A Linear Planning Analysis of Institutional Structure in the Economy

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"Policy Advice #2: Modifying institutions should be the exception rather than the rule."
Voigt and Engerer, 2002.

If institutional structures really matter there should be ways to quantify their impacts and accordingly design these structures.

Abstract

The paper uses the paradigms of the New Institutional Economics to quantify a linear optimal choice model to design perspective institutional clusters for a national economy. This model uses binary integer institutional choice variables and structural parameter values based on subjective probabilities collected from experts by calibration questionnaires.

The optimisation goal may be e.g. a high expected probability of stable national economic performance under socio-economic development-credibility constraints, dependent on the realisation of prospective significant events. The model may be useful as a complementary tool for the social design of the effective institutional structure, and especially for evaluation of the socially optimal values of co-ordinating shadow prices and implementing side-payments in the political institutional design game.

We use the Estonian case as an example. The model variables and data calibration table illustrations are provided mainly to demonstrate the broad spectre of issues that may be involved in this analysis.

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1. Introduction and General Methodology

Recent work has yielded robust mechanisms for the implementation of various choice rules and for different sets of agents. For example, a recent paper by Eliaz (2002) explores the question of robust implementation when the social planner is facing a limited number of agents who have a potential to err in their activities or being faulty etc.

A very well-known and powerful instrument of enhancing implementation robustness is the side-payment system or implementing transfers by social planner (Matsushima, 1993) but here of the computation of the correct values of these side payments may be complicated, especially when the choice rules are not "mathematically nice". The implementation models of institutional designs or structures certainly belong to the latter class of problems. These design models necessarily contain, among other things, binary choices, integer variables etc.

The reviews of literature in this field (the New Institutional Economics) are given in e.g. Voigt and Engerer (2002) and some titles of the latest works that have been seminal for our study are included in the References but the results of these theoretical studies are not explicitly reiterated in this more or less applications-oriented paper.

In this paper, a stylised linear planning (LP) model has been synthetically created to analyse the problems of implementation of optimal institutional structure for the economic sector. This is a

simplified version of the more general, conceptual, national social planner economic design model (in Ennuste, 2001, p. 332, formulae (1)).

This LP model may be a rational means of study in the cases where there are numerous institutional changes taking place for the national economy and the impacts of these changes may be closely interconnected and there are the conditions of complementarities of the institutions.

The implicitly conceptual logic behind the model is that the higher the expected prospective economic credibility is (or the less uncertainty there will be in the economy), then the more effective the prospective economic development.

We assume that the prospective quantity or magnitude of economic credibility may be modelled by a collection of proxy indicators. The values of these proxies will depend heavily on the prospective institutional structures of the economy that will mainly reduce the uncertainties connected with economic transactions, incentives, confidences, reduce impacts of shocks etc. The purpose of this model is to specify the optimal prospective institutional structure for the economy among possible structure clusters based on the values of some proxy indicators of economic credibility and the quantitative relationship between credibility indicators and institutional characteristics.

It is also important to model the institutional interaction phenomenon, e.g. introducing some new institutional elements may introduce also some additional supporting institutional arrangements or initial conditions (Saint-Paul, 2002, has named this as restricted local optima principle).

By Optimal institutional structure, we mean the structure that will prospectively maximise the quantified value of the indicator that is chosen as proxy for institutional credibility of the economy, and also satisfy some quantitatively expressed constraints. For example, we may institutionally maximise the stability t of prospective economic development (e.g.: t=q/s, where q describes e.g. average quantity of national income and s models standard deviation etc.) subject to a constraint that more than a given level of price stability should be guaranteed etc. The expected impact ("output") of the prospective existence of structural elements is conceptually modelled by the expected effects or outputs. It is assumed that these element's outputs add linearly to the overall credibility of the indicator.

