The Economic Model Used in Xuzhou Region Development Planning Project

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1. The Objectives of the Economic Modelling

In the calculation structure of the overall Xuzhou Project modelling, the economic model is the main sub-model. It receives inputs from the population model, the environment model, the land use model, the allocation model and from the infrastructure evaluation model and gives outputs back to the evaluation model and the land use model, sets the absolute level of the budget restrictions applied to infrastructure investment and provides the GDP objective function for the optimisation part of the whole model system. In more detail, the objectives for the economic modelling were:

(A) To describe the general economic development situation in the 115 spatial analysis units: one of the aims of the Research Project was to maximise the economic development level under conditions of limited investment resources. Normally, the GDP (Gross Domestic Product) is a comprehensive indicator of the general economic development level. The economic sub-model had to have the ability to describe changes of GDP values in all the spatial units in the four Plan Periods considered.

(B) To describe the economic structure change in the 115 spatial units: in general, the economic structure represents the development stages and features of an economy. Also, the structure of the economy will largely influence the structure of the employment which is one of the main points to which attention had to be paid in the Project. Therefore, the economic model had to have the ability to describe economic structure changes in the spatial units over the period 2000 to 2020. This means that the economic model had to be constructed for use down to the sector and branch level, not only at a high level of aggregation.

(C) To describe the capacity for infrastructure investment in Xuzhou City: there are budget constraints for settlement and transportation infrastructure investment which constitute one of the focal points of the Project. Whether these budget constraints are exogenously given or are endogenously created when running the model, they are in both cases largely dependent upon the investment capacity of Xuzhou City as a whole, which had to be determined by the economic model.

(D) To describe the influence of improvements in infrastructure levels, including transportation conditions, on economic development: infrastructure levels and economic development are inter-related. Positive development of an economy can provide investment funds for improving infrastructure levels, which is the objective outlined in (C) above. On the other hand, how much economic development will result from improvement in infrastructure levels is a question which also had to be answered by the economic model.

(E) To describe residents' income levels: all the objectives of social and economic development come to one point – to improve peoples' quality of life (or living conditions), which includes the improvement of infrastructure levels, safeguarding environmental conditions and increasing income levels. Infrastructure levels are described by the infrastructure evaluation sub-model. Environmental conditions are described by the environment sub-model. To describe and forecast residents' income levels in the 115 spatial units over the investigation period of 2000 to 2020 had to be one of the objectives of the economic modelling, because the results can be used as an implicit indicator of the quality of life.

2. The Basic Elements of the Economic Model

According to the above objectives and the data available for the 115 spatial units of the Project, the economic model included variables for which annual time series data were available from 1991 to 2000 for the spatial units as well as variables which had initial data only for the year 2000.

The variables for which time series were available were:

(A) GDP value, in current prices

(B) Value added by sector and branches, in current prices: in order to describe economic structure change, the economy was disaggregated into 15 sectors and branches in such a way that the sum of the value added of these is equal to the total GDP value. The 15 sectors and branches were:

1. Agriculture, which includes farming, forestry, animal husbandry and fishery
2. Mining, including coal mining and all other mining branches
3. Food processing, which includes food, beverage and tobacco processing and manufacturing
4. Textiles, including textiles, clothes and leather processing and manufacturing
5. Chemicals, including petrol processing, chemical, medical, rubber and plastic product manufacturing
6. Machinery, which includes machine, electrical, electronic and communication equipment manufacturing
7. Construction materials
8. Other manufacturing activity, which comprises all manufacturing activities excluding those of branches 2 to 7 above and branches 9 and 10 below
9. Water, electricity and gas production and supply
10. Construction
11. Real estate, including real estate management and real estate development
12. Banking and insurance, including banking, insurance and stock market activities
13. Transportation and communications
14. Commerce, which includes wholesaling, retailing and restaurants
15. Other service activities, comprising government and all other tertiary activities excluding those of branches 11 to 14 above

Among these 15 sectors and branches, agriculture comprises the primary sector, branches 2 to 10 comprise the secondary sector and branches 11 to 15 comprise the tertiary sector.

(C) Investment by sector and branches, in current prices: the sector and branch classification is the same as that for the value added described above.

(D) Employment by sector and branches: the sector and branch classification is the same as that for the value added described above.

(E) Residents’ income, in current prices: this is made up of two parts, one being the net income per capita of rural population (the available statistics concern only the net income), the other is per capita gross income for the urban (town and city) population.

The variables for which only initial data for 2000 by spatial units was available were the infrastructure evaluation values. These variables are used for measuring the influence of the improvement in infrastructure conditions, including transportation, on the economic development of the spatial units.

