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DEMP-1: Some Counterfactual Simulation Results

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DEMP-1: SOME COUNTERFACTUAL SIMULATION RESULTS

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FOREWORD

Roughly 1.6 billion people, 40 percent of the world's population, live in urban areas today. At the beginning of the last century, the urban population of the world totaled only 25 million. According to recent United Nations estimates, about 3.1 billion people, twice today's urban population, will be living in urban areas by the year 2000.

Scholars and policymakers often disagree when it comes to evaluating the desirability of current rapid rates of urban growth in many parts of the globe. Some see this trend as fostering national processes of socioeconomic development, particularly in the poorer and rapidly urbanizing countries of the Third World; whereas others believe the consequences to be largely undesirable and argue that such urban growth should be slowed down.

As part of a search for convincing evidence for or against rapid rates of urban growth, a Human Settlements and Services research team, working with the Food and Agriculture Program, is analyzing the transition of a national economy from a primarily rural agrarian to an urban industrial-service society. Data from several countries selected as case studies are being collected, and the research is focusing on two themes: spatial population growth and economic (agricultural) development, and resources/service demands of population growth and economic development.

This paper is the second in a series dealing with the Polish case study. In it, Dr. Pawlowski presents a reduced form of his demoeconometric model which draws together a number of economic, technological, and demographic variables to explain the past growth of the Polish economy. Also included in the paper are counterfactual simulation results and direct multiplier analyses.

A list of related papers in the Population, Resources, and Growth Series appears at the end of this publication.

Andrei Rogers
Chairman
Human Settlements
and Services Area

ABSTRACT

This is the second IIASA Working Paper on DEMP-1--the Demoeconometric Model of Poland. This model seeks to examine the process of economic growth and its impact on the time-behavior of demographic variables, such as birth, death, and migration rates, and population totals in urban and rural areas. The paper presents the reduced form of the model and illustrates some of its uses: counterfactual simulation results and direct multiplier analysis. The counterfactual simulation was based on two scenarios, one extrapolating to the 1970's the moderate growth experienced in the 1960's and one assuming from the start (since 1960) a high rate of growth, as was observed in the period 1971-1976. The analysis of direct multipliers shows that trends and sharp shifts of economic policy, which occur from time to time because of changes in relevant economic and administrative decisions, play an especially large role in the impact of economics on demographic factors.

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Zbigniew Pawlowski

1. INTRODUCTION

The present paper is a sequel to A Demoeconometric Model of Poland: DEMP 1* which presents the main features and characteristics of the Demoeconometric Model together with the estimation results of its structural and reduced forms. The DEMP-1 model has since been used for making a number of counterfactual simulations aimed at analyzing the impacts of different economic policies on the general state of the Polish national economy and on its demographic situation as well. The scenarios underlying these counterfactual simulations and the results obtained are discussed in this paper.

The notation and symbols of variables are the same as in the previous paper. For convenience, however, the Appendix in this paper gives the full list of definitions of the variables used and of their symbols.

2. THE LIMITED REDUCED FORM OF THE MODEL

Since the DEMP-1 model is--apart from a relatively small number of detached equations--of an interdependent character,

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*Pawlowski, Z. (1979), A Demoeconometric Model of Poland: DEMP 1, Working Paper WP-79-14, International Institute for Applied Systems Analysis, Laxenburg, February 1979.

any simulation or prediction based on it must be made by using its reduced form. The reduced form of the linear part of the model was given in the previous paper and is summarized here. Of special interest is the qualitative side of the reduced form, i.e., the information concerning which of the predetermined variables enter into the different equations of the reduced form. Such information is provided by Table 1 in which different rows correspond to the non-lagged endogenous variables Y_i while the columns indicate the predetermined variables. Whenever the coefficient* of the reduced-form equation is different

Table 1. Zero and non-zero coefficients of the limited reduced form.

Endogenous Variable	Predetermined Variables																					
	Z_1	Z_2	Z_3	Z_4	Z_5	Z_8	Z_9	Z_{11}	Z_{12}	Z_{13}	Z_{14}	Z_{18}	Z_{19}	Z_{20}	Z_{21}	Z_{22}	Z_{23}	Z_{24}	Z_{25}	Z_{26}	Z_{27}	Z_{30}
Y_1	x	x	x	o	x	o	o	x	o	x	o	x	o	x	o	x	o	o	o	o	o	o
Y_2	x	x	x	o	x	o	o	x	o	x	o	x	o	x	o	x	o	o	o	o	o	o
Y_3	x	x	x	o	x	o	o	x	o	x	o	x	o	x	o	x	o	o	o	o	o	o
Y_4	o	o	o	o	o	o	o	o	o	o	x	o	o	x	o	o	o	o	o	o	o	o
Y_7	x	x	x	o	x	o	o	x	o	x	o	x	o	x	o	x	o	o	o	o	o	o
Y_8	o	o	o	x	o	o	x	o	x	o	o	o	o	x	o	x	o	o	o	o	o	o
Y_9	x	x	x	o	x	o	o	x	o	x	o	x	o	x	o	x	o	o	o	o	o	o
Y_{10}	x	x	x	o	x	o	o	x	o	x	x	x	o	x	o	x	o	o	o	o	o	o
Y_{18}	x	x	x	x	x	o	x	x	x	x	o	x	o	x	o	x	o	o	o	o	o	o
Y_{19}	x	o	o	o	o	o	o	o	o	o	o	o	o	x	o	o	o	o	x	o	o	o
Y_{20}	o	o	o	o	o	o	o	o	x	o	o	o	o	x	o	o	o	o	o	x	x	o
Y_{22}	x	x	x	x	x	o	x	x	x	x	x	x	x	x	o	x	x	o	o	x	o	o
Y_{23}	x	x	x	x	x	o	x	x	x	x	x	x	x	x	o	x	o	o	o	o	o	o
Y_{24}	x	x	x	x	x	o	x	x	x	x	x	x	x	x	o	x	x	x	o	x	x	o
Y_{25}	x	x	x	x	x	o	x	x	x	x	x	x	x	x	o	x	x	o	o	x	x	o
Y_{26}	x	x	x	o	x	o	o	x	x	o	o	x	o	x	o	x	o	o	o	o	o	x
Y_{27}	o	o	o	x	o	o	x	x	x	o	o	o	o	x	o	x	o	o	o	o	o	x
Y_{28}	o	o	o	o	o	x	o	o	o	x	o	o	o	x	x	o	o	o	o	o	o	o
Y_{29}	o	o	o	o	o	x	o	o	o	x	o	o	o	x	x	o	o	o	o	o	o	o

