmentioned (observations 4-3 and 5-6).

5. Most studies of instrumental effectiveness of multiregional models are of an *ex ante* nature (observations 4-6 and 5-1). This may be a surprise, since there are various reasons why an *ex post* analysis is easier to perform (see section 2). On the other hand, an *ex post* analysis may clearly give rise to less welcome results for both policy-makers and model-builders.

6. Concerning the time span of the policy analyses, in general, it does not exceed 15 years. This means that multiregional economic models have only been used for short- and medium-run analyses up to now. Another finding is that the short- and medium-run effects of policy measures may differ considerably (observations 4-4 and 6-6). This indicates that models that do not allow one to study short- and medium-run effects separately (e.g. static models) are less adequate for certain policy analyses.

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