A further element contained in the economic model was a factor of "external influence" on the investment capacity of the spatial units. The reason for including such an element is that the investment capacities of different spatial units are decided not only by their own financial situation, but also by the financial aid available from higher administration levels, or from other sources. For some spatial units, the external factor can arise from the county to which the town belongs, or from the Xuzhou City Government, or from Jiangsu Province, or from the State, or even from some foreign sources.

Prices are not considered in the economic model because price levels in Xuzhou cannot be derived only on the basis of the Xuzhou economy itself.

3. The Structure of the Economic Model

The general structure of the economic model is illustrated in Figure 1. The structure shown is general, there are some differences when it is applied to different types of spatial units. In the Figure, all the exogenous variables appear in elliptical forms and all the endogenous variables are found in rectangular boxes.

In principle, the economic model is not a demand-driven model, but a supply-driven model. The reason is that every spatial unit is considered as a small region from the point of view of its macro-economy, and most of the economic activities in such small spatial units are not determined by their own demand. This is still true even if the whole of Xuzhou City is considered as a single region. On the other hand, it was impossible to construct an external model to describe the demand for Xuzhou production in the Research Project due to time and budget restrictions. Therefore supply-driven relationships were set up for most sectors and branches, which are shown by the solid lines directed towards the three rectangular boxes of the increase of value added in Figure 1.

Of course, there are some branches the production of which largely depends upon local demand. For example, the production of the construction branch in the secondary sector largely depends upon the scale of local investment. The production of most service branches in the tertiary sector largely depends upon local economic activities, including production, consumption, investment and foreign trade. The dotted lines directed towards the boxes for increase of value added show the demand-driven relationships used. The branches affected need to extend their supply capacity to meet the demand.