*The coefficients of the reduced form of DEMP 1 have been presented in Appendix B of WP-79-14.

from zero the symbol x appears at the intersection of the appropriate row and column. If the coefficient is equal to zero then zero appears in Table 1. Thus, the number of x symbols in a given row indicates the total number of predetermined variables influencing the endogenous variable and the location of x's shows which ones these variables are. On the other hand, the zeros reflect the situation when a predetermined variable has no effect on the endogenous variable.*

Table 1 does not have rows corresponding to the urban and rural population variables Y_5 and Y_6 nor has it rows showing the dependence of investment variables Y_{11}-Y_{16} on the predetermined ones. This is due to the fact that since Y_5 and Y_6 form the (only) non-linear part of the model and the estimation of investment equations was carried on differently, it was not possible to obtain by conventional methods** the matrix P of the reduced form for all the endogenous variables of the model. Since the reduced form reflected by Table 1 refers only to one part of the endogenous variables it will be referred to as the "limited reduced form".

A closer look at Table 1 reveals that there are four blocks of endogenous variables that are dependent upon similar predetermined variables. These blocks are: (Y_{22},Y_{24},Y_{25}), $(Y_1,Y_2,Y_3,$ $Y_7,Y_9,Y_{10},Y_{18},Y_{26})$, (Y_8,Y_{27}) and (Y_{28},Y_{29}). Note that the variables forming the first block depend on the largest number of predetermined variables (17 or 18) while the endogenous variables of the last block are related to the minimum number (4) of predetermined ones. The variables Y_4,Y_{19} and Y_{20} exhibit special, individual patterns of dependence.

*Had the structural form of the model been fully interdependent the non-lagged endogenous variables would have been dependent on all the predetermined variables. In fact this is not so because some of the structural form equations are of the recursive type or even of simple form, in which case the endogenous variables depend only on some predetermined variables.

**Premultiply the matrix C of the coefficients which in the structural form of the model stand with the predetermined variables by the inverse of the matrix B of structural form coefficients standing with the non-lagged endogenous variables. The matrix π is thus obtained from the formula $\pi = -B^{-1}C$.

Perhaps still more interesting is to look for the predetermined variables which have proved most often to have impact on the endogenous variables of the model.* There are eight such variables: $Z_1, Z_2, Z_3, Z_5, Z_{11}, Z_{13}, Z_{18}, Z_{22}$. Checking their definitions (see Appendix), we find that three of them: Z_1, Z_2 and Z_3, are lagged endogenous variables, three are exogenous decision variables (Z_5, Z_{18}, Z_{13}), one is a dummy variable Z_{22} connected with the especially strong economic growth of Poland in the early seventies** and, finally, one is a time variable Z_{11}. Such a composition of the most often occurring predetermined variables has important and far-reaching implications. Note that the three exogenous decision variables are very crucial, since they refer to wage level, construction of flats and to autonomous investment in non-agricultural productive sectors, respectively. This inference is further strengthened by the widespread influence of variable Z_{22} which summarily represents the 1971-1976 shift of economic policy aimed at fast economic growth coupled with a stronger rise in the standard of living.

On the other hand one must not overlook the importance of the time element, which manifests itself in two ways. The time variables accounted for in the limited reduced form. It is also important to note that Z_1, Z_2, Z_3 and Z_{13} are lagged variables, with Z_1 and Z_{13} being lagged one year while Z_2 has a lag of two years and Z_3 of three years. Thus, the model reflects a rather complicated dynamic mechanism of national economy, implying that the results of decisions undertaken by appropriate planning and other institutions are not always felt immediately but are usually spread over time with quite substantial delays. As can be inferred from Table 1, more than half of the endogenous variables for which the limited reduced form exists exhibit such long time-delayed impacts. These are the variables Y_1, Y_2,

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*From these considerations we exclude, however, the unit variable Z_{20}, since obviously it appears in all linear reduced form equations.

**For the definition of this variable and the reasons why it was introduced into the model see WP-79-14, pages 11-12.

$Y_3, Y_7, Y_9, Y_{10}, Y_{18}, Y_{22}, Y_{23}, Y_{24}, Y_{25}, Y_{26}$ all of which depend simultaneously* on Z_1, Z_2, Z_3 and Z_{13}. Finally, it is to be noted that also Y_{20} shows a well pronounced time-lag dependence since it is influenced both by one-year and two-years lagged predetermined variables. These variables are defined as total agricultural investment taken with appropriate lags, while Y_{20} is defined as agricultural labor productivity.

