Induced development in the transportation investments corridors - the probability appearance appraisal method based on the land use profiles

V. Depolo

*Urban Land Development Public Agency, Belgrade, Yugoslavia*

**Abstract**

Transportation system investments (Infrastructure and/or Public Transport Subsystem) produce the redistribution of existing (short-term effect) and generate the new travel demand (long-term impact of investment). The induced development is the key factor of new demand generation. The probability of induced development appearance appraisal method, developed by the author, is based on the use of the *Land Use Profiles*, defined for three basic land uses: housing, commercial activities and industry/storehouse, based on two criterion sets.

Forecasts based on the *Land Use Profiles* are evaluated by the use of experts' interview for real estate, whose estimates are in the range between 5 to 25 % (in some specific sites the percentage is even greater) compared to the existing/planned volume of development. This is equal with forecasts performed on the basis of the method and can be interpreted as an evidence of forecasting results.

The essential importance of the authors' work is that it describes *adjustment process* in the investment-influenced area. It also represents one step towards the induced demand forecasting method improvements, whose existence, despite evidences, was neglected by the part of the professional community.

**1 Problem definition**

In the previous period transportation system impacts were examined by land-use/transportation relationship. The goal was reaching balance, in steps and in the cycles, by defying middle / long - term programs of development. Each cycle defined a new state of balance. The state of balance in relation with the land-use/transportation replaced the state of imbalance and vice versa thus creating the
conditions for stimulating the new development/investment. The influence of cumulative (economic development and superstructure construction) and stabilization factors (infrastructure investments) are occurred in cycles.

When urban transportation infrastructure investments are in question, measurement of economic benefits is accompanied by the complex conceptual and the practical problems. The questions concerning social values and social welfare are in the first line. The influence of indirect, especially external effects has been insufficiently researched. As far as transportation investments are in question, positive external effects, especially those connected with induced development phenomena and following form of appearance are of particular importance. In the past 10 - 15 years research efforts have been more intensive, but still there is a need for new methods of research.

From the present theoretical and practical works in the field of urban transportation investments impacts analysis come that positive externalities arise as consequence of infrastructure offer.

In some circumstances, efficient means of the state intervention/regulation is represented by appropriate rules - in urban agglomeration urban planning appears as regulation. By land use and appropriate standards one can influence the demand elasticity, the quality of offer, and the land parcel values. But, because of the imperfect mechanisms in location quality measurement, the biggest rate of increased land value is internalized by owners/tenants.

When public land use is concerned (for example, infrastructure corridors), standards directly influence on the investment costs. If positive effects of agglomeration process (for of social benefit) are researched, appropriate development programs in the infrastructure investment corridor can help its efficient realization.

Existence of social benefits, positive externalities as consequence of infrastructure offer/development and their different shapes of appearance, are sometimes neglected by the part of the professional community (Button K, Quinet E, [1]). The reason is, after all, insufficient research of these phenomena. Having in mind these facts, the research of social benefit generated by transportation infrastructure influence, especially in urban agglomeration, has the essential importance in minimum two reasons:

1. Assessment of investment efficiency is more complete;
2. Possibilities for analysis and managing of cyclic changes are created with respect of the relation between the transportation system and the catchments.

---

1 Internalization of external effects is the procedure by which one can reach balance of economic and social optimum. For each external effect quantification method, there is an appropriate internalization procedure. It can be said that every method of external effect quantification is based on corresponding internalization procedure. In practice, command and control instruments of internalization are often used. They do not represent strict internalization, but have the character of quasi internalization procedure - state intervention.
2 On broader plan it is the matter of undeveloped regions progress, and in the urban areas, this relate to the activity, employment and development inducement, etc.
3 Once the benefit has been detected, it is natural to internalize it, which is one of the reasons of dispute. Because of this, external benefits of significant intensity appear in proportionally shorter period than the investment life period, and they are evident in the field of land for development.
area (shifting of state of balance and unbalance), in other words, possibility for defining of the role of cumulative (induced development) and stabilization (investment) factors relationship.