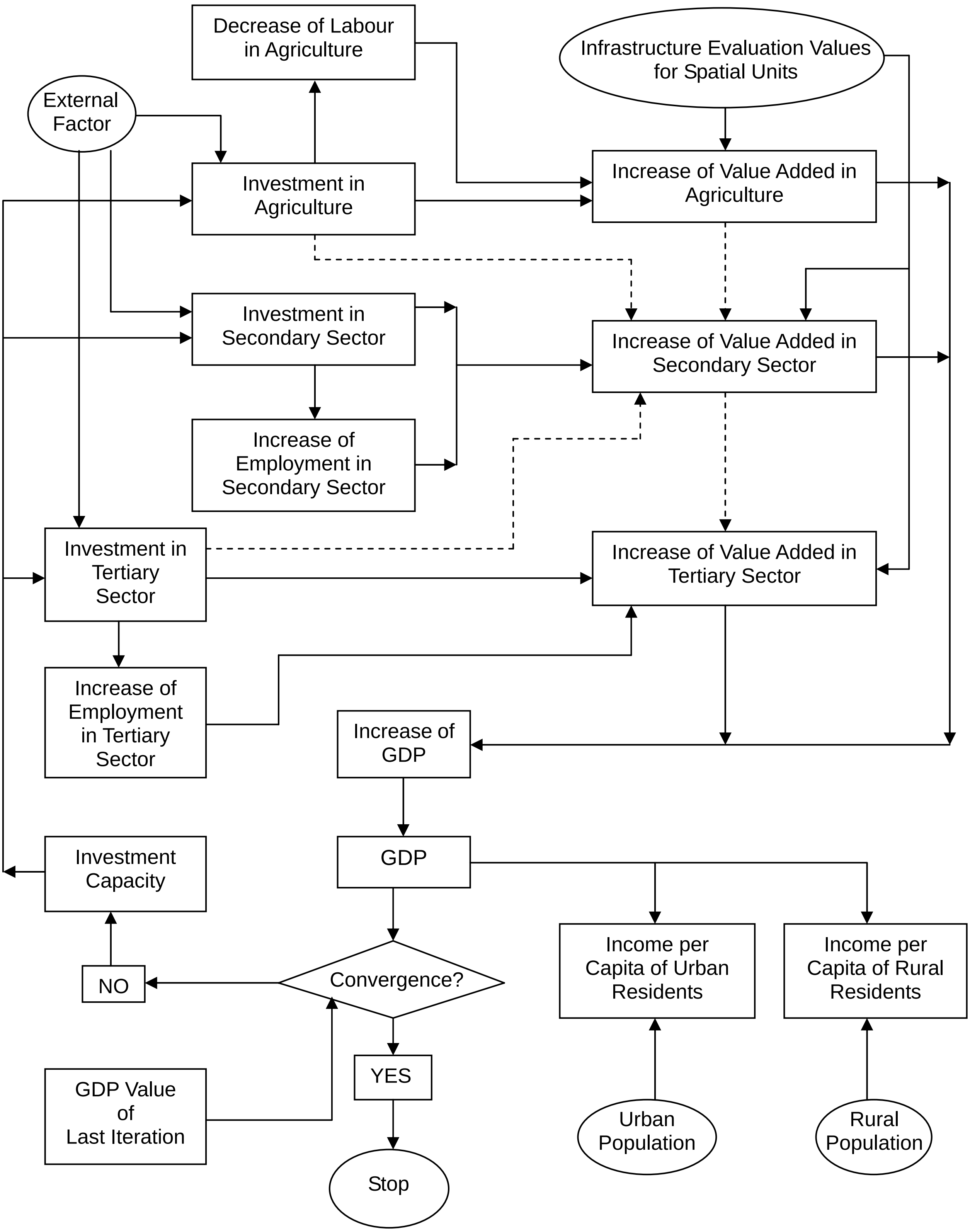

Figure 1 : General Structure of the Economic Model for one Time Interval

Therefore the economic model was constructed as a "mixed drive" model in which most sectors and branches are supply-driven but some are demand-driven.

With this background it is now possible to describe the general structure of the economic model starting from investment, which is the engine of development of the economy, which in turn is mainly driven by supply in the model created.

(A) Investment in the 15 sectors and branches was determined by two aspects: one is the local investment capacity which is described by the GDP level, the other is the so-called “external factor” described above.

(B) Investment in the agricultural sector improves agricultural production conditions thereby increasing the value added, on the one hand, and reducing the labor input on the other. Of course, the evaluation of infrastructure equipment conditions in a spatial unit is also a factor influencing the agricultural output of the unit.

(C) Investment in the secondary sector (by branches) provides new job opportunities, on the one hand. On the other hand, it expands production capacities in terms of capital equipment. Of course, the evaluation of infrastructure conditions in a spatial unit also has an influence on the value added of the manufacturing branches in the spatial unit. A typical production function relationship was created in this sense.

Demand determination formulae were used for some branches in the secondary sector. For example, the value added of the construction branch was determined by the total investment in the spatial unit.

(D) Investment in the tertiary sector by branches provides new job opportunities in branches 11 to 15 and therefore new labour input to these branches, on the one hand. On the other hand, the investment will extend the service capacities of these branches. Of course, the evaluation of infrastructure equipment in a spatial unit has an influence on the value added of the service branches in the unit. Such relationships also belong to a production function concept.

It proved possible to use demand determination formulae for the service branches except for the transportation and communication branch. In fact, the branches of real estate (branch 11), banking and insurance (branch 12), commerce (branch 14) and other services (branch 15, which includes education, health care, culture, sport, radio and TV) are largely dependent upon demand from residents (under consideration of their income level) and demand from the various organizations and institutions which have their main economic activities in the spatial unit concerned (with the exception of some special locations which are famous tourism sites). The demand arising from neighbouring spatial units with no or little service capacity was considered by using a scaling factor based the on the centrality functions of the spatial unit concerned.

(E) The sum of the increase in value added of the 15 sectors and branches is equal to the increase of the total GDP. The sum of the last period’s GDP and the increase of the GDP in the current period equals the total GDP in the current period.

(F) From the values of the GDP per capita, the total urban residents’ nominal income can be estimated. The nominal income per capita for rural residents can be calculated in a similar way.

(G) The GDP value from step (E) is a comprehensive indicator for describing the level of economic development, including the local investment capacity. This goes back to the starting point of the model and completes one iteration. The calculation procedure is stopped when the GDP values from the last iteration and from the current iteration of the model are very close, i.e. when convergence has been achieved.

3. The Crucial Points of the Economic Model

The economic model as sketched out above does not appear to be complex. However, there are several crucial aspects which are quite difficult to deal with compared with the usual econometric model:

(A) There has to be the exogenous variable called “external factor” in the model. It has influence on the investment which is the engine of a supply-driven economic model. The problem is that there are no direct and explicit statistical time series data for this variable, which is a difficulty for an econometric basis model. Several considerations were employed to solve this problem:

(1) Different initial values of the external factor were given to every spatial unit according to their basic character. For most spatial units, the value was set at 1.0. To the core area, county towns and the airport spatial unit, a slightly larger value than 1.0 was assigned. For some spatial units located in ecological sensitive areas, the value given was slightly less than 1.0. These values reflect the normal differentiation of attractiveness for external investment.