In conclusion let us point out that besides the eight "main" predetermined variables which influence the bulk of the endogenous variables of the DEMP-1 model, there are also other predetermined variables in the reduced-form equations. These other variables are more specialized in the sense that they seldom appear, i.e., they influence only a restricted number of endogenous variables. Altogether, there are** 21 predetermined variables in the limited reduced form of the model. Out of these, 6 are lagged endogenous, 7 are exogenous decision variables, 3 are purely exogenous quantitative variables (i.e., their variation is independent of actions undertaken by planning authorities) and 5 are exogenous dummy variables. These dummies can be split into two categories, the first one including variables referring to shifts of economic policy (2 variables) and the second one embracing all dummy variables that are connected with purely exogenous phenomena (3 variables).

3. THE EXTENDED REDUCED FORM OF THE MODEL

This section will be devoted to a brief exposition of how one could find the reduced form pertaining to all the endogenous variables of the DEMP-1 model. This consists of adding to Table 1 (or to its generalization presenting not only symbols o or x but numerical values of the coefficients instead) an appropriate number of rows corresponding to the variables

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*With the exception of Y_{26} which does not depend on Z_{13}.

**Excluding the unit variable Z_{30}.

excluded so far. These excluded variables are $Y_5, Y_6, Y_{11}, Y_{12}, Y_{13}, Y_{14}, Y_{15}, Y_{16}, Y_{17}, Y_{21}$ and Y_{30}. The additional rows are constructed according to the nature of the variables.

Let us consider the variables Y_5 and Y_6. It has already been pointed out in the previous paper* that the reduced-form coefficients can be found from the expressions

$$Y_5 = \left(1 + \frac{Y_{24} - Y_{26} + Y_{28}}{1000}\right) Z_6^o \qquad (1)$$

and

$$Y_6 = \left(1 + \frac{Y_{25} - Y_{27} - Y_{29}}{1000}\right) Z_7^o \qquad (2)$$

when Y_{24}-Y_{29} are substituted by their expressions provided by the limited reduced form, and where Z_6^o and Z_7^o denote the initial level of urban or rural population in a given year. Such substitution gives Y_5 and Y_6, respectively, as the product of a linear function of other predetermined variables of the model** and of Z_6 or Z_7, respectively. Table 1 presents the coefficients of such functions and Table 3 gives the values of Z_6 and Z_7 pertaining to the period 1960-1976. Let us observe that the resulting coefficients of the reduced form for Y_5 and Y_6 will not be constant in time which, however, was to be expected because of the non-linear form of the relations (1) and (2).

It is easy to find the reduced-form coefficients for the variable Y_{21}, defined as the general level of labor productivity in productive sectors of the national economy. By definition, there is

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*See page 26.

**The predetermined variables that show non-zero coefficients in the rows of Table 1 corresponding to the variables Y_{24}-Y_{29}.

Table 2. Reduced-form coefficients for equations of Y_5 and Y_6.

Endogenous Variable	Predetermined variables appearing in the reduced form equation									
	Z_1	Z_2	Z_3	Z_4	Z_5	Z_8	Z_9	Z_{11}	Z_{12}	Z_{13}
	-0.004715	-0.002121	0.004998	0.000024	0.000063	0.006100	0.000126	0.000663	0.011841	0.019510
Y_5	Z_{14}	Z_{18}	Z_{19}	Z_{21}	Z_{22}	Z_{23}	Z_{24}	Z_{26}	Z_{27}	Z_{30}
	-0.001360	0.000040	-0.001140	-0.138500	-0.120339	-0.001425	2.445000	0.000230	-0.000575	0.017500
	Z_1	Z_2	Z_3	Z_4	Z_5	Z_8	Z_9	Z_{11}	Z_{12}	Z_{13}
	0.009491	-0.004272	0.010068	-0.000085	0.018210	0.011100	0.000446	1.159333	-0.329636	0.033469
Y_6	Z_{14}	Z_{18}	Z_{19}	Z_{21}	Z_{22}	Z_{23}	Z_{26}	Z_{27}	Z_{30}	
	0.082963	-0.000990	0.069562	-0.027000	4.867211	0.086929	-0.014015	0.035065	0.005800	

Table 3. Values of z_6^o and z_7^o.

Year	z_6^o	z_7^o	Year	z_6^o	z_7^o
1960	13.95	15.45	1969	16.60	15.85
1961	14.35	15.45	1970	16.85	16.75
1962	14.65	15.55	1971	17.10	15.55
1963	14.90	15.65	1972	17.35	15.55
1964	15.10	15.75	1973	17.65	15.50
1965	15.40	15.85	1974	18.05	15.35
1966	15.70	15.90	1975	18.50	15.25
1967	16.00	15.85	1976	19.00	15.10
1968	16.35	15.80			

Source: Data from the Statistical Yearbooks of Poland 1961-1977.

$$Y_{21} = \beta_t Y_{19} + (1 - \beta_t)Y_{20} \quad , \tag{3}$$

where Y_{19} and Y_{20} denote labor productivity in non-agricultural and agricultural sectors of the national economy and β_t is the share of non-agricultural employment in total productive employment, i.e.,

$$\beta_t = \frac{Y_2 + Y_3}{Y_2 + Y_3 + Y_4} \quad . \tag{4}$$

Hence, in order to derive the reduced-form equation for Y_{21} one must find such equations for Y_{19} and Y_{20}* and then add them after having weighted these equations with β_t and $1 - \beta_t$, respectively. Below, in Table 4, we give the values of the β_t

*See Appendix B of the former paper.

coefficients for the years 1960-1976. As can be seen from this Table and from formula (3), the resulting reduced-form coefficients are not constant but change in time according to the changing (increasing) share of non-agricultural employment.

Table 4. Values of β coefficients.