Decisions connected with the social effects request more complex methodologies which integrate all known methods and techniques of analysis, forecasts, and assessment, and evaluation of impacts of transportation system to the environment, approved in current practice of transportation engineering. In that context, request for further improvement of transportation investment evaluation methodologies appears, especially when concerning cumulative influences, which stimulate secondary (induced) development.

The basic task of the investment impact analysis is identification of all potential influences that will be generated by the investment corridor, in other words, stimulation of the positive influences by which its entire efficiency will increase. Traffic generated as consequence of (induced) development is of special concern.

2 Research methodology

In the literature, induced development of superstructure objects, in terminological and essential meaning is treated in different ways. It is a process induced by direct investment influence on the level of accessibility. The inducement process takes time; it has a long-term character. Attractive location stimulates development, strengthening the "pressure" for its activation. This pressure manifests through the location prices or the other demand aggregates, and directly influences generation and intensification of imbalance between transportation system (offer) and transport needs (demand). It is, therefore, secondary consequence of investment and since it is not directly connected with physical presence of investment but with effects of functioning, it is considered as external effect.

The problem of the state of balance between transportation system and transportation demand (which comes from space distribution, structure and intensity of urban functions) definition is question constantly present in theory and engineering practice. However, the point is the process that has its continuity of life in observed urban area, in which there is a permanent change of states of balance and imbalance under the influence of cumulative and stabilization factors. Since in the process of adjustment between transportation system and its environment occurs "pressure" for development of new space of superstructure, it exerts influence on the continual increase of transportation demand.

In ideal circumstances this "pressure" originates from induced development, and in the course of time, creates such level of social costs, which require new investment cycle. Because of this, it is socially suitable, in the phase of creating each development cycle of urban transportation system, to clearly identify and define levels of acceptable deviations of balance, and, create measures for establishing "quasi" state of balance. In other words, this means establishment of marginal level of balance deviation. When transportation system and its environment reach these marginal conditions of imbalance, new
investment/development cycle starts. Described flow has analogy with Hirshman's thesis of continuing state of imbalance, as condition of progress.

Research of transportation investments impacts on the induced development is carried out through identification and systematization of impact components, their quantification, with parallel process of formulation appropriate stimulant measurers and evaluation of possible solutions by which stimulant measures could be reached.

Specialties of basic land uses (housing, industrial/warehouse development and commercial land development) have influence on the choice of methods for impact quantification, that is, on the techniques for induced development allocation. The estimations are to be performed in two steps. The first one, net increase of development inside urban area is calculated, and distributed between potential locations planned for development and area of investment influence.

When one researches influence of transportation investment on the location decisions in economy, specifically in commercial and industrial activities, number of models based on accessibility and transportation costs are in disposal; certain number of this models are also useful for distribution of housing space inside urban area (Banister D, Berechman Y, [2]). In the second step, appropriate net increase of corridor is allocated to the locations inside the corridor. In that step, factors generating induce development come into focus, and the analyzed locations are ranged according to the probability of attracting the induced development and then, the possible volume of development is calculated. Potential for acceptance of certain volume and structure of induced development is defined by location profiles, which plays the key role in this phase. Insufficient empirical research connected with induced development, cause that methods and techniques for second analysis step are based on analogy.

2.1 Location profiles

Two clusters of criteria are used in accessing the probability that certain location situated in investment corridor will attract corresponding volume of induced development: limiting and stimulating criteria. They are adapted to the type of investment, i.e., they are different slightly if investments are in streets from those in public transport.