As it is extremely complicated to quantify the named expected effects by their real values, as the experts have no experiences

regarding alternative institutions or about old institutions in the new environments. Therefore, first, we suggest that the experts calibrate the parameters by adjusting the values with the mainstream research results in this field such as is done in the engineering approach (Roth, 2002; Ledyard and Palfrey, 1999).

Second, to make the task of quantification even more convenient, we suggest approximate input-output parameter values by comparative probability values. In the last case, we base parameters on the present institutional structural elements (*status quo*). The output parameters of the perspective institutional elements are probability estimates (or their intervals) indicating that these elements will expectedly be more effective than the basic institutional element. Basing all the future comparisons on the present or the prior institutions makes the calibration estimates hopefully more reliable as some present institutional effects may be quantified statistically e.g. as parameters of linear regressions (Rajasalu, 2002). Also by basing comparisons on the present institutions, we take into consideration the importance of prior existence of many implicitly involved institutions such as language etc. (Hodgson, 1998 and 2002).

This model may be useful as one tool in the "political market game" of effective institutional structure design, and particularly for the evaluation of the values of co-ordinating shadow prices in the political institutional design game. In other words, this model may give some macro approaches and co-ordinating parameters for stimulating micro calculations in institutional design (Brekke and Moxnes, 2002, and Ennuste, 2001). By introducing correlated agents and relevant side-payment systems, we overcome the implementation problem (the problem of collecting un-manipulated information from the agents) (Aoyagi, 1998).

As of yet, There is no standard definition of institutions (Voigt and Engerer, 2002). In our model, we take a broad approach to defining economic institutions: devices and arrangements that co-ordinate the economic interactions and shape economic decisions by reducing economic interaction and co-ordination uncertainties (North, 1998). Or in other words, economic institutions are devices to enhance the credibility of economic transactions and create confidence in economic activities.

This paper models the institutions on micro-, meso- and macro-levels (Yu, 2001) including both internal and external institutions (Voigt and Engerer, 2002) and individual and public institutions. We also distinguish formalised (*de jure*) and unformalised (*de facto*) institutions. For example, the monetary system belongs to the set of

macro-level or society level public external institutions. Similar institutional alternatives include efficient public goods mechanisms versus their simplified approximations by national voting referenda (Ledyard and Palfrey, 2002). On the other hand, for instance, the reputation climate within a firm belongs to the set of internal micro-level individual or local institutions while the market organisation form (e.g. monopoly) of the firm belongs to the set of external formalised *de facto* institutions and the legal status of the state language is a *de jure* public external institution etc.

2. Technical-Methodological Remarks

As according to our previously stated assumptions, institutional structures are intended to enhance the credibility of economic interactions. We therefore use indicators or proxies that are important for forming credibility estimates and affecting institutions as maximands and constraints. In our model, the indicators used for initial factor-components or proxies for the synthetic economic confidence indicators (Laven and Perotti, 2001) include stable economic development, trade balance, attraction of foreign direct investments, and good access to capital markets. According to our approach the high economic credibility is in turn the main determinant of good industrial performance.

The structural parameters of the perspective design model should be based on deductive reasoning and therefore in essence the experts' subjective *a priory* probabilistic data (based of course on econometric studies). As for the experts, the most convenient way for them to model data in this "institutional accounting" may be to estimate subjective probabilities. Therefore, we model the structural parameters as probabilities, and with these simple questions we may avoid the phenomenon of pragmatic overconfidence of experts (Hvide, 2002) that may be a danger in the institutional analysis.

We set up this model as a linear planning model (additive effects) with binary integer (1; 0) decision variables. This could also be termed an optimal constraint choice model, or a design model. We take the target function (social maximand) and constraints here as linear combinations and all structural (input-output) parameters estimated by the experts are taken as descriptions of probabilities (possibly with interval distributions).

Namely: 1) for example, the probability of prospective good credibility can be adequately modelled as a sum of weighted

credibility indicators of economic activities, where the weights are based on the volumes of activities or other factors, 2) the probabilities of good credibility of certain activities can be easily estimated as dependent on certain institutional arrangements in the economy, and 3) in these probability estimates, prospective economic recession and crises can be taken into consideration.