Year	β_t	Year	β_t	Year	β_t
1960	0.38	1966	0.45	1972	0.53
1961	0.39	1967	0.46	1973	0.54
1962	0.40	1968	0.48	1974	0.56
1963	0.41	1969	0.49	1974	0.56
1964	0.42	1970	0.50	1976	0.57
1965	0.44	1971	0.51		

Finally, one could also envisage the construction of the reduced-form equations for the investment variables. The previous paper* shows that the investment structural equations are essentially used for splitting total sectorial investments into their endogenous and exogenous parts, and they do not enter the proper structural form of the model. In spite of this, an approximation to the reduced-form relations for either total or endogenous investment variables** can be found.

The general form of the equations pertaining to total investment is the following one

$$\frac{\text{Total investment in year } t\text{, sector } j}{\text{National income in year } t} = \alpha_1 \frac{\text{Total investment in year } t\text{-1, sector } j}{\text{National income in year } t\text{-1}} + f(v_1, v_2, \ldots, v_k) + \alpha_2 + \eta \qquad (5)$$

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*See pages 16-18.

**Note that total sectorial investment variables--since comprising the endogenous and the exogenous part of investment--are also treated as endogenous variables of the model.

where $f(v_1, v_2, \ldots, v_k)$ stands for a function of other exogenous variables, α_1 and α_2 are constant parameters and η is a random component. Let Y_{18} denote the non-lagged national income and Z_{33} denote the national income lagged one year. Clearly, (5) can be rearranged in the following way

$$\text{Total investment in year t, sector j} = \alpha_1 \frac{Y_{18}}{Z_{33}} \cdot \text{Total investment in year t-1, sector j}$$

$$+ Y_{18}[f(v_1, v_2, \ldots, v_k)] + \eta'$$

where $\eta' = \eta \cdot Y_{18}$. Since the reduced-form equation for Y_{18} is known, substituting it in (6) gives an approximation to the reduced-form relation of the total sectorial investment variable. Since total investment is related to endogenous investment by the simple identity stating that total investment equals the endogenous investment plus the exogenous one, this also provides an answer to the question of reduced form for sectorial endogenous investment variables.

In conclusion, let us observe that the solutions presented in this section are of an approximative character. This stems from the fact that in the approach adopted for finding the reduced-form coefficients no provision was made for the feed-back effects of influence of Y_5 and Y_6 or of investment variables on the other endogenous variables of the model. For this reason we have used for the heading of this section the term "extended reduced form" to accentuate the fact that the resulting coefficients do not reflect the full impact of the predetermined variables, i.e., the impact when all the dependencies and feed-backs have been accounted for. In classical linear models where all equations have been jointly estimated, the reduced form obtained by standard methods is obviously reflecting such a full impact of predetermined variables.

4. THE POSSIBLE USES OF DEMP-1

Once a model has been built and estimated it can be used for various types of analysis and inference. Since the main objective of the research which led to the construction of the DEMP-1 model was to analyze the existing interrelations between the economic and demographic factors in Poland, the analytic approach must provide answers to the following questions:

1) Is there an impact of economic factors on demographic variables and, if so, what is its magnitude?
2) Are demographic factors important to economic growth?

A solution to this problem can be obtained in different ways. So far, the main accent has been on counterfactual simulation procedures. If the counterfactual simulation is performed over a sufficient time interval and the underlying scenarios are carefully chosen as to differ significantly from each other with respect to "control" variables, the results will usually prove to be fruitful. They will give a clear insight into the mechanism of interrelations and the role of different control variables. Counterfactual simulation, however, is not the only possible device. Much inference can also be obtained from analyzing single coefficients of the reduced form of the model since these are direct multipliers expressing the expected change of endogenous variables given an assumed change of a chosen predetermined variable.

The next two sections of the paper will be devoted to the exposition of counterfactual simulation scenarios and to the results obtained when using these scenarios. Subsequently, one section of the paper will deal with the analysis of some of the more interesting multipliers.

To complete the argument on the possible uses of the DEMP-1 model let us point out, however, that counterfactual simulation and multipliers are not its only possible uses. As a matter of fact, the model can also be used for straightforward predictions into the future. Such experiments have not been done as yet, however.

5. COUNTERFACTUAL SIMULATION SCENARIOS

Since the model in its present DEMP-1 form is constructed in such a way as to stress the interconnections of economic factors and the impact of economics on demographic phenomena, the counterfactual simulation scenarios are designed to study diverging economic and demographic situations originated by substantially different economic policies. Starting with two (or more) sets of initial assumptions and looking at the results obtained, it is possible to judge whether really the demographic phenomena in Poland are conditioned by economic factors and if so, to what extent.

With this in mind, two different scenarios were designed which will be referred to as Scenario A and Scenario B. In agreement with what was said about the necessary divergence of scenarios, the two decided upon are representing two extreme situations in the economic history of the Polish economy during the years 1960-1976.* Scenario A reflects the hypothetical assumption for the whole time interval of a moderate rate of growth which was typical for the sixties. On the other hand, Scenario B has been designed on the assumption that right from 1960 onward Poland experienced a continuously high rate of growth and a visibly rising standard of living, as in fact was the case for the years 1960-1976.

Tables 5 and 6 contain the values of different predetermined variables assumed for the two scenarios while Table 7 shows the observed data. As can be seen in these tables, the real path of national economy fell between the lines assumed for the two scenarios, with Scenario A being closer to the observed data than Scenario B.

Along with the assumption that Scenario B represents not only a faster economic growth but also a more substantial rise in the standard of living, the scenarios differ both as to the values of variables inducing growth (investments) and with

*Since the model has been estimated by using time series data referring to 1960-1976, it seems logical that any counterfactual simulation based on it refers to the same time interval.