Criteria that limit the probability of induced development involve: technical function characteristics of investment corridor, and land use characteristics in area of influence (disposed locations, type of ground, urban limits, etc.). Quoted characteristics belong to the domain of state intervention instruments by which the emission of external effects is regulated. Marginal planned levels of development increase by locations are defined by estimation of indicators from this cluster of criteria. Criteria that stimulate the probability of induced housing development involve: location of corridor in relation to the city center network and posts of employment, and the potential of economic life. Housing locations are analyzed on the basis of corresponding location profiles (Holm T, A.V, [3]). Profiles of locations position related to the city center network Pc, is
defined by cluster with elements "accessibility quality" - \( C_i^j \) for which the function of common feature \( P(R_i^j) \) exists, that is:

\[ P_c = \{ C_i^j | P(R_i^j) \} \] (1)

Where:

- \( P_c \) - Profile locations position related to the city centre network,
- \( C_i^j \) - "Accessibility quality" of location \( j \) related to the centre belonging to class \( i \)
- \( R_i^j \) - Change of accessibility index of location \( j \), calculated by relation:
  \[ I_p^j - \text{Value of accessibility index of location } j \text{ for network without investment} \]
  \[ I_p^j_{\text{inv}} - \text{Value of accessibility index of location } j \text{ for network with investment} \]

"Economic life" profile \( P_e \) of housing location is defined in the similar way, i.e., it represents cluster with elements "relative price" of apartment/house of class \( i \) on the location \( j \), \( R_c^j \), with common feature function \( P(R_i^j) \). That can be expressed by:

\[ P_e = \{ R_c^j | P(R_i^j) \} \] (2)

Where:

- \( P_e \) - Economic life profile of location in investment corridor,
- \( R_c^j \) - Relative price of apartment/house of class \( i \) on the location \( j \) in the zone of influence of investment in relation to the accessibility index change by influence of investment, that is, \( R_c^j = f(R_i^j) \), where:
  \[ I_p^j - \text{Value of accessibility index of location } j \text{ for network without investment} \]
  \[ I_p^j_{\text{inv}} - \text{Value of accessibility index of location } j \text{ for network with investment} \]

Both profiles are de facto two-dimensional matrices - \( i \times j \).

Allocation of net increase of industrial/warehouse space performs on the basis of accessibility profiles and mobility profiles. Before defining of those profiles, locations must be systematized by type, i.e., by a characteristic that represents transportation volume intensities (Depolo V, [4]).

The induce criteria that are used for commercial space analyzing involve: agglomeration potential and economic life potential.

Basic element in agglomeration potential analysis is corridor absorption power of demand. Key indicator for calculations of absorption power of demand is frequency of commercial space user (expressed by number of users in given time period). When daily needs of consumer space are concerned, the systematization of frequencies in appropriate clusters is performed owing to the satisfactory number of valid results of empirical research. The clusters are called "absorption power profiles" - \( P_a^j \) (Depolo V, [4]). They enable the determination of agglomeration of induced development probability for locations, which is

---

4 The probability for investment in housing stock of certain type is to be more profitable in shorter period of time than it is its economic lifetime comparing the same investment in any other part of urban area is calculated.
proportional to its accessibility, in comparison with the same ones in investment corridors. Possible volume of induced development is determinate by:

\[ P_{am} = \{AM_j|^D(FU_j)\} \]  

Where:

- \( P_{am} \): Absorption power profile of commercial locations,
- \( AM_j \): Absorption power of commercial space class \( k \) (\( k=1,2, \ldots, m \)) on the location \( j \) (\( j=1,2, \ldots, n \)) in the investment corridor,
- \( D \): Common feature function, by which frequency of users of commercial space class \( k \) is performed, that is, \( FU_k=f(d) \), where:
- \( FU_k \): User frequency of commercial space class \( k \) in the investment corridor (on the location \( j \)), in function of distance of commercial space from demand zone middle-point.