It is important to note that if multiplicative effects of activities or arrangements are considered initially in the model, the logarithmic transformation allows us again to reduce the model to the linear form.

The optimisation vector denotes various alternative economic institutions applied by economic organisations and companies. Here we differentiate between two kind of institutions: 1) public institutions which have the impact on the overall economy and work through governmental legislation and other organisations and 2) individual or local non-public (e.g. company, municipality etc.) institutions implemented by companies and municipalities for themselves and effective only in the same company and municipality etc.

The target function is a linear combination of the optimisation vector which maximises the average weighted probability of high national economic performance (e.g. economic growth). The constraint inequalities are linear combinations of weighted probabilities of certain socio-economic development effects ("outputs") that should in sum be not less than certain specified levels. Certain constraints of the model contain also institutional "in-puts": for the implementation of certain institutional arrangements there is the need for existence of certain public institutional arrangements.

Here we assume the set of constraints may have different parameter values dependent on the realisation of the states of nature in perspective (e.g. national economy will be member of the EU or alternatively will not be member) with the given probabilities. This enables the model to apply to a variety of circumstances, both now and in the future. Note that the values of parameters of the target function may vary according to the realisation of prospective events.

It is important to note also that the proxies of the Lagrangean solutions of this model may be used by social planners as co-ordinating indicators (shadow prices and optimal side-payments, e.g. Matsushima, 1993, etc.) for design and implementation of an optimal institutional structures in a co-ordinated game form.

The paper is organised as follows. In the third section, we describe the framework of the model. Next we give an abstract example. The paper concludes with an experimental Estonian case study of the prospective partial optimal national economic design and

conclusions. We also provide an illustrative table form for collecting experts' calibration data for the model.

3. Set-up

In this paper, we consider only the optimisation of the institutional aspect or economic institutional structure $x=(x_j)$, $j? N=(1,\ldots,n)$ *ceteris paribus* and abstract away optimisation of other aspects (e.g. intensities of economic activities, technological structure etc.). We take these other activities as given exogenously with optimal intensities. 2) In this model, we make an optimal choice of optimal institutional structure and model this by describing the co-ordinate variable values x_j by binary digits 1 or 0, where 1 denotes the choice or enforcing x_j type of institution, and 0 rejecting x_j type. 3) Institutional effects on the national socio-economic development probabilities are here assumed to be additive (linear combinations) and the chosen institutional structure x should satisfy the given linear constraint system $Ax=b$, where $A=(x_{ij})$, $i? M=(1,\ldots,m)$; $j? N$ is institutional "input-output" matrix where element x_{jj} describes the additive impact of application of institution x_j (e.g. progressive income tax system) on the value of the national socio-economic development indicator (e.g. average weighted probability of avoiding national economic failure). The constraint vector $b=(b_i)$, $i? M$ is the vector of the external limiting constraint values of socio-economic indicators for the economy. 4) Note that the triple $\{x,A,b\}$ may contain also "technical" elements to model the constraints like e.g. $x_1+x_2=1$1 e.g. to model that x_1 and x_2 are alternatives. 5) The target indicator of the model is functional cx, where vector $c=(c_j)$, $j? N$ and co-ordinate c_j is the impact value (weighted probability) of institutional choice x_j on the target indicator (e.g. the probability of the growth of national economy).

And, last but not least, there should be in the model a constraint to avoid too many institutional adjustments and changes to build stable expectations (Voigt and Engerer, 2002) and credible institutional evolution.

4. Some Solution and Calibration Notes

Implicitly we consider a two-stage model. At the first stage, a structure of x is fixed ("here and now"). At the second stage, this

structure must meet a certain set of alternative constraints based on certain events (e.g. constraints in the case of EU membership, in the case of staying out of the EU etc.) and maximise the expected value of the target function. For simplification, we do not consider possibility of corrective ("wait and see") x_j type activities in the second stage. Note that the probabilities of realisations of certain events are used for the calculation of the expected values of target function coefficients.