Table 5. Values of predetermined variables assumed for Scenario A.*

Variable	1971	1972	1973	1974	1975	1976
z_1	650	685	730	770	810	860
z_2	130	137	144	151	158	165
z_3	120	130	137	144	151	158
z_4	565	580	595	610	625	640
z_5	122	124	126	128	130	132
z_8	0	0	0	0	0	0
z_9	133	142	151	160	169	178
z_{11}	12	13	14	15	16	17
z_{12}	0	0	0	0	0	0
z_{13}	68	71	74	77	80	83
z_{14}	17	18	19	20	21	22
z_{18}	650	670	690	710	730	750
z_{19}	-0.2	0	0	0	0	0
z_{20}	1	1	1	1	1	1
z_{21}	0	0	0	0	0	0
z_{22}	0	0	0	0	0	0
z_{23}	0	0	0	1	1	1
z_{24}	0	0	0	0	0	0
z_{26}	38.5	41.0	43.5	46.0	48.5	50.1
z_{27}	36.2	38.5	41.0	43.5	46.0	48.5
z_{28}	144	169	196	225	256	289

*For the years 1960-1971 values assumed for Scenario A are the same as observed data--see Table 7.

Table 6. Values of predetermined variables assumed for Scenario B.

Variable	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
z_1	300	330	363	400	440	484	532	585	644	710	781	860	944	1038	1142	1256	1380
z_2	50	60	64	72	80	90	100	110	125	150	176	210	270	335	400	470	550
z_3	45	50	60	64	72	80	90	100	110	125	150	176	210	270	335	400	470
z_4	385	415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
z_5	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180
z_8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
z_9	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228
z_{11}	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
z_{12}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
z_{13}	28	32	37	43	50	57	65	75	85	99	114	131	153	176	202	233	268
z_{14}	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37
z_{18}	414	474	534	600	660	720	880	840	900	960	1020	1080	1140	1200	1260	1320	1380
z_{19}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
z_{20}	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
z_{21}	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
z_{22}	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
z_{23}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
z_{24}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
z_{26}	12	13	14	16	20	25	29	32	37	50	53	58	60	65	70	76	82
z_{27}	10	12	13	14	16	20	25	29	32	37	50	53	58	60	65	70	76
z_{30}	1	4	9	16	25	36	49	64	81	100	121	144	169	196	225	256	289

Table 7. Observed values of predetermined variables (for selected years).

Variable	1960	1962	1964	1966	1968	1970	1972	1974	1976
z_1	297.8	335.0	384.9	449.8	518.5	619.2	704.0	885.5	1116.3
z_2	48.3	60.6	76.5	80.1	97.1	119.4	133.9	191.3	306.2
z_3	43.4	57.5	66.4	78.8	88.9	109.6	130.2	148.7	246.0
z_4	385	401	421	451	491	539	588	671	791
z_5	100.0	103.0	107.7	111.3	115.5	119.5	134.4	155.7	175.5
z_8	0	8	1	-10	-14	7	-14	13	30
z_9	36.5	44.1	49.1	66.4	93.4	123.6	149.1	173.6	193.3
z_{11}	1	3	5	7	9	11	13	15	17
z_{12}	0	1	0	0	0	1	0	1	1
z_{13}	28.2	36.2	32.7	43.2	52.9	55.0	101.0	157.0	152.6
z_{14}	5.7	7.8	10.9	13.0	15.3	15.9	21.7	30.8	32.5
z_{18}	414.8	411.1	475.2	517.1	569.5	630.0	697.5	895.4	1009.4
z_{19}	-0.7	-1.0	0.1	-0.9	0.0	-0.2	-1.5	-7.2	-9.5
z_{20}	1	1	1	1	1	1	1	1	1
z_{21}	1	0	0	0	1	0	1	1	1
z_{22}	0	0	0	0	0	0	1	1	1
z_{23}	0	1	0	0	0	0	0	0	1
z_{24}	0	0	0	0	1	0	0	0	0
z_{25}	43.0	45.9	49.3	54.2	57.6	64.5	69.7	80.5	96.2
z_{26}	12.0	15.0	17.9	24.7	29.9	35.2	37.8	51.0	70.1
z_{27}	10.0	13.5	16.5	21.2	27.2	32.5	36.2	43.5	60.2
z_{30}	1	9	25	49	81	121	169	225	289

respect to the variables pertaining to the standard of living (wages, housing).

The counterfactual simulations performed were of the deterministic type, i.e., the random components of the extended reduced-form equations were set equal to zero. The choice of the deterministic variant was made for computational reasons. Stochastic simulation is much more tedious since it involves several runs of computations for every year considered, and since it also requires devising a stochastic mechanism yielding "observations" of the random effects. If the random components are autocorrelated this may be quite a complicated task. On the other hand, however, stochastic simulation is very rewarding since it not only gives the expected values but also conveys information about possible deviations of a variable from its expected path.

6. ANALYSIS OF COUNTERFACTUAL SIMULATION RESULTS

Using the scenarios described in the preceding section, counterfactual simulation was performed with respect to all the endogenous variables of the model referring to national income, employment, and demographic conditions. Thus, for every variable considered, two sets of its "theoretical" values were obtained, each set being composed of 17 numbers referring to the consecutive years, 1960-1976. The first set represents the expected values of the variable computed assuming Scenario A to be true and the second set refers to the results that can be expected under Scenario B.

Tables 8-12 present the results of the counterfactual simulations performed. For the sake of clarity of presentation these tables give the results of computations performed for every second year.