User frequencies, systematized in relation to the accessibility of the commercial space, are also used for potential of economic life \( P_{ek} \), which is represented by cluster of elements \( R_{kF} \) - relative frequencies with common feature function \( F_k \) represented by relation of users frequencies of commercial \( k \) in the investment corridor, and same class space frequencies on locations sited anywhere inside urban area (and/or defined by normative frequencies). This can be also described as:

\[ P_{ek} = \{P_{eik}|F_k(F_kR)\} \]  

Where:

- \( P_{eik} \): Economic life profile of commercial space class \( k \) inside investment corridor,
- \( P_{eik} \): Economic life of commercial space of class \( k \) on the location \( j \) inside investment corridor,
- \( F_k \): Common feature function of cluster element \( P_{eik} \) whose volume is calculated for each element of cluster from ratio of frequencies of commercial space of class \( k \) in investment corridor and same ones located anywhere in urban area - \( F_kR \), that is, normatively defined. Value of function \( F_k \) can be:
  - \( F_k > 1.0 \)
  - \( F_k = 1.0 \)
  - \( F_k < 1.0 \)

Locations with value of function greater than 1.0 are potentially attractive for induced development.

### 2.2 The probability of induced development appearance

In second phase, estimates are performed and locations in investment corridor are ranked according to the probability of induced development to be attracted. Probability assessment are estimated by adapted multicriteria analysis method and using location profiles.

For the inducement of housing and commercial spaces, one can measure characteristic of location in regard to the real estate investment efficiency. The comparison of economic life potentials of certain locations with the average ones for urban area shows the potential of investment efficiency in commercial space n the investment corridor.
Each industrial and warehouse location profile is labeled with corresponding probability of the induced development attraction of complementary production/warehouse land uses, by using accessibility profiles. Volume of induced development quantification by locations was performed by the use of distribution factors related to the change of accessibility index influenced by investment, i.e., probability of attracting the same.

Test results show that there is a high correlation between the location induced development probability and its estimated volume. In absence of recent concrete empirical evidence, confirmation was obtained by inquiry of experts for superstructure development. The result of inquiry approved that volume of induced development is frequently greater than 20% in comparison with the planned one, which was also approved by the use of quantification method described above.

2.3 Induced development time scenario

As far as the description of time scenario by which agglomeration process is performed, there is no evidence in sufficient volume to perform scientific analysis. On the basis of terrain inquiries performed for impact analysis of public transport terminus zones on the commercial space agglomeration process (Depolo V, [5]), it can be described by "S" curve with two asymptotes; the first one represents the existing level of developed commercial space, and the other is proportional to the market potential of terminus gravity area:

Phase I: Gradual start of agglomeration process; slow tempo of development (on the example of analyzed terminus, the tempo was about 9% of average annual increase of development in the first five year period);

Phase II: Dynamic tempo of induced development with high value of annual rate of development (at analyzed terminus zone example, the rate of development reaches value of 20% annually in the second five years period), and

Phase III: The process gradually slows down and the process of induced development stops. New level of transportation demand generated by process of inducement needs adaptation of transportation system. Depending on the established criteria, new transport system investment cycle begins in this phase.

One of the opened questions concerning the described flow is connected with the problem of determination of its starting point. This is essential from standpoint of economic benefits estimation of new investment.

5 In the case study for the city of Belgrade, evidence of development changes in the corridor investments which was used, were generated by synergetic influence both planned location development and investment. As it is the matter of investment dated from earlier period, it was not possible to delimit clearly influence of two factors (because the existence of development plan stimulates itself a part of induced development). According to this, author performed method of real estate expert inquiry, as a method of result approval.
3 Concluding considerations

Are the evidences about induced development existence under the influence of investment obtained?

Before answering, one brings out the opinion that divides professionals and scientists dealing with this matter into two diametrically opposite groups:

- The first state that appearance of induced development and thus induced transportation demand can be attributed to inadequate forecast methods, unproved development hypothesis, etc.
- The second one doesn't find that the existing forecasts methods are inadequate, but think that they produce reliable results to the extent in which relevant development tendencies are included and profiled. They consider that induced development exists and that in creating new methods and improvements of existing ones more effort should be taken.