The initial values of the model parameters calibrated by the opinions of experts are asked in the form of intervals (e.g. $a_{ij} = (a_{ijl}, a_{ijh})$ where letter l denotes lower value of the estimate and h denotes higher value of the estimate).

The use of intervals makes the calibration more convenient and the range of the estimation intervals gives some information on uncertainties connected with the parameters of the model. The interval setting also enables us to perform sensitivity analysis and the elements of the "wait and see" solution approach can be evaluated. Namely, by random selection of the point values of parameters from the intervals, it is possible to formulate numerous random collections of the point parameters of the model. We are then able to produce numerous optimal x structures based on combinations of possible parameter values. Analysis of the variations of these structures may give some additional information for the social institutional designer.

In the mechanism constructed, the social planner is required to disseminate 1) the shadow cost system to achieve the allocative efficiency and 2) the side payments system for the truth telling to the agents. The agents are required to reveal their direct estimates of input-output quantities.

5. Illustrative Specification Example and Discussions for Estonian Case Studies

For illustration, we present a reduced example of that specification of model for the partial economic institutional system of the Estonian economy. This partial specification demonstrates the very broad spectre of issues that may be studied using this approach. The specification of the optimisation vector of the partial institutional structure x, the constraint vector b, input-output matrix A and objective function parameter vector c in this illustration mainly reflect the present Estonian transformational socio-economic institutional issues. The experimental solution is based only on point estimates.

The choice of the dimension of the vector of institutional choice variables in the linear programming problem is as follows: $x=(x_1, x_2, \dots, x_{17})$ is the set X of $n=17$ dimensional integer co-ordinate values (0;1). In the following Table,- the vector of constraint constants is presented $b=(b_1, b_2, \dots, b_{76})$ in the set $E76$, $m=76$. In this vector, the first 38 co-ordinates are the constraint values reflecting a situation that would occur if Estonia were to miss the first accession wave into the EU in 3 years or so (situation *C1*), and the next 38 constraints belong to a situation where Estonia takes part in the first wave of accession and becomes a member of the EU in 3-4 years (*C2* situation). In addition to the 76 essential constraints, there are also several technical solution constraints, denoted as +.

Matrix A of the institutional input-output has $nxm+$ elements, and c is a given vector in $E17$. The dual problem variables (Lagrange multipliers) vector was denoted as $y=(y_1, y_2, .. ,y_{26})$ in the space $E76+$. Note here that vector c elements (co-ordinates) follow the names of vector x elements and the elements of the matrix A obtain their names as elements in the set defined by names of the elements of vectors x and b.

The specific characteristics of the 17 choice variables (0;1) in the experimental model are described as follows:

x_1 - Estonian language as single official state language;

x_2 - changes in the laws to make the Russian legally another state language (the relevant formalised technical constraint of alternativeness for x_1 and x_2 is: $x_1+x_2=1$);

x_3 - present flat personal income tax;

x_4 - progressive personal income tax ($x_3+x_4=1$);

x_5 - present company income tax on distributed profit only;

x_6 - company income tax on gross profit ($x_5+x_6=1$);

x_7 - kroon as the single national legal tender will stay;

x_8 - two parallel national legal tenders will be implemented: kroon and euro ($x_7+x_8=1$);

x_9 - national stock exchange as autonomous company;

x_{10} - national stock exchange affiliated with the Finnish *counterpart* ($x_9+x_{10}=1$);

x_{11} - national electric generating system as state monopoly in the closed market as it is now;

x_{12} - the same system but in the open market;

x_{13} - disintegrated privatised monopoly in the open market ($x_{11}+x_{12}+x_{13}=1$);

x_{14} - present monopoly price regulations by the state will stay;

x_{15} - new amended more effective monopoly price regulations ($x_{14}+x_{15}=1$);

x_{16} - status quo corporal party policy (partocracy) system in national socio-economic decision making will prevail;

x_{17} - shift in election and governmental laws towards civic society rules in socio-economic decision making based on more technocratic principles and national referendums ($x_{16}+x_{17}=1$).