When both sectoral and total national income are considered, one finds that the pattern of growth corresponding to Scenario B leads to substantially higher figures (in constant prices!) than in the case of Scenario A. This is not surprising, since the basic difference in the two scenarios consists in assuming much stronger growth stimuli for Scenario B. The non-trivial

Table 8. Counterfactual simulation of national income variables.

Variable, Scenario	1960	1962	1964	1966	1968	1970	1972	1974	1976
Y_1 - Scenario A	307	346	409	478	562	674	741	838	940
Y_1 - Scenario B	331	400	491	594	721	866	1039	1192	1390
Y_8 - Scenario A	126	107	128	133	140	127	153	136	141
Y_8 - Scenario B	113	118	123	128	133	138	142	147	152
Y_{18} - Scenario A	433	453	537	611	702	801	894	974	1081
Y_{18} - Scenario B	444	518	614	722	854	1004	1181	1339	1542

Table 9. Counterfactual simulation of productive employment variables.

Variable, Scenario	1960	1962	1964	1966	1968	1970	1972	1974	1976
Y_2 - Scenario A	5.1	5.9	6.7	7.5	8.4	9.3	10.1	11.0	11.9
Y_2 - Scenario B	5.2	6.0	6.9	7.8	8.7	9.7	10.8	11.8	12.8
Y_3 - Scenario A	0.5	0.6	0.7	0.7	0.8	0.9	1.0	1.1	1.2
Y_3 - Scenario B	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3
Y_4 - Scenario A	10.8	10.7	10.6	10.5	10.4	10.2	9.8	9.7	9.6
Y_4 - Scenario B	10.3	10.1	10.0	9.8	9.6	9.4	9.3	9.1	8.9
Total-Scenario A	16.4	17.2	18.0	18.7	19.6	20.4	20.9	21.8	22.7
Total-Scenario B	16.1	16.7	17.6	18.4	19.2	20.1	21.2	22.1	23.0

Table 10. Counterfactual simulation of employment in services.

Variable, Scenario	1960	1962	1964	1966	1968	1970	1972	1974	1976
Y_9 - Scenario A	1.6	1.6	1.7	1.7	1.7	1.8	1.8	1.9	1.9
Y_9 - Scenario B	1.6	1.7	1.7	1.8	1.8	1.9	2.0	2.1	2.2

observation, however, is that in 1976 the national income figure is about 43 percent higher for the counterfactual simulation B than it is for simulation based on Scenario A. The inference which can be drawn is that should the policy of fast growth have been started ten years earlier, the country's economic potential would be significantly higher. Another striking observation to be seen in Table 8 is, that even if following the Scenario B growth pattern, one would not have observed a substantial rise of the agricultural sector which is always lagging well behind the other productive sectors.

When analyzing the counterfactual simulation results applying to employment variables, one notices that under both scenarios employment of full-time, one-job workers and employees in non-agricultural productive sectors rises quite substantially --and at almost the same annual rate. A slightly different pattern is seen with respect to peasant-workers whose number also rises but this rise is different for the two assumed situations. While under Scenario A the expected number of peasant-workers (variable Y_3) in 1976 is almost 2.5 greater than in 1960, under Scenario B the similar index has only the value of 2.17. However, this is not surprising. Scenario B leads in 1976 to a larger overall employment in non-agricultural productive sectors than does Scenario A (14.1 versus 13.1 million people), and a more extensive construction of flats in urban areas. Thus, new workers attracted from agricultural to non-agricultural productive sectors not only change their jobs but can, in larger numbers, effectively migrate to towns where they will find lodging opportunities.

As far as agricultural employment is concerned, both scenarios show a large decrease in the number of people working on the land. In the case of Scenario B, this decrease is slightly more pronounced (1.4 instead of 1.2 million persons). This is understandable since the "pumping" of labor force from agriculture would be stronger and this scenario assumes higher investment outlays in agriculture which will make such exodus possible without a corresponding loss of output.*

*This implies sbustitution of labor force by capital.

Employment in services is supposed to rise faster under Scenario B than A, this difference being especially visible during the seventies. What is a bit surprising, nevertheless, is that the observed data reveal, for the last two or three years, a higher level of employment in services (Y_9) than that computed under Scenario B. This is perhaps due to government decisions taken in the mid-seventies and aimed at expansion of small trade and craftsmanship which provide direct services to the population.

Table 11. Counterfactual simulation of demographic coefficients.

Variable, Scenario	1960	1962	1964	1966	1968	1970	1972	1974	1976
Y_{24} - Scenario A	16.2	16.3	16.4	16.6	18.6	16.8	17.0	17.0	17.0
Y_{24} - Scenario B	16.6	16.6	16.6	16.7	18.7	16.8	16.9	16.9	17.0
Y_{25} - Scenario A	24.9	22.4	20.5	20.0	19.5	18.8	18.0	15.0	13.0
Y_{25} - Scenario B	37.3	35.1	32.7	30.3	27.8	25.4	23.0	20.5	17.0
Y_{26} - Scenario A	7.2	7.1	7.0	7.0	7.2	7.7	7.8	8.4	9.0
Y_{26} - Scenario B	6.6	6.4	6.3	6.0	6.3	6.4	6.5	6.8	7.2
Y_{27} - Scenario A	8.3	8.1	8.0	8.0	7.9	8.0	8.2	8.8	9.1
Y_{27} - Scenario B	8.1	8.1	8.0	8.0	8.1	8.2	8.3	8.5	8.7
Y_{28} - Scenario A	6.0	6.2	6.4	6.7	6.7	6.9	7.0	7.0	7.1
Y_{28} - Scenario B	6.0	6.2	6.4	6.7	7.1	7.7	8.4	9.5	10.7

When viewing the results of simulations performed for the demographic coefficients represented by the variables Y_{24}-Y_{29}, it can be seen that one of these variables, Y_{24}, is unaffected by the changes of assumptions underlying the two counterfactual scenarios. The urban birth rate shows for both scenarios a very slow upward trend which, however, decreases in the last years of simulation.