From the point of view of this work, both groups are right. Namely, if procedures and methods are inadequate, and accordingly, development tendencies are inadequate, act of rational judgment about advantage of one compared to an other potential possibility, no matter if professional or "unqualified" individual brings the decision. Then, "perception" factor of potential benefits from transport infrastructure investment comes in focus. Someone will anticipate advantages at the very beginning (project design phase), and others will need more evident and tangible proof. By the described behavior of potential demand, one can support arguments for proposed flow chart of induced development, represented by "S" curve. The empiric research will define the slope of curve and points of its changes.
without arguments, proposed method gives possibility for improvement of the existing procedures. On the other hand, advocates of induced development existence are given certain contribution to its arguments, and offered procedure for possibility assessment and estimation of induced development volume. Location profiles, as induce components of the probability assessment of induced development, show that there is possibility for location ranking according to its potential for inducement generation. Profiles are connected with the changes of transportation variables so they are under the influence of investment. Is the reliability of results, by offered methodology and methods of quantification ensured?

Empirical results, which present strong evidence of result reliability, are not numerous. One of the analogous examples that has very important influence on this work is based on the extensive research of Goodwin and associates, from SACTRA, who researched induced traffic phenomenon at new road network in Great Britain (Goodwin P.B. 1996, pp 53 [6] ). In the resume of research, author quotes: "... the balance of evidence reasonably clearly indicate that additional traffic may be induced by the provision of extra road capacity, as result of combination of wide variety of different behavioral responses. ... the amount of extra traffic will vary according to the specific circumstances, .... In UK conditions, an average result ... may be of the order of 10% in the short run and 20% in longer run, with a range of 0-20% in a short run and 0-40% in the longer run ... these effects take place over time, with relevant period of several years for behavioral changes and possibly longer for land - use changes...."

Research conducted in this work confirms the existence of the planned volume of development violation, which is proportionally greater in the zones of higher accessibility. The calculations of induced development appearance probability show that locations in the investment corridor demonstrate different intensities of inducement. They are under the strong influence of the accessibility changes. By varying the criterion weights in the final estimate of probability of both clusters, starting from greater significance of limit criteria (measures of state intervention concerning external effects), to the predominantly greater share of stimulate criteria (where significance of investment influence increase through change of accessibility attributes) which is by its nature closer to the market principles, it was shown that final estimate, by rule, is connected with the criteria in which accessibility is essential indicator. This proves that the investment influence on the process of development inducement is essential. The volume of the induced development greatly corresponds to the results concerning induced transport demand on the roads in Great Britain.

What is the specific contribution of this work?

One of the most important findings is connected with the quantification of "push" (induce) criteria, especially in the fields of housing and commercial activities. Available evidences, which are used for relative price of housing development model, are limited to the estimation of, so called one-time effects. Existence of
evidences concerning rent prices on the rent market enables, by the similar procedure, relation definition of relative rent in function of relative change of accessibility caused by investment influence. That is how it will also be possible to calculate the "repeated" effects transferred through life time period of transportation investment.

As far as commercial use location, by means of common feature function in the economic life profile (or absorption power) new characteristic of profile can be determinate. Owing to increase of location accessibility, absorption power of commercial space increase. Locations with greater value of absorption power in comparison with average conditions for the whole urban area are proportionally profitable, or, time of return for invested money is shorter - they have greater economic life potential. This characteristic of locations is attributed to the influence of positive external effects of transportation investments.

The research field started with this work (in Yugoslavia), and with the offered methodology, the space for its improvement in future is opened. Methodology is very important for interpretation of agglomeration processes that are significant for urban growth. It is also important, from the point of new improvements of methodology for urban transpiration investment evaluation.

References

4. Depolo V (1999a): *Uticaj tokova saobracaja na indukovanu izgradnju komercijalnog prostora u zonama terminusa javnog gradskog i prigradskog prevoza putnika*, Tehnika, Saobracaj 1, SITJ, Beograd

---

7 This market is, in the most developed countries, especially in Europe, partially under the influence of state intervention mechanisms (rent maximization). This is the evidence of the strong influence of external effects.