The institutional characteristics and names of the essential constraint vector elements were formulated according to the following Table-Form indicators and two times in succession: first *C1* and then *C2* state. The first indictor is the objective function so we start with the second indicator.

Table-Form
(Probability %)

Input-output indicators	Alternative institutional variants					
	Status quo		New alter.1		New alter.2	
	Prospective events					
	C1	*C2*	*C1*	*C2*	*C1*	*C2*
In the economic sphere (E) 1. Higher stability of economic development						
2. More stable employment						
3. Improvement of trade balance						
4. Higher attraction of foreign direct investments						
5. Bigger inflow of portfolio investments						
6. Better access to international capital markets						
7. Better ratio of financial reserves/budget						
8. Stable prices						
9. Stable interest rates						
10. Stable currency						
In the social sphere (S) 1. Lower value of Gini coefficient						
2. Improvement of average ratio of pensions/salaries						
3. Improvement of unemployment support						
4. Stronger penalties for late payments						
5. Increase of education expenditure						
.....						

In socio-economic transactions sphere (T) 1. Better tax legislation			
2. Better labour legislation			
3. Better social insurance legislation			
4. Stronger penalties for late payments			
5. Stronger penalties for breach of contracts			
6. Better protection of property rights			
7. Better enforcement of contracts			
8. More rigorous regulation of monopolies			
.....			
Inputs ("consumption") of all-national and other complementary institutional designs (tick the necessary) (M) 1. Member of the EMU			
2. Zero investment tax			
3. Proportional income tax			
4. Progressive income tax			
5. Better social security system			
6. Stronger penalty systems for breach of economic regulations			
7. Better monopoly regulations			

The probabilities of the states *C1* and *C2* to realise were e.g. estimated to be 25% and 75% respectively, and the average expected values of the vector *c* elements were weighted according to these probabilities. The matrix *A* elements have been estimated by experts experimentally and one example of the initial estimation data for one economic institutional activity is given in Appendix B. All the activities were given the same significance factors and accordingly the weighting coefficients of all columns of the preliminary matrix *A* and vector *c* got the same value –(1) in this example. Vector *b* elements were all the same for the *C1* situation - 60%, and for *C2* - 70%, meaning that membership in the EU demands a greater probability of the realisation of higher institutional effectiveness.

6. Conclusions

The purpose of this paper has been to specify a quantifiable linear planning model for the design and implementation of an optimal

institutional structure for an economic sector of a country.

In this model, the choice variables denote alternative institutional arrangements and the objective function and constraints are mainly focused on modelling economic credibility and stability. These are the indicators that are the main targets institutional designs.

The structural parameters of this model in their content are markedly different from the typical macroeconomic models where direct input-output effects are described. Here, the structural parameters describe probabilities that the given institutional alternatives will have the prospective better effects than the currently implemented alternatives would have in the future. These types of parameters are most convenient for the experts to quantify as subjective probabilities. Experiments suggested that, in the case of interval estimates, there is not much danger to quantify experts' pragmatic overconfidence.

From the modelling aspect, the model has binary integer institutional choice variables and the numerical values of the structural parameters are subjective probabilities given by expert questionnaires.

This paper demonstrates that the application of a linear planning model for institutional design should help to arrange and systematise the lines of reasoning in this field and to quantify the mysterious effects of institutional arrangements. Therefore, the presented model may be a useful complementary tool in the design of national industrial institutional structures. By moving from the results of this type of macro-models to the complicated micro-economic "political market games", we may have a better understanding of how to socially co-ordinate these games in a more positive direction.

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