(2) The values given initially were modified when running the overall model according to the factors arising dynamically from the land use and environment sub-models. To do so is to reflect the constraints on external investment from land use and environment protection considerations.

(3) The values given initially were also dynamically modified when running the overall model according to whether investment occurs in a railway public transportation project or not in the particular spatial unit. To do so is to reflect the fact that direct access to a station of the RBPTS will increase the attractiveness of the spatial unit for external investment.

(B) The forecasted economic values for each spatial unit cannot be regarded as independent of each other, i.e. isolated. There has to be a framework concept for the economic development forecasting for Xuzhou as a whole. The aggregates of forecasted values of the economic variables in the 115 spatial units should be consistent with the corresponding economic variables forecasted for Xuzhou as a whole. It was not easy to reach this target.

To solve the consistency problem, the 115 spatial units were divided into 5 different economic types according to their economic development level in 2000. The definition of the type groups is different from the definition of the Spatial Unit Classes. The spatial unit 1 was defined as being of type 1. All the county towns, including the District Town of Jiawang, were defined as being of type 2. The other towns the GDP per capita of which were greater than the minimal GDP per capita in the type group 2 were defined as type 3. The rest of the towns were defined as belonging to types 4 and 5, respectively, according to their GDP per capita level. On the basis of spatial unit type definitions, the consideration of consistency made is illustrated in Figure 2.

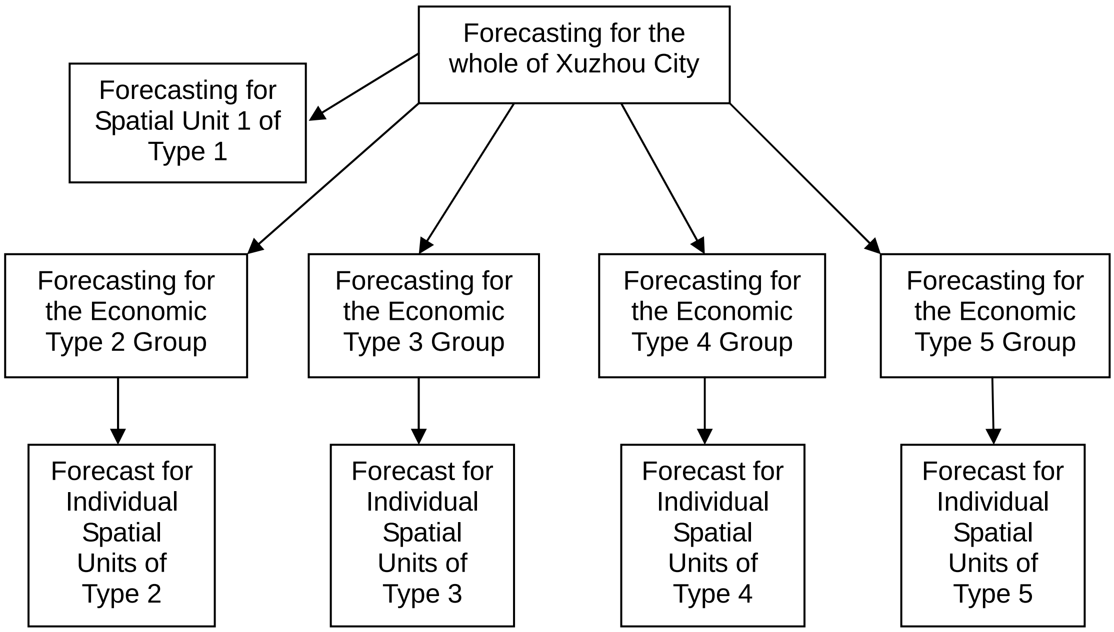

Figure 2 : Consistency Relationships of the Economic Forecasting

Firstly, development forecasting for Xuzhou as a whole takes place, which is consistent with the respective development framework concept for Xuzhou, Scenario A or Scenario B. This is the top box in the diagram of Figure 2. The second step is that of forecasting analysis for economic type groups of spatial units as a whole. This is shown at the second level in the middle of the diagram, but in which economic type 1 (the core urban area of the City) has a special position. The aggregated values from the forecasting analyses for the spatial unit type groups are adjusted to the corresponding forecasted values for Xuzhou as a whole from the first step, and the forecast values for the type groups are adjusted accordingly. The adjustment operations are represented by the arrowhead lines between the top box and the boxes located in the middle of the diagram.