All other variables considered show distinct paths whether Scenario A or Scenario B was applied. These differences, however, are only of quantitative and non-qualitative character, i.e., the general characteristics of variation are generally the same. Contrary to the urban areas, the rural birth rate visibly decreases with time*, its levels being however definitely different for the two scenarios. An interesting conclusion can be drawn from counterfactual simulation figures pertaining to death rates. The urban and rural death rates are higher in Scenario A than in B which is probably due to the fact that achieving higher national income makes it possible to spend more money on health care. A still more interesting feature of both death-rate variations is that after a temporary decline they start rising again, their minimum level being situated in the late sixties. The present version of the model does not permit one to ascertain with certainty the cause of such a pattern and one can only suppose that this is due either to the aging of the population or to the worsening of natural environmental conditions.** Finally, some points are worth making with respect to the variable Y_{28} which is defined as urban net immigration. Under both scenarios, this immigration rises but there is a net distinction in its behavior. If a rather moderate growth is assumed, the simulated values show an upward trend but this trend has remarkably slowed down in the last years. On the other hand, net urban immigration coefficients seem to be increasing in time with an increasing rate of growth. This, however, is not surprising. Scenario B assumes fast growth due to intensive investments and also assumes an intensive construction of flats. Thus, people who have been living in rural areas not only are economically attracted to non-agricultural sectors but also they are given real opportunities to find suitable accommodation in towns.

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*Because for rural areas this rate depends positively on the level of consumption (but negatively on other factors).

**The reader is reminded that the variables Y_{24}-Y_{28} are expressed as coefficients per 1000 of population.

To conclude this overview of counterfactual simulation results, Table 12 shows urban, rural and total population levels corresponding to the two scenarios. The general pattern of urban population growth is the same in the sense of the upward trend, but the computed population numbers tend to coincide for the two Scenarios at the end of the simulation period. In spite of outmigrations, the rural population is found to be growing also, but shortly after 1970 one finds that the number of rural population stabilizes if not actually declines. This is the effect of the declining birth rates and rising death rates of the migrants. Consequently, as seen from the data pertaining to Scenario B, under the conditions of fast economic growth any growth in the total Polish population would have been due to increases in the urban population.

Table 12. Counterfactual simulation of urban and rural population totals.

Variable, Scenario	1960	1962	1964	1966	1968	1970	1972	1974	1976
Y_5 - Scenario A	14.2	14.8	15.2	15.8	16.5	17.0	17.5	18.1	18.6
Y_5 - Scenario B	14.0	14.4	14.9	15.4	16.0	16.6	17.2	17.9	18.6
Y_6 - Scenario A	15.4	15.6	15.8	15.9	15.8	15.7	15.7	15.7	15.6
Y_6 - Scenario B	15.8	16.5	17.2	17.8	18.2	18.6	18.8	18.9	18.8
Total Population - Scenario A	29.6	30.4	31.0	31.7	32.3	32.7	33.2	33.8	34.2
Total Population - Scenario B	29.8	30.9	32.1	33.2	34.2	35.2	36.0	36.8	37.4

7. DIRECT MULTIPLIERS OF THE MODEL

In Section 4, while discussing the possible use of the DEMP-1 model, it was pointed out that the model provides grounds for an analysis of different types of multipliers which measure the expected impact on a chosen endogenous variable on unit change of the corresponding predetermined variable.

Consequently, we shall focus now on the multiplier values as they are obtained from the model. More specifically, our attention will be restricted to the simplest case of direct of the reduced form.* The number of such multipliers, even for a comparatively small model, usually is very large.** Since, however, the DEMP-1 model is designed mainly for the analysis of influence of economic factors on the demographic ones, the present section will follow this general line of approach. Consequently, we shall present and comment on the multipliers that reflect the final impact of various predetermined variables on variables $Y_{24}-Y_{28}$, i.e., on the variables that belong to the demographic block. In doing so, however, we shall consider only such multipliers (reduced-form coefficients) which are large enough to represent a practically significant shift of the endogenous variables induced by the predetermined variable. A further restriction will consist in dropping from the first stage of our analysis the multipliers that pertain to the situations when the predetermined variable is a time variable or a dummy one. This means restricting ourselves to those predetermined variables that have a causal relationship to the corresponding endogenous variable.

Retaining only such reduced-form coefficients that are large enough to yield--after their multiplication by a standard level of change of the predetermined variable--a product equal to at least 0.01 (in its absolute value), Table 13 and 14 were obtained. Entries in these tables show the direct multipliers of the endogenous variables indicated in rows while columns refer to various predetermined variables. The symbol 0 in the tables indicates the resulting multiplier to be equal to zero, while the symbol n denotes the corresponding multiplier to have a negligible numerical value.

Let us now consider the multipliers connected either with time variables or with dummy variables. The results are presented in Table 15.

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*Note, nevertheless, that since some of the predetermined variables are lagged, this means that the direct multipliers can be either static or dynamic.

**The DEMP-1 model has altogether more than 190 such multipliers.

Table 13. Direct multipliers with respect to selected quantitative predetermined variables Z_1-Z_9.

Endogenous Variable	Predetermined Variables of the Model						
	Z_1	Z_2	Z_3	Z_4	Z_5	Z_8	Z_9
Y_{24}	0.000154	n	n	n	-0.000299	0	n
Y_{25}	-0.009591	-0.004271	0.010068	-0.001482	0.018212	0	0.007679
Y_{26}	-0.004869	-0.002191	0.005163	0	n	0	0
Y_{27}	0	0	0	0.001397	0	0	-0.007233
Y_{28}	0	0	0	0	0	0.011100	0

Table 14. Direct multipliers with respect to selected quantitative predetermined variables Z_{13}-Z_{27}.