The last step is to perform economic development forecasting for each of the 115 spatial units, which is the operation described by the boxes at the bottom of the diagram. The values forecasted initially for the 115 spatial units are aggregated according to their type. A comparison between these aggregated values and the corresponding forecasted values from step 2 is made. On the basis of the comparison, some adjustment operations are done for the individual spatial units concerned when inconsistency occurs. The adjustment operations achieve consistency between the aggregated values from each type group of spatial units in step 3 and the forecasted value for that same type group in step 2. These adjustment operations are represented by the arrowhead lines between the boxes at the middle level and the boxes at the lowest level in Figure 2.

(C) To consider the five years of a Plan Period as one calculation time interval was a challenge for the economic modelling in the Project. The use of the Plan Periods as the calculation periods had several big advantages, especially for the investment allocation sub-model. However, it brought with it estimation problems for the parameters of the behavioural equations in the economic sub-model. As mentioned above, for most variables in the economic model the available time series data for estimating these parameters only extend from 1991 to 2000. This means in terms of five year intervals that only two periods of data were available, and it is impossible to build an econometric model on the basis of a two-point time series only.

The problem was solved by adopting an annual economic model and running it year by year five times in each of the Plan Periods, which provide the five-year basis for the whole model. After the Period internal run of five times the economic model, the annual results are aggregated to five-year totals and passed on to the other sub-models of the whole model system.

For this solution, there was still the question that the economic model, as an annual model, needed infrastructure evaluation values annually for each spatial unit. But on the basis of a five-year Plan Period allocation of infrastructure investment funds the evaluation model nominally only provides infrastructure evaluation changes every five years, not at the end of every year. To deal with this issue, a simple method was used. The infrastructure category statistics, including the accessibility times in both the road and RBPTS networks in both Scenarios A and B, were linearly interpolated over the Plan Period and then annually evaluated for input into the economic model and the environment model. In some respects, especially for large infrastructure projects, this is realistic since large projects take several years to complete and are normally designed to go stepwise into operation.

4. The Calibration of the Economic Model

The economic model considers 15 economic branches for each spatial unit. For each economic branch, the relationships between investment, employment and production were quantitatively described through estimation of the parameters of economic behaviour equations.

The initial calibration was started by estimating the equation parameters for the spatial unit 1, which is the core area of the Xuzhou City and the most important spatial unit in the Project.

For the other 114 spatial units, the initial calibration was done in two steps. The first step was to estimate the equation parameters for the spatial unit types 2, 3, 4 and 5 as a whole respectively. The second step was to adjust the parameters for each spatial unit within the corresponding spatial unit type group. These calibrations were done only using time series data from 1991 to 2000 without infrastructure evaluation values, which were available solely for the year 2000 in the calibration period.

The quality of the parameter estimation of the equations was checked by looking at the statistical test value R^2 which is a comprehensive indicator reflecting the degree of fit between the actual time series values and values calculated by the equations. Table 4.1 shows the R^2 values obtained from the equation estimations. It can be seen that the results are satisfactory with, over all variables and economic types, 88% of the values lying over 0.7 (1.0 represents a perfect fit).

Table 1 : R^2 Values from Economic Behaviour Equation Estimations (%)

R^2	Type 1	Type 2	Type 3	Type 4	Type 5	Total
<0.7	14	3	23	14	7	12
0.7-0.8	12	8	6	9	5	8
0.8-0.9	21	18	17	15	27	20
0.9-0.95	15	35	25	25	31	26
>0.95	38	38	29	38	30	34
Total	100	100	100	100	100	100

On the basis of the initial calibrations for the model, an estimation for the influence of the infrastructure equipment evaluations on economic growth was carried out. The analysis was performed for the variable value added of the secondary and tertiary sectors as a whole, rather than branch by branch for the 15 economic branches. The reasons for doing this were:

(A) The increase of value added in the agriculture sector is influenced only weakly by infrastructure conditions which mainly belong to the urban part of the spatial unit.

(B) A branch by branch analysis could not be performed due to limited time since it was already November, 2002, when the infrastructure evaluation values became available. On the other hand, it was not necessary to have such analysis branch by branch to be consistent with other parts of the Project.

The conclusion from the analysis was: 81.7% of the increase in ΔGDP (the annual increase in GDP as referred to the previous year) is due to the contribution from an increase in direct economic investment, 18.3% of the increase in ΔGDP is due to the contribution from an increase in infrastructure evaluation. This conclusion is quite close to that of the JOP work. For convenience, 20% of the increase in ΔGDP was assumed to be due to the contribution of increasing the infrastructure evaluations through infrastructure investment. Necessary adjustments were made for the initial estimated parameters of the behaviour equations according to this conclusion. These adjusted parameters were used in all the final calculations performed with the overall model system.