Endogenous Variable	Predetermined Variables of the Model						
	Z_{13}	Z_{14}	Z_{18}	Z_{19}	Z_{25}	Z_{26}	Z_{27}
Y_{24}	n	-0.001360	0.000016	-0.001140	0	n	n
Y_{25}	0.002969	0.082963	n	0.069562	0	-0.014015	0.035085
Y_{26}	0	0	n	0	0	0	0
Y_{27}	0	0	0	0	0	0	0
Y_{28}	0.019500	0	0	0	0	0	0

Table 15. Direct multipliers with respect to time and dummy variables.

Endogenous Variable	Predetermined Variables of the Model						
	Z_{11}	Z_{12}	Z_{21}	Z_{22}	Z_{23}	Z_{24}	Z_{30}
Y_{24}	0.019789	0.011841	0	-0.029075	-0.001425	2.445500	0
Y_{25}	-1.146133	-0.722271	0	4.636468	0.086930	0	0
Y_{26}	-0.018120	0	0	-0.091264	0	0	0.017300
Y_{27}	-0.013200	0.392635	0	0.230743	0	0	0.005800
Y_{28}	0	0	-0.138500	0	0	0	0

Without entering into a more sophisticated analysis, one easily finds that the absolute values of the multipliers presented in Table 15 are usually much larger than those standing with the "normal" quantitative predetermined variables. This confirms the argument that the trends of the Polish national economy are predominantly monotonic with a substantial role being played by sharp changes in the economic policy. This argument applies to the demographic as well as the economic phenomena.

APPENDIX: LIST OF VARIABLES
APPEARING IN DEMP-1

1. The Endogenous Variables

Y_1 - national income (computed according to material product concept) from non-agricultural sectors in billions zlotys, constant prices

Y_2 - employment in non-agricultural productive sectors, in millions, peasant-workers excluded

Y_3 - employment of peasant-workers in non-agricultural productive sectors, in millions

Y_4 - employment in agriculture, both in private, cooperative and state farms, part-time work on private farms by family members included, in millions

Y_5 - urban population, in millions

Y_6 - rural population, in millions

$Y_7 \equiv Y_2 + Y_3$

Y_8 - national income from agriculture in billions zlotys, constant prices

Y_9 - employment in services, in millions (the sector of services corresponds to all non-productive sectors, i.e., state administration, health care, education, culture and science, trade, individual craftsmanship)

$Y_{10} \equiv Y_2 + Y_3 + Y_4 + Y_9$

Y_{11} - endogenous investment in non-agricultural productive sectors, constant prices

Y_{12} - endogenous investment in agriculture, constant prices

Y_{13} - endogenous investment in services, constant prices

Y_{14} - total investment in non-agricultural productive sectors, constant prices

Y_{15} - total investment in agriculture, constant prices

Y_{16} - total investment in services, constant prices

Y_{17} - total investment in industry, constant prices

$Y_{18} \equiv Y_1 + Y_8$

Y_{19} - labor productivity in non-agricultural productive sectors

Y_{20} - labor productivity in agriculture

$Y_{21} \equiv \beta_t Y_{19} + (1 - \beta_t) Y_{20}$

Y_{22} - consumption out of private funds, constant prices

Y_{23} - overall index of consumer prices

Y_{24} - urban birth rate

Y_{25} - rural birth rate

Y_{26} - urban death rate

Y_{27} - rural death rate

Y_{28} - urban net immigration rate

Y_{29} - rural net emigration rate

Y_{30} - endogenous investment in industry, constant prices

2. The Predetermined Variables of the Model*

Z_1 - Y_1 lagged one year

Z_2 - Y_{14} lagged two years

Z_3 - Y_{14} lagged three years

Z_4 - fixed assets in agriculture, constant prices

Z_5 - real wage per capita (index) in socialized non-agricultural sectors

Z_6^o - initial level of urban population in a given year

Z_7^o - initial level of rural population in a given year

Z_8 - difference between Z_5 and the index of real per capita farmer's income

Z_9 - use of artificial fertilizers in agriculture

Z_{11} - time variables $Z_{11} = 1$ for 1960, $Z_{11} = 2$ for 1961, etc.

Z_{12} - weather dummy variable, $Z_{12} = 1$ in years when agriculture suffered from exceptionally dry or wet weather

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*The list includes only these predetermined variables which finally have entered the extended reduced form of the model.

Z_{13} - exogenous investment in non-agricultural productive sectors, billions zlotys, constant prices

Z_{14} - exogenous investment in agricultural sector, billions zlotys, constant prices

Z_{18} - flats constructed in 10^5 rooms, residential construction in rural areas excluded

Z_{19} - balance of foreign trade (exports minus imports)

Z_{20} - unit variable

Z_{21} - heavy investment dummy variable, equal 1 in years when investing was especially favored by current economic growth

Z_{22} - fast economic growth variable, Z_{21} equals 1 in the years 1971-1976

Z_{23} - bad agricultural production dummy variable, $Z_{23} = 1$ in the years when there was $Y_{8t} < Y_{8,t-1}$

Z_{24} - demographic echo dummy variable equals 1 in years when the large number of babies born during the post-war baby-boom started bearing children themselves

Z_{25} - Y_{19} lagged one year

Z_{26} - Y_{15} lagged one year

Z_{27} - Y_{15} lagged two years

Z_{28} - square of time variable Z_{11}

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